IKUWA6

Shared Heritage: Proceedings of the Sixth International Congress for Underwater Archaeology

edited by

Jennifer A. Rodrigues and Arianna Traviglia

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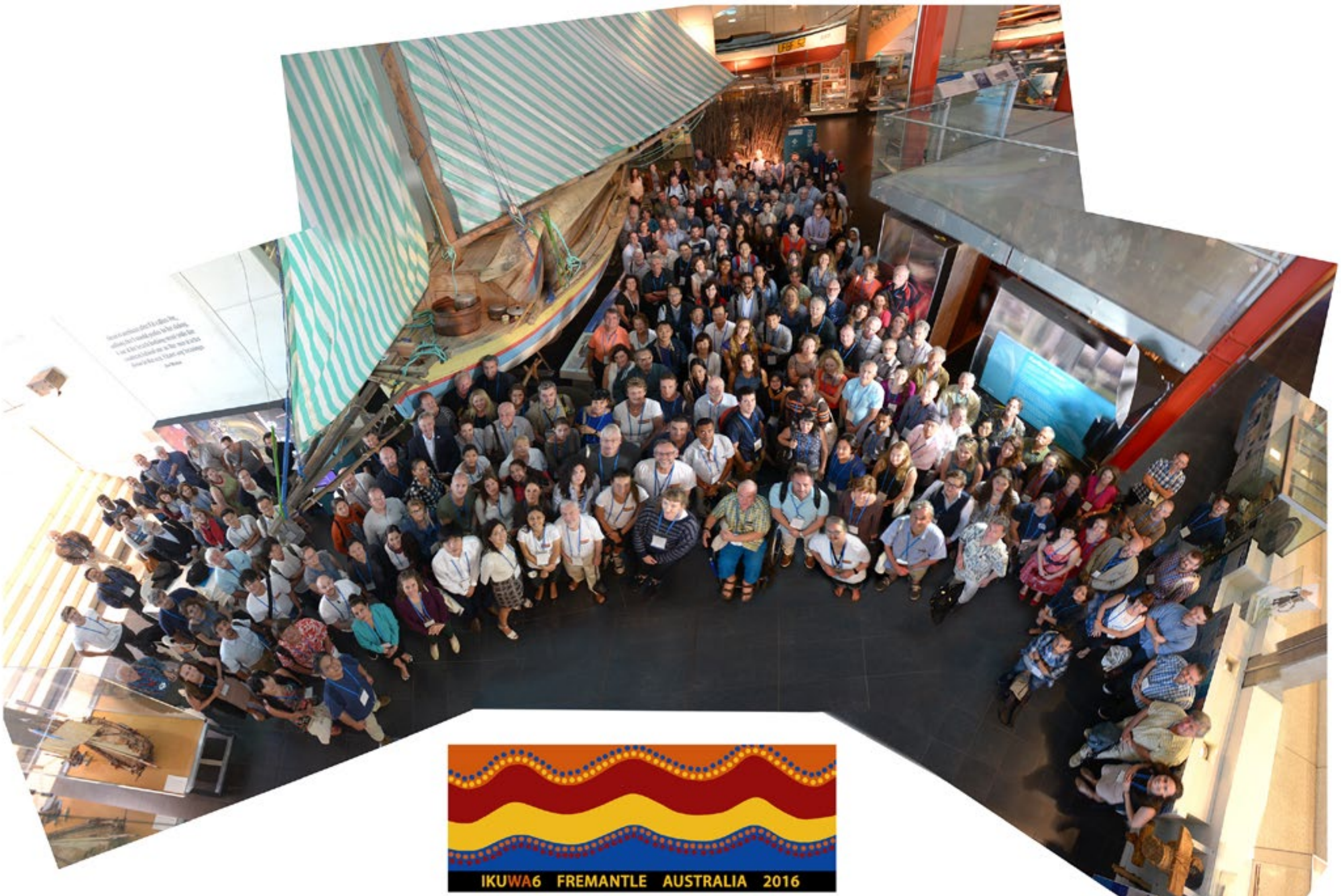

Photo by P. Baker, Westen Australian Museum

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Shared Heritage: Proceedings of the Sixth International Congress for Underwater Archaeology

28 November–2 December 2016,
Western Australian Maritime Museum
Fremantle, Western Australia

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Acknowledgment to Country

On behalf of the IKUWA International Steering Committee and the IKUWA6 Organising Committee and its partners, we acknowledge the Wadjuk Nyoongar people, traditional owners and custodians of the land on which the IKUWA6 conference was held, and we pay our respects to elders past, present and emerging. We thank them for having allowed us to meet on their land and for granting everyone safe passage.

Preface

This volume is comprised of 70 peer-reviewed papers (articles as well as short and technical reports) that were part of a larger number of papers and posters presented at the *Sixth International Congress for Underwater Archaeology* (IKUWA6), held at the Western Australian Maritime Museum in Fremantle, from 28 November to 1 December 2016. Acceptance and processing of submissions for this volume began the following year, in 2017.

The papers in this volume have been largely organised according to their session themes, arranged here as chapter themes. Given the broad subject areas included, some of these themes were consequently merged or broadened to accommodate other papers, and avoid the occurrence of just one or two papers in a chapter. As will be evident, this was not possible for every paper; however, the chapter themes are indicated in the contents table as a guide to the sequencing of the flow of papers.

As much as possible, we have attempted to leave the language and style as close to the authors' original as possible. This has meant that certain papers may have a 'speech' feel in certain contexts, but overall, the language has been kept as formal and consistent as reasonably possible.

As this is the first of the IKUWA conference proceedings to be peer-reviewed, the editors accepted a risk in deciding to undertake the additional layer and complexity of tasks that would consequently be involved; and, the time it would take to complete the entire process for each submission. Although extremely time consuming and painstaking in many respects due to the sheer workload (all of the work had to be undertaken in personal time, and outside of normal, full time work, and even holiday commitments), the resulting peer-reviewed publication has been a worthwhile effort.

The remainder of this preliminary section describes the organisation of the conference primarily to acknowledge all those who played a part in the entire journey, and gives insight into some of the mechanics involved in preparing these proceedings.

We hope that researchers of all capacities will find this volume helpful, informative and thought-provoking.

Editors, April 2020

Conference Organisation and Acknowledgements

This section serves to acknowledge all those who were involved in, and who supported, the organisation of IKUWA6. Given the scale of the event and the number of people involved in so many ways and at so many levels, it is impossible to name everyone who contributed to the resounding success of the conference and its associated academic and social programming. Nevertheless, a number of individuals, organisations, businesses and agencies deserve special mention. Those whose contributions were most essential are acknowledged and thanked in the following pages.

Background and objectives

The idea to bid for IKUWA6 was conceived by Jennifer Rodrigues who felt it would be timely to bring a major international conference that covers the broad content of maritime archaeology and history to Australasia, and to provide a very real opportunity for countries in the region and the wider southern hemisphere to participate. Attending conferences in Europe or the US has long been a significant challenge for many of our South-east Asian neighbours and colleagues in particular, yet important research and initiatives that were being undertaken in this region meant that their programmes had much to offer on the international stage. This was, thus, identified as a favourable occassion to forge and reinforce connections with our colleagues in the Pacific as well as East and South-east Asia, and to bring together northern and southern hemisphere researchers in this field. In particular, it was a chance to highlight the connections of our shared heritage stories across the globe. Holding a major conference such as IKUWA was a chance to overcome years of challenges faced by Australian colleagues who were trying to bring other major international conferences held in the US to Australia, but met much resistance due to the distance and cost for northern hemisphere colleagues to travel to Australia.

Having obtained the support of the Perth Convention Bureau, Tourism WA and the Western Australian Museum, the decision was made to bid for IKUWA6 at the meeting of IKUWA4 at Zadar, Croatia, in 2011. The bid team comprised Jennifer Rodrigues, Wendy van Duivenvoorde, Michael Gregg, Andrew Viduka and Arianna Traviglia who played essential roles in the preparation and delivery of the bid, as well as in promoting the unique benefits of holding IKUWA6 in Australia, which was integral to the eventual outcome of the bid in terms of garnering support from the voting delegates. Australia unanimously won the bid, and we thank everyone who supported it. The IKUWA Steering Committee agreed for Australia to host the conference in 2016, only two years after IKUWA5 — held at Cartagena, Spain, in late 2014 — in order to coincide with Western Australia's 400th anniversary of the first recorded European landing in October 1616. It seemed timely to have these events corresponding in the same year culminating in major State and institutional celebrations. These led to 2016 being a significant year for Western Australia's contributions to the field of maritime cultural heritage and history, all of which were hugely successful due in no small part to the strength and support of the Western Australian Museum.

Acknowledgements

All major international events require a significant and sustained effort to deliver a successful outcome in many disparate ways, and IKUWA6 was no different. The organisation of this international conference — the first time it has been held outside of Europe — required the genuine and long lasting commitment and support of so many individuals, teams, agencies, committees, institutions and supporters to finally deliver a hugely successful outcome for the delegates, the committees, sponsors, patrons and all who were connected to it. Holding the conference outside Europe for the first time presented some significant challenges such as the fact that the rest of the Steering Committee members were based in Europe so that the usual site inspections, meetings and normal protocols had to do be done differently. For this reason also, a considerable number of associated programmes were offered as part of the IKUWA6 conference, and aggressive marketing carried out very early promoting Western Australia and the rest of the country as a summer destination in conjunction with attending IKUWA6. As well, IKUWA is an inclusive conference that encompasses all aspects of the field of maritime archaeology, heritage management, museum representations and community engagements, amongst many others. The structure and scale of its conferences, therefore, require careful management in terms of representation and thematic organisation especially where parallel sessions occur. The complete support received from members of the Steering Committee, and their trust in the IKUWA6 organisers, gave the organising team much confidence in delivering a high quality and memorable event.

IKUWA steering committee

The IKUWA Steering Committee consists of founding members and those who were involved in chairing previous conferences, since the time of its inception in Germany in the late 1990s. The committee is wholeheartedly thanked for their invaluable advice the whole way through the organisation of IKUWA6. Special mention is made of Hanz Martin (Germany), Mark Beattie-Edwards (England), Beat Eberschweiler (Switzerland), David Blackman (England) and Hrvoje Potrebica (Croatia) for their outstanding support in the lead up to, during, and after IKUWA6, drawn from their own past experiences and humble leadership.

Hanz Guenter Martin	Chair	Deutsche Gesellschaft zur Förderung der Unterwasserarchäologie e.V., Germany
David Blackman	Vice-Chair	University of Oxford, England
Peter Winterstein	IKUWA1	Deutsche Gesellschaft zur Förderung der Unterwasserarchäologie e.V, Germany
Beat Eberschweiler	IKUWA2	Swiss Society of Underwater Archaeology, Switzerland
Mark Beattie-Edwards	IKUWA3	Nautical Archaeology Society, England
Luka Bekić	IKUWA4	International Centre for Underwater Archaeology, Croatia
Hrvoje Potrebica	IKUWA4	University of Zagreb, Croatia
Iván Negueruela	IKUWA5	National Museum of Underwater Archaeology (ARQVA), Spain
Jennifer Rodrigues	IKUWA6	Western Australian Museum, Australia
Arianna Traviglia	IKUWA6	Italian Institute of Technology / Università Ca 'Foscari Venezia, Italy

IKUWA6 honorary committee

An Honorary Committee was formed well ahead of the conference to strengthen the event's profile. The composition of the Committee signified the highest governmental and institutional support for the principles that IKUWA6 represented in promoting the preservation and sharing of our collective global maritime heritage, community engagements and educational opportunities. In alphabetical order, the committee comprised:

Alec Coles	Chief Executive Officer, Western Australian Museum / IKUWA6 host, Perth
His Excellency Paulo da Cunha Alves	Ambassador of Portugal to Australia, Canberra
The Honourable John Day, MLA	Minister for Health, Culture and the Arts, Western Australia, Perth
Elisa de Cabo de la Vega	Secretaría de Estado de Cultura, Ministerio de Educación, Cultura y Deporte / IKUWA5 host, Madrid
Ulrike Guérin	Secretariat of the 2001 Convention on the Protection of the Underwater Cultural Heritage, Cultural Heritage Protection Treaties Section, UNESCO Paris
Martin Hadlow	Deputy Chair, Australian National Commission for UNESCO, Queensland
Chris Johnston	Assistant Secretary, Department of the Environment and Energy, Canberra
His Excellency Christophe Lecourtier	Ambassador to Australia for France, Canberra
Her Excellency Mrs Erica Schouten	Ambassador to Australia for the Kingdom of the Netherlands, Canberra
Arturo Rey da Silva	Secretariat of the 2001 Convention on the Protection of the Underwater Cultural Heritage, Cultural Heritage Protection Treaties Section, UNESCO Paris

Each member was kept updated in the lead up to, and following, the conference in relation to the planning, status, programmes as well as final statistics and outcomes. Being directly connected with the conference via a high profile online presence, it was important to ensure that all members of the committee were in agreement with decisions made and programmes organised, including feedback from delegates after the event. The IKUWA6 organisers remain deeply grateful to the Honorary Committee for its support during the entire journey.

IKUWA6 conference chairs

The three Conference Chairs led the organisation and decision-making of every logistical aspect of the conference —planning, managing, budgeting, accounting, making, choices, solving issues, editing, and completing a large volume of endless tasks.

Jennifer Rodrigues	Western Australian Museum, Fremantle
Arianna Traviglia	University of Venice, Venice
Andrew Viduka	Department of Environment and Energy, Canberra

Organising committee and volunteers

The IKUWA6 organising committee of volunteers was carefully selected for their expertise, abilities, skills, professionalism and reliability to undertake and efficiently deliver on expectations to a very high level. The Conference Chairs are deeply indebted to each one for delivering on a wide range of expectations that are too many to list here but included seemingly minor details that made an important difference in delivering the sorts of outcomes that impacted on delegates' experiences. A select few went beyond the call of duty especially as it became evident that others were hampered by heavy remote work commitments and time in the field but were still able to contribute much effort and energy to help bring everything together. These are highlighted under their relevant sections below. This Committee comprised:

Nicolas Bigourdan	Western Australian Museum, Fremantle
Charlotte Minh Ha Pham	Murdoch University, Perth
Michael Gregg	Western Australian Museum, Fremantle
Vicki Richards	Western Australian Museum, Fremantle
Danielle Wilkinson	Cosmos Archaeology Pty Ltd, Sydney
Kotaro Yamafune	Texas A&M University, Texas
Jim Stedman	Archaeos Pty Ltd, Perth
Kevin Edwards	Tempus Archaeology, Fremantle
Della Scott-Ireton	University of West Florida, Florida
Rebecca Ryan	University of Sydney, Sydney
Cassandra Wilson	Western Australian Museum, Fremantle
Abhirada Pook Komoot	Independent Researcher, Bangkok
Jun Kimura	Tokai University, Japan
Graeme Henderson	Wreck Check Inc., Perth

Thanks are also due to: Jocelyn Skeggs (formerly with Perth Convention Bureau) for her invaluable support and advice for the team to travel to Croatia to present a very strong bid; as well as Heather McFarlane, Patrick Baker, Donna Wallis-Smith and Carol Harwood (Western Australian Museum, Perth) for their significant support and contributions along the way.

A small cohort of local and international student volunteers joined the organisers at the last stage to assist with day-to-day integral duties to ensure everything would progress smoothly, indeed progress at all. These volunteers play a critical role in major occassions such as this, and each one is warmly acknowledged for his or her commitment, professionalism and collegiate spirit they brought with them. Servicing of the registration desks at the beginning and throughout the conference meant that the sudden influx of registrants on the very first morning was managed smoothly. The background work in organising the administration was pivotal in seeing this progress smoothly from the start. The accepting, testing and delivering of all electronic files for speaker presentations ahead of respective sessions resulted in an extremely efficient and smooth running of these sessions. They also provided general technical support, which ensured that on-the-spot technical challenges were resolved quickly and efficiently to reduce or eliminate any potential impact on the extremely tight session timeframes and, consequently, the overarching schedule. Thanks also to the large number of volunteers who helped with the tedious but important organisation of the delegate conference bags, nametags and other logistics.

Major partner and sponsor

As the sole major partner and the biggest sponsor, the Western Australian Museum, deserves a very special acknowledgement. In particular, its Chief Executive Officer Alec Coles deserves particular mention for his extraordinary support at so many levels — for agreeing to host the conference at its Maritime Museum venue in Fremantle at what was the height of its commercial opportunities for event bookings, for seeking a second venue as a third presentation space (without being asked!) when it became evident that the numbers were growing with more delegates wanting to be included in the programme, for underwriting the event, and for the organisational resources that went into delivering the conference in its entirety, which by the end was enormous. Securing the third presentation space and negotiating its free use on behalf of the organisers enabled more presenters to be included in the programme and was deeply appreciated. The Organising Committee remains indebted to Alec Coles and the Western Australian Museum for providing immense support for IKUWA6.

Additional sponsors, supporters and exhibitors

Another major sponsor, the Honor Frost Foundation, funded a considerable number of delegates to attend IKUWA6 and present their research. The Perth Convention Bureau and Tourism WA provided critical and substantial funding for the bidding of IKUWA6 in 2011 in Zadar, Croatia, and then subsequently for the marketing and promoting of the conference within Australia and overseas. Silentworld Foundation sponsored the opening night's Welcome Reception, which allowed for a very successful and fun evening.

James McKibbin (Fremantle Zoetrope) produced and supported the series of lighthearted and deliberately amusing promotional videos titled 'Are you in?' as part of the marketing campaign for the conference. It provided an element of fun for those involved and delighted many viewers. The organisers thank all those who participated in these videos because each person had to be filmed, or had to organise their own filming, which was done all around the world. Nicolas Bigourdan is specially acknowledged for his enormous efforts in managing this series of recordings and pulling together so many challenging elements. The Embassy of the Kingdom of the Netherlands in Canberra sponsored a social networking event on the second night of the conference. This was an added celebration to Western Australia's state commemorations of the 400th anniversary of the first recorded European (Dutch) contact with the west coast, a major State government programme that the Western Australian Museum played a key role in delivering through a combination of award-winning programmes in 2016, and which connected nicely with IKUWA6.

SRA Technology provided important financial support and delegate gifts, and was as an event exhibitor. Fremantle Port Authority allowed for the use of historic C Shed as a third parallel session space, and which included the poster display. Professional Diving Services in Melbourne, especially Malcolm Venturoni, are thanked for their financial support and gift for the delegates' conference packs. The Australasian Institute of Maritime Archaeology permitted the conference website to be hosted via its web domain. The content was subsequently scaled down and migrated to the website of the Nautical Archaeology Society (NAS) in the UK after IKUWA6 was over, and for the processing of the proceedings; the NAS generously hosts all legacy web content of all previous IKUWA conferences.

Patronage

Patrons of the conference are acknowledged for the support that their respective and collective brands and high profiles afforded IKUWA6. These comprised agencies, academic and government departments, as well as associations of international standing that provided the highest form of ethical and moral support for the principles of IKUWA6. Members included:

- United Nations Educational, Scientific and Cultural Organisation (UNESCO), Paris
- Advisory Council on Underwater Archaeology (ACUA), International
- Australia's International Council on Monuments and Sites (ICOMOS), Australia
- Nautical Archaeology Society (NAS), England
- Alliance Francaise de Perth, Perth
- Embassy of France, Canberra
- Università Ca 'Foscari Venezia, Venice

Before the conference

Because IKUWA6 was the first time an IKUWA conference was to be held outside Europe, promoting the event and attracting delegates from the northern hemisphere posed a challenge, whilst the opportunity — a primary objective for bringing the conference to Australia — was also identified in being able to attract delegates, researchers and practitioners from the Pacific island states, South-east Asia and the surrounds. Consequently, promotions started in the years prior in order to attract as many delegates and supporters as possible and raise the profile of the conference to far reaching destinations. The aggressive marketing was viewed as necessary to allow individuals and agencies to factor this event into their projected schedules and budgets for attending the conference, allowing as much lead up time as possible for interested participants to attempt to make the most of their visit in their planning. IKUWA6 was also promoted at other international conferences in Europe, and the IKUWA6 organisers thank these organisations.

Andrew Viduka very successfully managed the sponsorship responsibilities and vital stakeholder relationships for the conference including other crucial responsibilities from Canberra — these were integral for the success of progressing various elements. Arianna Traviglia provided much needed technical and administrative input, designs, budgeting, and important communications, first from Sydney then from Venice. Jennifer Rodrigues built and maintained the website for the conference and associated tours; and, managed the marketing strategy, logistics and administration necessary including the team on the ground. Jennifer had designed the conference logo in 2011 as part of the bid in Zadar. The concept took its inspiration from at least one age-old Australian aboriginal art practice, with colours and patterns representing earth and sea. The logo design features the central wave pattern of past IKUWA logos whilst incorporating indigenous Australian motifs and colours that embody both the prehistoric and maritime identities of Australia. Support from the Museum particularly with on-line registration for the conference and associated programming meant this process was smoothly carried out. This was the first time registration was created for an event of this nature and scale by the Museum, and a special thanks is extended to Heather McFarlane and the IT team for their crucial support.

IKUWA6 was the first time that a call for sessions was publicised rather than the organising committee constructing these first then inviting abstracts. Once finalised, a call for papers was announced. In vetting the sessions and associated papers, it became clear that there was a massive oversubscription of abstracts for both paper and poster presentations then could be accommodated. As a result, the conference chairs felt it necessary to manage the accepted papers and posters closely to ensure the venue could physically and practically accommodate the submissions accepted within a reasonably planned schedule. Like all IKUWA conferences, all abstracts were peer and blind reviewed; any disagreements were handed over to a third appropriate reviewer in the subject matter before final decisions were made. Here again, the organisers sincerely thank all reviewers and authors, and the IKUWA Steering Committee.

As the organisation progressed in 2016, it became evident that the marketing strategy had been overly successful. Registrations were became over-subscribed, with more local, national and international presenters wanting to be included but who had to be placed on the waitlist, or offered the opportunity to present a poster due to limitations for speaker spots available. The third space (C Shed) outside of the Western Australian Maritime Museum but within close walking distance was secured, which allowed for the number of presenters to be immediately expanded, though still not all could be included. Nevertheless, it further fulfilled IKUWA's desire to include as many delegates and presenters as possible at all conferences. IKUWA also has a tradition of viewing and treating all delegates and presentations as equal, a reason why no keynote addresses were included in the programme. Ideally, a conference with a single session would allow the richest of engagements for all delegates. Understandably, however, large conferences face time constraints and high costs meaning that this is often impossible, particularly conferences that cover all areas of the field such as IKUWA does. Consequently, registrations were closed more than a month before the conference due to the oversubscription, as considerations had to be made regarding space, safety issues and the sheer management of delegate numbers.

The conference and associated programmes

The conference was organised with several objectives in mind — to allow the maximum number of high quality papers and posters to be included; to attempt the least number of parallel sessions as possible for maximum engagement for all participants; to allow as many opportunities as possible for participants to reconnect and develop new networks for potential collaborations during the conference; to keep all associated fees and costs as low as possible for maximum participation; and, to ensure everything ran as smoothly as possible so that delegates could enjoy and take away the best experience possible.

IKUWA6 welcomed nearly 300 delegates representing 41 nations or islands; more than half travelled from overseas to hear, read about or discuss some 170 presentations in the programme. More than 30 posters and more than 130 oral presentations were delivered over the four days across three parallel sessions, which included dedicated sessions for viewing of posters and ability to engage directly with poster presenters. A UNESCO roundtable session was held as the first session on day one. Our thanks to Ulrike Guerin from UNESCO Paris for leading the organisation of this, and coordinating the programme. All session organisers, session chairs and presenters are acknowledged for their efforts, and all delegates are thanked for participating in the conference, as everyone played a part in making IKUWA6 the success that it was.

A dedicated 'book room' was organised in the Maritime Museum for delegates and sponsors who wanted to promote their publications and projects, including banners, flyers and other materials. The room turned out to be a welcome quiet 'getaway' for delegates who needed to do some focused work or preparations whilst enjoying views of Fremantle's working harbour and the Indian Ocean.

Pre-conference workshop

The weekend before the start of the formal presentation sessions saw a two-day intensive workshop on 3D Multi-Image Photogrammetry. This two-part, two-day course was sold out several weeks before the conference yet organisers still kept receiving requests so both classes were beyond capacity but manageable. Taught by Kevin Edwards and Kotaro Yamafune, and assisted by Patrick Baker, the first day was an introduction to basic concepts and applications; and, the second involved more intermediate and advanced concepts and applications. All instructors are duly acknowledged for their initiatives and efforts in preparing for the workshop and for organising all equipment and materials.

Opening Night Welcome Reception

As acknowledged above, Silentworld Foundation sponsored the Welcome Reception on the opening night. It was a hugely successful occassion that allowed many old friends and colleagues to reconnect as well as establish new networks ahead of an intense but fun week. The Foundation was particularly understanding and generous in agreeing to increase its sponsorship late in the process when registration for this opening went beyond expected numbers and hit capacity so that catering and associated costs consequently increased. The organisers remain extremely grateful to Paul Hundley and the Foundation for their generous support, which enabled the event to be a huge success.

To pay respect to the fact that we were on Aboriginal land and country, Len Collard (University of Western Australia) is warmly thanked for conducting, as part of the opening ceremony, a very moving 'Welcome to Country', an extremely important Australian Indigenous ceremony that can only be performed by a recognised elder. Visitors are welcomed to their Country (local homeland), enjoying the safe passage granted, and recognising the ancestral spirits past, present and emerging. In Australia, this sacred observance highlights the cultural significance of the land and surrounds to a particular clan or language group.

John Bannister & the Charisma Brothers provided the entertainment on the Opening Night, a meaningful connection with the Museum in that the lead, John Bannister Jr., is the son of the late John Bannister, a former CEO of the Western Australian Museum. All speakers on the night are gratefully acknowledged: Len Collard, Alec Coles (Master of Ceremonies), Jennifer Rodrigues, Hanz Martin and last but not least, then Minister for Culture and the Arts, John Day, for officially opening the event.

Informal Networking Evening

As acknowledged above, the Embassy of the Kingdom of the Netherlands in Canberra sponsored this event. The organisers are grateful to the Embassy and its staff for their generosity and for organising the event. It was a nice ending to what was an extremely intense year of commemorations surrounding the 400th anniversary State celebrations.

Conference Dinner

A social dinner was held on the last night of the conference. Leading this planning was Vicki Richards who deserves special acknowledgement. The dinner was held at the Fremantle Sailing Club, situated with spectacular views of the Indian Ocean and its unique sunsets. Considering the various dietary requirements, a desire to keep costs as low as possible and other logistical factors involved, the dinner and entertainment was a massive success and all who were involved are duly acknowledged. The same IKUWA6 student volunteers and Charlotte Pham are also acknowledged again for the critical part they played in ensuring everything ran smoothly.

Conference Tours

The conference offered four tours to delegates — before, during and after the formal presentation sessions. A very special acknowledgement must go to Nicolas Bigourdan for his noteworthy achievement in singlehandedly organising all of these, coordinating participants who registered, fielding all queries, and liaising with tour operators including hiring and driving of buses to assist participants with pick-ups and drop offs.

- ***Abrolhos Islands Shipwrecks Special Tour (Full Day)***
  This was a very rare and unique day trip that involved participants flying from Perth to Geraldton, then flying in a small aircraft over the stunning Abrolhos Islands to view the *Batavia* (1629) and *Zeewijk* (1727) Dutch VOC shipwrecks. It included time for snorkelling, morning tea and lunch on one of the islands. It was an opportunity to view the beautiful Houtman Abrolhos, 60km west of Geraldton on the mid-west coast. The Abrolhos consists of 122 islands and associated coral reefs. The marine environment is a meeting place for tropical and temperate sea life, and is one of the world's most important seabird breeding areas.

- ***Fremantle Prison Torchlight Tour (Evening)***
  This fascinating, peculiar and somewhat eerie evening tour involved going through the old Fremantle Prison — Western Australia's only World Heritage Listed building.

- ***Swan Valley Wine Tour (Half Day)***
  This fun tour included wine, cheese and beer tastings, and historical background information about the Swan Valley — one of the oldest wine regions in Western Australia, and Australia.

- ***Rottnest Island Dive and Snorkel Trip to Shipwreck Sites (Full Day)***
  This popular day trip involved a boat ride from Fremantle to selected shipwreck sites around Rottnest Island (19 km west of the mainland) with a barbeque lunch on board.

The phenomenal effort in organising all of these tours was no mean feat and the team remains deeply grateful to Nicolas.

Post IKUWA6 and proceedings

Feedback received from a vast number of delegates personally to the organisers, through emails and primarily via social media, strongly indicated that the entire conference event was a resounding success. Delegates felt it was very professionally organised, presentations were of high quality, and that they had a meaningful and enjoyable experience. This was heartening for the organising committee, volunteers and for the Museum who, individually and collectively, invested an enormous volume of resources and sacrifices to deliver the best experience possible.

A heartfelt 'thank you' is extended to all of the volunteers, named and not named here, for their time and efforts, which played a part in the experiences of the conference delegates, many of whom came from very far flung locations and were first time visitors to Australia. The Conference Chairs are also grateful to those who helped with the clean up and post conference tasks after IKUWA6 was over.

Processing of the conference proceedings began the following year, in 2017. The editors thank everyone who was involved in this process including authors, reviewers and sponsors of this publication (listed below). To manage the entire process, a free online journal management system, Open Journal System (OJS), was selected. The system was acceptable overall albeit with a few technical issues. Much confusion occurred at the submission stage in terms of text and image files being uploaded to incorrect categories, uploading of incorrect or duplicated image files and missing figures, and image files that did not meet requirements. Non-compliance with author guidelines was an overall significant challenge that proved extremely time consuming to rectify and this occurred at all stages with some of the submissions. Many of these issues caused significant confusion, which needed to be rectified before subsequent stages could proceed. The system was new to many so the lack of familiarity was often a factor. Another time-consuming element involved reviewers who agreed to review papers, held onto these for months, but were then unable to review them due to being ill or busy; and, unfortunately, a number of papers went through this cycle multiple times. Despite the many challenges, all authors are acknowledged for seeing through the processing of their papers until the end and are thanked for their patience. All reviewers are acknowledged for their time and effort in enabling this to be a peer-reviewed volume — their time, valuable input and decisions and recommendations on the papers they reviewed are very much appreciated. Particular acknowledgement to Hanz Martin, Chair of the IKUWA

Steering Committee, for his consistent and valued support and for taking on more than the allocated reviews when this was urgently needed. Some papers could not be accepted into this volume due to reviewers' feedback and recommendations; we hope these authors were able to publish their work via other avenues in order to disseminate information about their projects and findings.

A number of agencies provided financial support that enabled publication of this volume. Special thanks again are extended to the Western Australian Museum and Commonwealth Department of Environment and Energy, and we specifically acknowledge once again Andrew Viduka for his invaluable efforts in this regard.

Western Australian Museum

Commonwealth Department of Environment and Energy & Australian Historic Shipwreck Preservation Program

Heritage New Zealand Pouhere Taonga

Environment, Land, Water and Planning, Victoria

New South Wales Office of Environment and Heritage

Norfolk Island Museum

Northern Territory Government

South Australian Department of Environment, Water and Natural Resources

Tasmanian Government

Queensland Government

Final thoughts

IKUWA6 would no doubt have benefited from availability of more session rooms and an expanded programme, which could have allowed for a higher number of presenters; however, this would have increased overall costs. Importantly, it was simply impossible despite exhaustive investigation by the team to seek further additional spaces to be available at that time within reasonable distance. The conference was over subscribed so that registrations had to be closed when numbers were becoming too high. The strict, blind review process that was implemented to select submissions based on quality and accuracy ensured that the standard of presentations, and therefore the academic and scientific substance of the conference, was very high. This was especially evident based on the feedback received from a vast number of delegates during and after the event. For all the efforts involved, and for all those who participated in the conference in all capacities, those who travelled long distances to Fremantle, and all who were involved in one way or another from the very early days until the end, the organisers are deeply grateful to each and every person. IKUWA6 brought together a vast number of delegates, these included pioneers in the field, students and researchers just starting their training or careers, mid-career professionals, and many other individuals and practitioners who had a genuine interest to be at IKUWA6. The programmes, presentations, supporters, sponsors, organisers, hosts, businesses and delegates collectively and individually contributed to the event's resounding success.

The organising of IKUWA6, whilst largely rewarding and valuable in many respects, was undoubtedly a considerable challenge with many unforeseen and unfavourable situations that arose. Fortunately, the strength of the organising team and volunteers, the ongoing support of the Steering Committee and the Western Australian Museum, and the consistent encouragements from colleagues around the world ensured that the IKUWA6 team was able to achieve its aims. With the bid accepted in late 2011, the conference happening at the end of 2016, and the publication reaching its final stage in late 2019, the entire process has occupied a large portion of the Conference Chairs' and Editors' personal lives. It is with a large degree of relief that this project finally comes to an end. Notwithstanding the impact that organising a major international conference of this scale can have on individuals holding key roles, we nevertheless encourage others to genuinely consider taking on this challenge of organising future IKUWA conferences in as many different parts of the world as possible, with the aim of building upon past successes and experiences. Although exhausting, it is ultimately a rewarding experience, especially as IKUWA6 was able to attract many colleagues from nearby and neighbouring regions, which was a primary goal for bringing the conference to Australia.

We look forward to reconnecting with friends and colleagues at the next IKUWA meeting, IKUWA7, in Helsinki, Finland.

A Brief Update on Australia's Consideration and Status for Ratification of the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage

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Abstract

Australia has been actively considering ratification of the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage since 2009. This short paper outlines the status of Australia's consideration as of December 2014 and highlights the announcement made at the opening of the IKUWA6 Conference, by the Australian Government Minister for the Environment and Energy, that Australia will introduce new underwater cultural heritage legislation that would align with the Convention.

Keywords

Australia, Underwater Cultural Heritage, UNESCO 2001 Convention

Background up to 2007

Australia has played a leadership role in the development and negotiation of the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage. In 1996 Graeme Henderson, then Director of the Western Australian Maritime Museum, formed a special interest group within the Australian branch of the International Council on Monuments and Sites (ICOMOS) called The International Committee on the Underwater Cultural Heritage (ICUCH) (Henderson 2014: 9–11). ICUCH was formed to promote international cooperation in the protection and management of underwater cultural heritage, and to advise ICOMOS on issues related to underwater cultural heritage around the world. One of the most significant outcomes of the group to date was the drafting of the 1996 ICOMOS-adopted International Charter on the Protection and Management of Underwater Cultural Heritage (ICOMOS 1998), which was confirmed in 2001 as the Annex to the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage (the Convention). Other Australians—namely Lyndel Prott and Patrick O'Keefe—are better known for their significant roles in drafting the Convention itself (O'Keefe 2014: 7–8; Prott 2014: 5–6).It is, however, important to note that the efforts of these Australians are not in isolation and that many people throughout Australia, including Australian Government officers, by their actions, publications and research, have encouraged improvements to Commonwealth legislation in Australia and consideration for ratification. It is impossible to list everyone who has contributed to changing Australia's policy position with regards to the Convention but David Nutley and Mark Staniforth have been consistent vocal advocates for ratification and should be recognised for their individual efforts (Henderson and Viduka 2014: 1–36; McKenzie 2010: 63–68; Nutley 2005: 40–43; Viduka 2012: 1–9; Viduka 2014: 15–18). Equally important has been the advocacy of the Australasian Institute for Maritime Archaeology (AIMA) and its members (Green 2004: 33–42; Jeffery 2002: 75–82). AIMA is Australia's pre-eminent not-for-profit organisation dedicated to the preservation of underwater cultural heritage and represents a varied base of individuals from professionals through to interested members of the public. AIMA's ethics align with the Convention and AIMA Executive has been a vocal and ongoing advocate for the principles outlined in the Convention as well as Australia's ratification.

While Australia was present on 2 November 2001 and voted for the Convention, the fourth Convention protecting cultural heritage, Australia has not yet ratified. This is seven years after the Convention came into force on 2 January 2009, following ratification by 20 States. Indeed, in the Asia-Pacific region only two States have ratified, Iran and Cambodia.[1] This region is one of the least represented and Australia's lack of participation, ratification and leadership is noted by other regional States.

Why ratify?

Why should Australia ratify? A critical formal step in the ratification process is for a National Interest Analysis to be tabled in Parliament demonstrating the benefits and costs of ratification. It is, thus, important to understand the domestic and international reasons for ratification. Some of the objectives for Australia to amend its legislation and enable ratification of the Convention would be to:

[1] On 19 April 2018, the Federated States of Micronesia ratified the Convention, becoming the third State in the Asia-Pacific Region to do so.

- Provide a similar level of protection and recognition for underwater cultural heritage as that afforded to land-based heritage;
- Enable the Australian Government Department responsible for administering the relevant legislation to lead in protecting Australia's underwater cultural heritage located outside of Australian waters;
- Simplify and create certainty in marine planning by incorporating all aspects of underwater cultural heritage protection within an updated Act;
- Extend protection to aircraft wrecks and to their associated human remains;
- Enable differentiation of human remains from other underwater relics;
- Enable the Australian Government to use the cooperative protection mechanisms within the Convention to better protect our underwater heritage, outside of Australian jurisdictional waters, from the threat of interference and illegal salvage;
- Incorporate international underpinning to domestic heritage legislation;
- Enable Australia to control the actions of foreign individuals and foreign flagged vessels, directed at underwater cultural heritage in waters beyond the Contiguous Zone out to the end of the Exclusive Economic Zone; and
- Take an international role in the protection of underwater cultural heritage and 'lead by example' on this significant heritage preservation issue.

From a policy perspective, once Australia ratifies the Convention, it will enable the Australian Government to more actively engage with ratified and non-ratified countries to protect our overseas underwater cultural heritage.

Activities since 2007

Since 2007, Australia has been 'actively' considering the question of ratification. After several earlier efforts at reviewing the Historic Shipwrecks Act 1976, in 2009 the Australian Government commenced a public review of the Act and consideration of ratification of the Convention (Viduka 2012: 3). The review itself was concluded without a report being finalised (McKenzie 2010: 63–68; Viduka 2012: 3; Viduka 2014: 17). However, results from the review indicated that amending the Historic Shipwrecks Act 1976 and ratifying the Convention were supported by the community, States and the Northern Territory (Viduka 2014: 16–17). Ratification was not universally supported in 2009 within the Australian Government; a question was raised about the potential impacts on sovereignty over sunken warships and aircraft.

The most significant outcome stemming from the review was the endorsement by the Commonwealth, States and the Northern Territory of the 2010 Australian Underwater Cultural Heritage Intergovernmental Agreement (IGA). The IGA codifies the practices and processes for administering Australia's underwater cultural heritage that have been in use for over 20 years and requires all relevant States and the Northern Territory governments to undertake all necessary activities to enable the Commonwealth to ratify, should the Australian Government decide to do so (Viduka 2014: 18). Ratification of the Convention will require: minor policy amendments to the Historic Shipwrecks Act 1976; a positive report by the Joint Standing Committee on Treaties of a National Interest Analysis; drafting of enabling legislation; and the agreement of the Federal Executive Council.

Following extensive consultation, on 14 January 2014 the then Minister for the Environment agreed to pursue amending the Historic Shipwrecks Act 1976 to enable ratification of the Convention. This support was substantially withdrawn in late 2014 due to other Government priorities having precedence. In December 2015, both the amendment of the Historic Shipwrecks Act 1976 and consideration for ratification were included in the Australian Heritage Strategy (2015: 31) as outcomes to be delivered by December 2018.

Announced at the opening of the IKUWA6 Conference, the Minister for the Environment and Energy, the Hon Josh Frydenberg MP, committed to repealing the Historic Shipwrecks Act 1976 and the associated Historic Shipwrecks Regulations 1978, and to introducing new legislation that would align with the Convention. The Department of the Environment and Energy is now engaged in seeking drafting resources to prepare the Underwater Cultural Heritage Bill and associated regulations, and will work to meet the Australian Heritage Strategy timeline within available resources and Government priorities.[2]

This approach is in line with the Australian Government's policies to modernise legislation and to have legislation in place that aligns with, and supports, a Convention prior to signing the Convention.

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The Belitung Shipwreck Collection and Maritime Archaeology in South-East Asia: What is the Way Forward?

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Abstract

The 'Belitung' or 'Tang Shipwreck' collection, currently housed and cared for at the Asian Civilisations Museum in Singapore, has long been at the centre of contention concerning 'best practice' of underwater cultural heritage (UCH) management in South-east Asia, from a global perspective. Much research has been conducted on the collection with beneficial and valuable information still emerging, despite concerns raised over the method of excavation. Today, issues surrounding this dilemma remain contentious and unresolved. This overview explores this one case study, summarising: i) how the Asian Civilisations Museum has approached curating and managing the collection; ii) distinct views that have been at play; and, iii) responses to the question about how high-risk shipwrecks in South-east Asia should realistically be managed in the immediate and longer terms.

Keywords

Belitung, Tang Shipwreck Collection, disappearing history, effective protection

Introduction

This paper forms part of a series of brief, topical presentations on the management of maritime cultural heritage, including legacy issues and consequent future options, using the case of the Tang shipwreck Collection. The 'Belitung shipwreck' or 'Tang Shipwreck' collection—as it is interchangeably referred to—is the focus of this paper due to ongoing contentious issues, and continuing challenges faced in South-east Asia. The region is expected by those on the outside to effectively manage their historic shipwrecks in accordance with accepted international standards, regardless of available resources and expertise. The 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage, which stipulates *in situ* preservation as the first option, and that UCH should not be commercially exploited or irretrievably dispersed, are used as the accepted standard to be measured against.

This paper presents an overview of the realities and factual details of the contemporary political context surrounding the finding and excavation of the Belitung shipwreck, and the continuing controversy surrounding the associated collection because of who was involved in the excavation. It further raises questions about what we do with such a collection that embodies controversy yet still holds valuable, rare and important historical information not found elsewhere about Asia's past—findings that continue to build upon existing knowledge and contribute comparative data to ongoing international scholarship. What lessons can we learn from this experience? Is there a way forward that benefits communities, international scholarship, and the cultural heritage managers?

The questions and arguments that are still being raised reflect the complex issues embodied within the Tang cargo case in terms of the impact on the site from the point of discovery; management of the site following discovery and excavation; management of the collection; and conditions that have long faced South-east Asia. Other examples are briefly touched on as points of reference but are otherwise outside the scope of this paper.

It is worth noting that 'maritime archaeologists' do not consider professionals who operate in a commercial context such as in the Belitung excavation, to be maritime archaeologists; and, they do not consider the nature of the work to be 'archaeology' regardless of the methods and processes involved and even if the collection was kept together afterwards. Many historians with expertise in this area and long involvement with the discipline in South-east Asia do not share this view because of the valuable historical information that has resulted from the excavated evidence and subsequent research publications. For these reasons, this paper is written on the assumption that it will be read mainly by persons involved in this debate and familiar with this case study.

Background

In 1998, an Indonesian fisherman diving for *trepang* (sea cucumbers) in shallow waters discovered the Belitung shipwreck located within the Gaspar Strait, which lies between the Indonesian islands of Bangka and Belitung. Less than 3km from Belitung Island in the Java Sea, he stumbled upon a mound of ceramics—mostly bowls and ewers—in an otherwise flat and featureless seabed (Flecker 2011: 101; Guy 2011: 30). The ship had been carrying ceramics, coins, bronze mirrors as well as other metal objects such as gold and silver boxes, bowls, platters and cups, and one glass bottle (Murphy 2017: 19). The diver and his companions sold the position of the wreck site to Seabed Explorations GBR, a German company that held a survey and excavation licence issued by the Indonesian government. The subsequent recovery process or excavation, which occurred in 1998 and 1999, was, therefore, a legally-conducted process.

However, criticisms of the excavation citing ethical concerns still arise from maritime archaeologists based outside South-east Asia. These relate to who led the excavation and how the site was managed. There has also been aggressive pressure put on institutions to not showcase the collection to the public as this 'endorses' the 'unethical' treatment of UCH sites by non-archaeologists and potentially confuses the public—with two distinct arguments arising in a constantly heated debate that has seen virtually no progress on this polarising issue.

Valuable information from the shipwreck

Although the existence of Arab or Persian vessels on the sea route between the ports of West Asia and China had long been suspected, the Belitung shipwreck provides the first physical evidence of direct maritime trade between these regions during the Tang period (Murphy 2017). Based on the study of the ship's construction, materials and hull form including conjecture derived from the available evidence, the Belitung vessel appears to have been of Arab origin, suggesting that the Arabs and Persians traded directly with China as early as the 9th century. The Belitung vessel also carried the largest and most intact collection of Tang dynasty ceramics found in a single location. Given Belitung Island's location off Southern Sumatra and proximity to Palembang, the capital of the maritime power, Srivijaya (7th–14th centuries), it is reasonable to assume that the ship was destined to dock at this port. This suggests the key role that Srivijaya played in the maritime trade routes that stretched from the Middle East to China.

Active trading had, therefore, been underway long before the Portuguese arrived in Asia in their search for goods and spices. As further research by scholars advanced, there were indications that the ship 'was manned by an international crew ... who lived and slept on deck' while heavy loads of cargo were tightly packed below deck (Flecker 2017: 28–32). Importantly, the discovery, excavation and subsequent research significantly widened the boundaries of knowledge surrounding Chinese Tang dynasty maritime history, including the nature and dimensions of early Asian trade (Leow 2009).

This is believed to be the earliest evidence of maritime trade between the Tang dynasty (618–907) and the Abbasid caliphate (750–1258). It reveals details not only about the ship and the men who sailed it but also the cargo, its production and markets (Murphy 2017). Its evidence has revealed valuable information that has filled historical gaps and confirmed previous hypotheses that commercial links between China, South-east Asia and the Middle East occurred at an earlier date than previously thought. In addition, the information acquired allowed for the study and reconstruction of a replica Arab dhow—the *Jewel of Muscat*—and for the replica to sail from Oman to Singapore, where it is now displayed at the Maritime Experiential Museum on Sentosa Island.

The Cirebon wreck found off Java provides another example. In 2004–2006 a private company salvaged this wreck which revealed information about the Maritime Silk Route and other common trading routes between South-east Asia and other ports. No underwater archaeologist dived on this very deep site; however, the head of the diving team recorded the ship's structure and condition in impressive detail. In actual fact, the vast volume of historical information on maritime trade in South-east Asia has come from wrecks excavated by non-archaeologists and their resulting publications. Much less has derived from works by professional maritime archaeologists.

Fate of the Tang Shipwreck Collection

It is important to note a few facts about the Belitung shipwreck case. The material was legally excavated and recovered by Tilman Walterfang/Seabed Explorations, permitted by a license issued by the Indonesian Government. After time spent in storage and much negotiating, on 24 February 2005, the entire collection was acquired for US$32 million by the Singapore Tourism Board (STB) on behalf of the Singapore government through Sentosa Leisure Management Pte Ltd. Singapore, therefore, became the sole owners of the Tang Shipwreck Cargo (Press release Sentosa Development Corporation 8 April 2005). This sparked controversy with some suggesting that, following this purchase, the Belitung cargo should be renamed the 'Tang Shipwreck Collection' to disassociate the wreck from its find location, thereby allowing Singapore to more easily lay claim to the wreck (Pearson 2016a: 10).

To raise the profile of valuable information embodied within the Tang Shipwreck Collection, it has been publicly exhibited extensively in Singapore and internationally. Much of the impetus for the travelling exhibitions from 2014 onwards has come from the borrowing institutions, many of which have national, municipal or provincial museum status in their respective countries. They are fully cognizant of the conditions under which the material was recovered but recognise the significance and value of this collection, and the importance of exhibiting it to the general public.

Soon after the collection was acquired, highlights were displayed at the Asian Civilisations Museum (ACM) in Singapore, in an exhibition named *Tang Treasures from the Sea.* This took place from 15 June to 31 July 2005 with over 100 objects shown including gold, silver and a selection of Chinese ceramics. The show drew visitors totalling over 150,000 (Krahl *et al.* 2011: xi).

In 2011, an exhibition titled *Shipwrecked: Tang Treasures and Monsoon Winds* had been developed. It was jointly organised between the Singapore Tourism Board and the Freer Gallery of Art and Arthur M. Sackler Gallery, Smithsonian Institution (FSG). Consisting of some 450 artefacts from the collection, it was to first be exhibited in Singapore at the ArtScience Museum from 19 February to 31 July 2011 then scheduled to travel to the FSG in the spring of 2012. The first leg of the exhibition at the ArtScience museum went as planned. However, at the same time, objections were beginning to surface across the Pacific, particularly amongst US-based archaeologists who argued that the FSG should refuse to exhibit the collection on ethical grounds. The issue began to grow more divisive in the US and, as the critics became more vocal, the FSG decided to re-evaluate its position and eventually the Smithsonian Institution cancelled the show. As a result, the show at the ArtScience Museum was extended until 2 October.

By 2011–2012, serious consideration was being given to the Tang Shipwreck Collection being transferred over to the ACM from the Singapore Tourism Board so that it could not only be given a permanent home, but also become part of the national collection. This would also mean that the collection would now be managed by the full gamut of museum professionals—curators, collection managers and conservators. This would help to mitigate one of the strongest objections internationally—that the collection was owned by a tourism agency rather than a national museum.

In March 2013 the Tang Shipwreck Collection was transferred over to the ACM. Construction of a new, purpose-built gallery was completed in September 2015. The gallery, named after the Khoo Teck Puat Family in recognition of their donation, opened on 14 November 2015 and displays over 800 objects from the wreck. A new catalogue, *The Tang Shipwreck: Art and Exchange in the 9th century* was published in April 2017 to accompany the new gallery. The rest of the collection is stored at the Heritage Conservation Centre—the storage and conservation facility for Singapore's national collection—and is accessible to scholars and students for research. The whole of the excavated Belitung collection has been kept together because of fortuitous circumstances. It could easily have been sold piecemeal to private collectors, as was the case with the Binh Thuan wreck (referred to below). The ACM's public display specifically highlights and explains the difference between an archaeological excavation and a commercial approach recovery such as in this case. It, thereby, in no way claims that the site was adequately excavated in a scientific way from the perspective of archaeologists, and, just as crucially, seizes the opportunity to inform its visitors about this difference.

In the interim, the collection travelled to the newly opened Aga Khan Museum (AKM) in Toronto and was exhibited from 13 December 2014 to 26 April 2015. During the planning stages of the exhibition, it had been agreed between the ACM and AKM that the controversy should be tackled head-on. A one-day symposium was consequently organised for 28 February 2015. Key figures involved in maritime archaeology were invited to participate in a roundtable discussion on the issues surrounding this case. The show garnered positive reviews in the local and national Canadian press and there were no protests or objections received from the archaeological community in North America.

With the success of the Aga Khan Museum show, a number of international museums began to approach the ACM about borrowing items from the Tang Shipwreck Collection. The first was the Institut du Monde Arabe, Paris, and the Museum of European and Mediterranean Civilisations in Marseille who wished to borrow some items as part of a larger exhibition they were mounting called *Aventuriers des mers*. The ACM agreed. The show ran from 17 November 2016 to 5 March 2017 at the Institut du Monde Arabe; and from 17 May to 25 September 2017 at the Museum of European and Mediterranean Civilisations.

On 7 March 2017, a jointly curated show between the ACM and the Asia Society opened in New York. Titled *Secrets of the Sea: A Tang Shipwreck and Early Trade in Asia*, the exhibition ran until 4 June 2017. Initial press previews were rather neutral with a *New York Times* article of 21 February 2017, outlining that the exhibition was happening despite the previous controversy. In a similar approach to the AKM show, two symposia were organised around the exhibition to deal with both the academic and historic significance of the collection as well as issues surrounding maritime archaeology and UCH management in South-east Asia. The exhibition also had a dedicated room dealing with the controversy, with folders made available containing related reading material and press cuttings. Asia Society and the ACM viewed this as an opportunity to draw attention to the complex questions surrounding archaeological finds, artefact preservation and commercial salvage or excavations. On 6 March 2017, the *Wall Street Journal* published a very positive review of the exhibition and the historical significance of the shipwreck.

The success of the Asia Society show was due to certain factors:

- By introducing a strong educational aspect within a progressive approach, and discussing issues surrounding the recovery, and maritime archaeology in general, it essentially fulfilled a 'teaching moment' role;
- The collection was now in the care of a museum as opposed to a tourism board. The Asia Society could refer critics to the fact that the ACM now housed the collection, had it on permanent display and made it available to scholars and researchers—a situation that was not possible in 2011; and,
- From a media perspective, there was no real story surrounding the controversy anymore. There was no new angle to take *per se*, with newspapers generally not printing old news.

From 11 December 2018 to 17 March 2019, part of the Tang Shipwreck Collection went on display at the National Research Institute of Maritime Cultural Heritage, Korea. This institute houses the Sinan shipwreck, a 14th-century vessel that sank off the coast of Korea. Fisherman discovered it in 1975 and it was excavated between 1976 and 1984 by Korean maritime archaeologists. It too reveals fascinating information about cultural exchanges that took place—this time between China, Korea and Japan in the 14th century. The exhibiting of the Tang shipwreck at a Korean national institution, dedicated to maritime archaeology, emphasises just how much viewpoints have shifted since 2011. The National Research Institute of Maritime Cultural Heritage clearly understood the significance of the Tang Shipwreck Collection with regards to Asian maritime history; and it was a unique opportunity for visitors to view two shipwrecks side-by-side.

The permanent gallery at the ACM and the international exhibitions that have taken place to date illustrate just how much can be done with a collection like that of the Belitung shipwreck. Overall, it has not only made significant contributions to our understanding of Asian maritime history, it has also heightened awareness of maritime archaeology, issues relating to salvage, and the laws governing such resources in South-east Asia. Given all of this, is it really a feasible position to maintain—that this shipwreck should never have been recovered in the first place, even if this meant losing it, together with all that it has revealed to date?

Realities of operating within local conditions

The Belitung wreck shares similarities with the Binh Thuan wreck found off Vietnam's south coast, but there are also differences between the two cases (e.g. the Belitung artefacts were kept intact; Binh Thuan artefacts were auctioned off). The Binh Thuan case, like the Belitung discovery, reinforces the necessity for a swift response to protect and record a shipwreck the moment it is discovered. The Binh Thuan was a Chinese vessel dating to the early 1600s, found off southern Vietnam's coast in 2001 by fishermen whose nets became entangled with the remains. Local fishermen begin indiscriminately removing artefacts from the site and quietly selling them to local and international antique dealers (Pearson 2016: 14). The result: loss of valuable archaeological and historical evidence because, naturally, collectors will take what looks 'nice' and 'valuable' and leave behind broken pieces that are of little or no monetary value. HMAS *Perth* is another in an endless list of examples of sites exposed to destruction, looting and exploitation (Pearson 2017; Yap 2016) in this region where no system of policing or protection can realistically be imposed at such remote yet accessible locations.

Flecker (2002: 23) observed that the South-east Asian context is very different to the environment in which many other places operate—here, 'the priority must be to document those sites and the artefacts recovered before too much information is lost ... if commercial transactions are banned outright, the finders will be driven underground, and there will be no hope of archaeological intervention.' It has been commercial companies hurriedly brought in by local governments to record and excavate these sites before looters remove all of the evidence and destroy the site who are then criticised for their level and quality of recording by those who have not proposed a feasible alternative by which to save the evidence. Can these countries really afford a maritime archaeological operation such as those of the *Batavia* (1629) or *Mary Rose* (1545), for example? The governments of these countries cannot yet afford to fund such a large-scale excavation or gather the expertise necessary, and in time, to excavate and analyse sites of such scale and importance (G. Wade, pers. comm. 2014).

No one on either side of the argument denies that a full and sufficiently resourced archaeological approach to excavating the Tang shipwreck site would have been the ideal option, allowing the most comprehensive recording to yield the most information. However, the fact that extensive looting had already started—and occurred between excavation seasons and afterwards—highlighted the urgent response needed. And, without any offering from maritime archaeological circles to assist or fund an archaeological excavation and manage an *in situ* preservation programme, the evidence and information that was saved would undoubtedly have been lost and the site potentially obliterated.

In South-east Asia, how feasible is state-sponsored archaeological excavation? And, at what cost should *in situ* preservation be implemented when looting is certain to occur at the expense of irreplaceable, valuable cultural heritage? Who gets to decide on a black-and-white approach that is certain to result in a negative outcome? Like the Binh Thuan case, Pearson (2016: 11) logically observes that if the Belitung wreck was discovered today, a commercial excavation permit would not have been issued; but, just as significant, the wreck would also not have been preserved *in situ*. The collection currently displayed at the ACM would likely have been looted and sold on the black market to the detriment of international scholarship. Is this the preferred solution? Flecker (2017: 38) returned to the site in 2013 and found that the entire hull had been ripped apart by looters. As Nord (2017) observes, taking the black-and-white, purist approach can mean one ends up with the destruction of the site and loss of valuable information rather than what one is hoping to achieve.

The way forward?

In the current context, there are two distinct schools of thoughts:

Purist approach?

The maritime archaeological community generally has a black-and-white, purist view regarding archaeological sites being excavated by non-archaeologists. Interestingly, this does not factor in the pioneers of the field who were not formally trained in archaeology—since there was no formal training then—or inexperienced archaeologists who themselves have excavated sites using questionable approaches and some of whom do not publish their results.

For the purists, such excavations should be conducted by archaeologists, or not at all. The problem with this approach in a context like the Belitung and other similar sites is that it does nothing to preserve and protect these sites, once they are discovered by fishermen, in regions where livelihood is far more important than history. Furthermore, the idea that fishermen should, therefore, be educated is deeply flawed.

- Would we rather see a site desecrated and destroyed than excavated by non-archaeologists?
- If not, how then should local authorities deal with high-risk shipwreck sites completely at the mercy of looters?

Ratifying the 2001 Convention does not, overnight or in the long-term, suddenly afford a site the protection it needs. Are looters really going to comply with the Convention or an *in situ* preservation programme because 'experts' implemented it? Now that the Belitung wreck collection exists in a museum but some prefer that it never be displayed for the public, what then, should be done with the collection? Should it be discarded or sold off?

A compromise?

Commercial maritime companies and maritime historians working in the South-east Asian region and who are very familiar with local conditions and limitations, have suggested options of a combined approach as a workable compromise:

i. Allow archaeologists to be part of their rescue efforts to meticulously record the site. This joint approach, however, will attract no archaeologist who intends to build a career in his or her field because once 'tainted', it will be difficult, if at all possible, to rebuild one's reputation to be accepted to work in the maritime archaeological field.
ii. Bring in a commercial team who can immediately work on saving what is left of the site in order to save the archaeological evidence that would otherwise be completely lost to looters. Obviously, this approach already exists as in the Belitung and Cirebon cases.

Key questions to address here are the involvement of professional archaeologists in salvor excavations, and what happens to the excavated artefacts.

Discussion

At least some commercial operators have admitted to the potential deficiencies of their method. However, the information that they have so far provided means that their contribution to human history and knowledge is still far greater than the consequences of leaving a shipwreck site to looting and destruction. Therefore, by urging the South-east Asian nations which did not, and most still do not, have the conditions, skills, funds and expertise, to ratify the UNESCO Convention and be required under Article 2.7 to deny licences to commercial salvors or operators, leaves the maritime patrimony completely open to exploitation and destruction by looters—a far more damaging option.

Importantly, most commercial operators, historians and archaeologists are aware and agree that there is an inherent problem with chance discoveries of shipwrecks in South-east Asia, and the potential for sites to be immediately destroyed. The disagreement is in the conflict between the 'most practical' and 'ideal' approaches to address this problem. Whilst most maritime archaeologists urge unconditional ratification, there has been a deep failure to examine carefully the complex issues in South-east Asia, to genuinely explore how best to address the issue, but above all, to listen to what the complexities are and seek a resolution.

Those who work in the region, including commercial operators and maritime historians, are keen to seek a realistic and practical resolution that is feasible for all parties. However, professional maritime archaeologists based outside the region have been unwilling to engage in this dialogue, continuing instead to insist on ratification, as if this 'box-ticking' approach would automatically protect all shipwrecks and resolve the region's challenges. Very little effort, if any, has been made to analyse the historical facts, contemporary challenges and harsh realities that led to the Belitung shipwreck being managed the way it was. Consideration of whether these countries are actually able to comply with the Convention's principles seems to be of secondary value. The issues such countries face in terms of funding and expertise are not to be underestimated. It is no surprise then that today, the political undercurrents still cause much angst for all with a vested interest in what has come to be a symbolic case to prove or disprove a point. 'As the historian Wade (13 October 2013, pers. comm.) observed, ' This seeking of universal ratification is meant to apply to a world that is not uniform in its capacities, situations, attitudes, beliefs, funds or skills. Whilst it is true that commercial salvors have destroyed artefacts and sites, this is even more true of the damage done to these sites by looters.' Sadly, most professional archaeologists seem unprepared to question the appropriateness of the western world's orthodoxy to the South-east Asian situation. The significant lack of representation from South-east Asian countries in the signing of the 2001 UNESCO Convention is a clear indication of the complex problems these countries are still facing. Ironically, the US and Australia—where most of the most zealous critics reside—have not ratified the Convention either.

The more difficult and complex the issue, the greater should be the urgency in addressing it. Yet, the political undercurrents and dispute continue. It will be up to this region to resolve the challenges it faces, and some are already finding creative and innovative ways of addressing this problem such as with greater local community engagement.

Conclusion

The issues from all sides are no doubt complex, contentious and deeply polarising but one of the fundamental goals being overlooked is the initiative, courage and leadership to address these challenges. There must be a reason that this region is one of the least represented of the signatories to the 2001 Convention. There is no denying that had the Belitung site not been excavated by the non-archaeologists, we would have learned nothing of the new information derived from the cargo.

So, what does the maritime archaeological community propose as a way to address this issue in South-east Asia, including the legacy issues forever encapsulated within the Tang Shipwreck Collection? While this region is faced with a situation where, from the point of discovery, local fishermen and others have unregulated access to underwater shipwrecks and where the culture of collecting shows no sign of abating, how can such sites be realistically managed in order to save as much as possible of their historical data and archaeological evidence?

Pearson (2019) has been extensively exploring this and highlights that these issues are not as simplistic as some maritime archaeologist might believe—proposing that public-private partnerships, cultural diplomacy, commercial involvement, and increasing professionalisation of maritime archaeology in the region need to be explored. No one denies that the situation in South-east Asia is far from ideal—the disagreement lies in *how* to resolve this complex situation.

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An Rov Can Engage Young People in Community Archaeology

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Abstract

This paper reports the results of an on-site educational programme with a low-cost remotely operated vehicle (ROV) that was carried out at the Yarabuoki underwater site off Ishigaki Island, Okinawa, during 2013–2016. The educational programme was developed for local high school students to enhance their understanding of the underwater site, where there are several iron grapnel anchors and Okinawan ceramic jars at a depth of 12–32m. The major component of the programme included students' involvement in operating the ROV to explore and access the site while archaeologists were working underwater. The ROV, especially designed for untrained operators, can be guided by a video game controller, which allows the operators easy access to an underwater site. Through the programme, we aimed to stimulate the students' interest in the local underwater site and to pursue appropriate management of the site in cooperation with the Ishigaki community. We surveyed the students with a set of questionnaires at the beginning and end of the programme to examine its effectiveness. The results indicate that our educational programme was successful in terms of increasing students' awareness of the existence and nature of local underwater cultural heritage.

Keywords

ROV, community archaeology, Okinawa, school education

Introduction

Underwater robots, such as remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), are devices useful for underwater surveys, considering their efficiency in deep water and high-risk areas. ROVs and AUVs vary in size and type, depending on the working environments and operating depths. We designed and constructed a purpose-built small ROV at low cost, for an on-site archaeological education programme for high school students. Using the portable ROV, the education programme has been held at the Yarabuoki underwater site off Ishigaki Island (Figure 1) once every year since 2013. The Yarabuoki underwater site, consisting of a concentration of Okinawan jars (tsuboya-yaki) and iron grapnel anchors, was an old anchorage sometime during the Ryukyu Kingdom period (1429–1879) (Ono *et al.* 2014); and the site is important for understanding the history of shipping and local involvement with maritime trades. The project team evaluated how an ROV can contribute to promoting archaeology in the community by offering local school students on-site education about underwater cultural resources (UCH, Underwater Cultural Heritage). Thus, a major component of the educational programme included students' involvement in operating the ROV to gain experience in exploring a site while archaeologists were working underwater. By providing this opportunity, we intended to increase the students' interest in the local underwater archaeological site. Students answered questionnaires at the beginning and end of the programme to allow us to assess whether our attempts to increase their knowledge were successful.

The article first addresses using the ROV for archaeological survey work and its potential to be utilised for educational purposes. One of the authors developed the ROV with a focus on both on assisting the underwater survey and being manoeuvrable by school students. Following a brief introduction to the Yarabuoki underwater site and its archaeological contexts, an overview of the education programme is presented. Finally, based on the results of the questionnaire, we address some perspectives on the utilisation of an ROV for public outreach and community-based archaeology.

ROV development for archaeology

ROVs are classified into categories depending on their size: Micro, Mini, and General classes, Light Workclass, and Heavy Workclass (Remotely Operated Vehicle Committee of the Marine Technology Society 2017). For deep-water survey activity, Light Workclass, Heavy Workclass, or large AUVs are employed because of their high propulsion power, manipulator(s), or wide survey area. In the Black Sea, the Workclass ROV Surveyor Interceptor has been utilised as a survey tool in deep water (Black Sea Maritime Archaeological Project

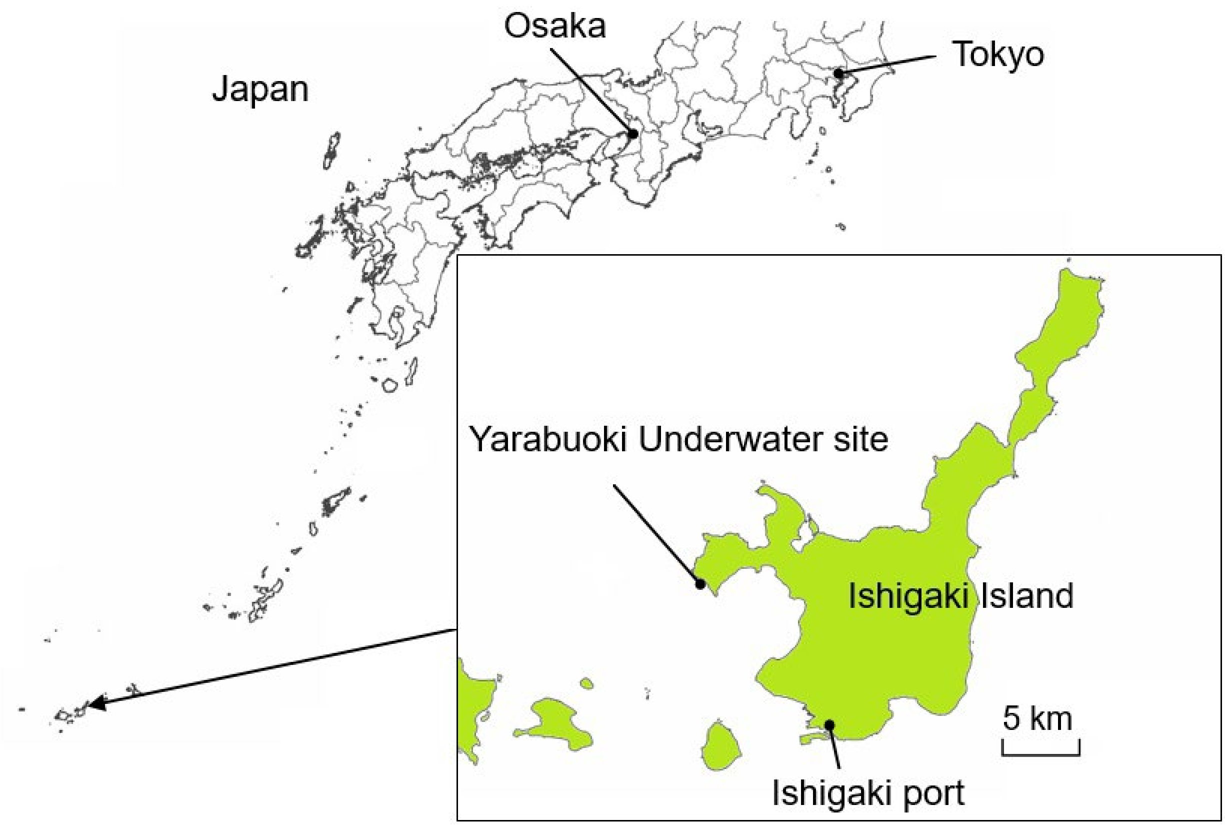

Figure 1. Location map of Yarabuoki Underwater site in Ishigaki Island, Okinawa Japan.
(This map is based on the Digital Map 25000 (Map Image) published by Geospatial Information Authority of Japan.)

2016). It weighs 4700kg in air, can dive to a maximum depth of 2000m, and has propulsion output of 220HP. The ROV Hercules has been used as a scientific tool on NOAA-funded missions. Hercules dived into the Titanic at a depth of approximately 3800m for archaeological survey work in 2004 (Weirich *et al.* 2004). The ROV weighs 2450kg, and its depth rating is 4000m. These two ROVs used for deep-water archaeological surveys are classified as Workclass ROVs. Other Workclass ROVs support deep-water archaeological missions elsewhere in the world (Dobson *et al.* 2011; Singh *et al.* 2004).

AUVs are also utilised as archaeological tools in a few projects worldwide. The first commercial AUV, C-Surveyor I, was used as a deep-water archaeological survey tool in the Gulf of Mexico in 2001 (Warren *et al.* 2007). Its weight is 1400kg, with a depth rating of 3000m. The sonar-based investigation was conducted for broad area and site-specific surveys and site analysis. The SeaBED AUV (Bingham *et al.* 2010) was operated for an ancient shipwreck survey near the island of Chios, Greece. This AUV made use of high-resolution seafloor imaging of the artefacts at the Chios shipwreck site. It is 200kg in weight, and its depth rating is 2000m.

Micro- and Mini-class ROVs or portable AUVs are mainly used for surveys in shallow water. These underwater robots are inexpensive and easy to carry, and they can be operated without any special equipment for deployment and recovery. For example, a Video Ray ROV was deployed for use in archaeology study (Clark *et al.* 2008). The Seabotix ROV (vLBV 300), which weighs 18.1kg, digitally recorded video of the wreck of an unknown vessel in Greater Farallones National Marine Sanctuary, off the coast of California (Delgado *et al.* 2016).

Moreover, in addition to their use in surveys and studies, ROVs controlled by professional operators have featured in public outreach about underwater archaeological explorations. Video footage of a scientific archaeological survey sent from the ROV is distributed in the form of on-line resources and documentaries for educational and public outreach (NOAA 2013). In recent years many educational and outreach programmes using robots have been developed in the field of ocean engineering. OpenROV (2017) has released small and inexpensive do-it-yourself (DIY) ROVs that are potentially useful for various educational purposes. It could be possible to make use of Micro- and Mini-class ROVs for better understanding underwater sites and for UCH education. In our educational programme, a portable ROV was used for high school students on Ishigaki Island to learn about the archaeological site.

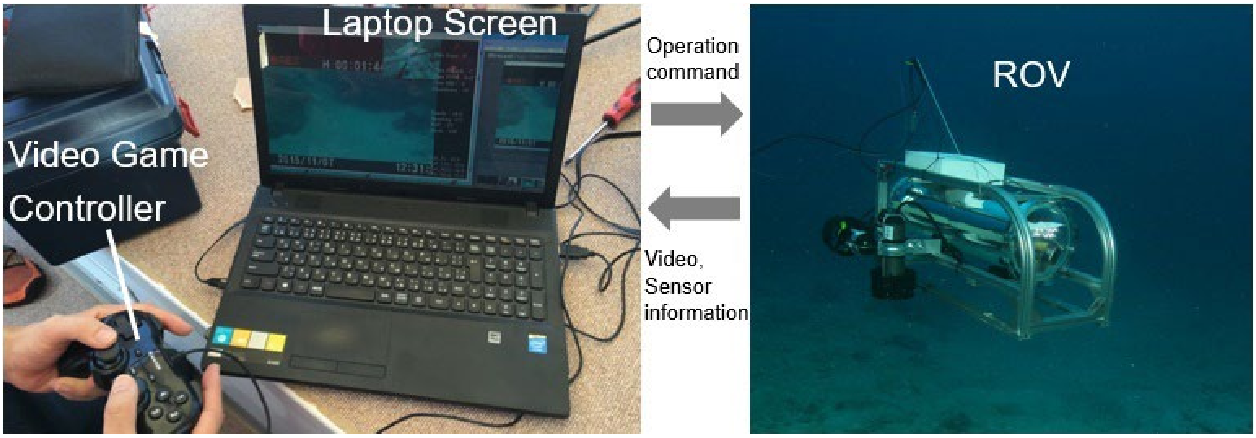

Figure 2. ROV and its operating system (Yuji Yamamoto).

The ROV and its software were developed so that users could operate it by means of a video game controller. Therefore, the local high school students could easily gain access to the underwater site and explore it by themselves.

Robotic systems for archaeology

One of the authors has developed several ROVs for ship hull inspection, dam inspection, soil sampling, and assessments (e.g. Sakagami *et al.* 2013). A Mini-class, low-cost and easy-to-carry ROV was also developed to investigate underwater archaeological sites. Since underwater site researchers need to dive more than 20m deep to investigate the major part of the Yarabuoki, bottom time is limited in the case of SCUBA diving searches. On the other hand, underwater robots such as ROVs and AUVs have the advantages of long survey times, saving overall project time, and safety. The ROV has a high definition camera to record video for archaeological survey. Figure 2 shows the ROV and its operating computer with a video game controller. We developed our own waterproof hardware, electrical circuits, and control software for the ROV, underscoring that it is easy to customise or improve it to serve the archaeologist's specific needs and to make the ROV suitable for an untrained operator to use. It weighs about 15kg and is 0.7m long, 0.55m wide, and 0.3m high. Its cylindrical waterproof housing contains equipment including the video camera, a small computer, depth sensor, magnetic digital compass, motor drivers, and batteries. The ROV has two horizontal and two vertical 110-watt thrusters to achieve surge, heave and yaw motions underwater. It dives to a depth of around 40–50m with a 60m fibre optic cable. Live video is sent via the cable, and video images as well as a magnetic compass are displayed on a computer screen.

For archaeological survey, we also used a surface robot for an underwater visual positioning system with a monocular digital camera to estimate the absolute position of underwater archaeological artefacts at the Yarabuoki site. The surface robot, developed by Fumiaki Takemura (Takemura *et al.* 2015), floats on the surface of the sea and estimates the position of underwater objects using the monocular camera, an attitude sensor, and a GPS. Its image processing software detects the position of an underwater target. According to Takemura *et al.* (2015), measurement errors in a swimming pool were approximately 10% of the distance between an underwater object and the surface robot. In general, acoustic sonar systems are widely utilised for positioning in waters. However, the seawater in Okinawa is transparent enough to use the optical positioning system. The image camera can capture underwater objects at a depth of more than 20–30m. This visual positioning system is more cost-effective than sonar systems. From several experimental results at Ishigaki Island, the positioning accuracy of the optical system is being verified to estimate the position of the anchors.

Yarabuoki underwater site in Okinawa

Okinawa prefecture in Japan has a number of archaeological sites that are in a relatively good state of preservation, including the Yarabuoki site off the western coast of Ishigaki Island. Discovered by a local diver in 2009, the Yarabuoki underwater site contains a cluster of Early Modern Okinawan ceramic jars and seven iron grapnel anchors, at a depth of around 12–32m. Ishigaki Island is in the subtropical zone, the site is near a popular diving area, and these artefacts are in good condition at a shallow depth. Therefore, the Yarabuoki site has great potential to become a focal point in terms of cultural resources and for heritage tourism on the island. For these reasons, we selected the site for educational and cultural programmes.

Following the discovery, the first archaeological investigation was conducted in 2009 (Katagiri *et al.*

2010). It was confirmed that the Yarabuoki underwater site contains iron grapnel anchors and Early Modern Okinawan ceramic jars. Notably, it was the first case in which grapnel anchors had been found in the Okinawan region, although they are widely known around mainland Japan. In 2011 a broadband multibeam sonar survey was conducted at the site to produce an accurate bathymetric map at a lateral grid resolution of 1m (Ono *et al.* 2014). The distribution of the well-preserved anchors indicates that they were abandoned at the historic anchorage, and these anchors could originate from Ryukyuan traders, or Satsuma (from main island Japan) or Chinese traders. The twelve ceramic jars concentrated next to some of the iron anchors are all the same type and were produced in Naha city on the main island of Okinawa from the sixth to ninth centuries. Most of the jars are intact, but the formation processes of the jar concentration have not been clarified, and it has not been ascertained whether these jars were part of the wreck cargo.

An important issue is how this site, closely connected to local maritime history, can be protected, bearing in mind that the site is in shallow water and located near popular diving and snorkelling spots. Development of a policy ensuring public access to the site is a key to promoting it as a cultural and tourism resource. Expanding people's knowledge about the historical value of the site is a primary consideration, and community involvement is part of that. The on-site educational programme for local high school students on Ishigaki Island was designed and implemented as an attempt to enhance their understanding of submerged historical resources. Through the programme, we aimed to stimulate their interest in their UCH and pursue locally appropriate UCH management.

Educational programmes on Ishigaki Island

A UCH-related educational programme was designed and conducted for local high school students to explore the site with the ROV while underwater archaeological survey was undertaken. Since a familiar video game controller can easily operate the ROV, local students can explore the underwater archaeological site with simple instructions without any need for special skills or training.

The on-site educational programme involving local high school students was carried out during four seasons from 2013 through 2016. The students visited the site with archaeologists and gained experience in viewing and exploring the site by operating the ROV, as outlined in Table 1. First, safety instruction was conducted for the students. Then the archaeologists explained the archaeology of the Ishigaki Island site, and one of the authors gave instructions for ROV operation. Meanwhile, the ship departed for the site from the port of Ishigaki. At the site the students practised operating the ROV near the surface as the archaeologists were preparing to dive. While the archaeologists were conducting their underwater survey, the students viewed and explored the site using the ROV. To verify the effectiveness of our programme, we had students complete questionnaires at the beginning and the end of the programme. The rest of this section describes this in more detail.

First UCH education session

The first educational programme was held on 9 November 2013 with the involvement of six students from Yaeyama High School (YHS) and Yaeyama Commercial and Technical High School (YCTHS). All the students practised operating the ROV and then drove it to check the archaeological site. During this session the archaeologists were taking measurements and investigating the distribution of the archaeological artefacts. There was an opportunity for the students to learn how archaeologists investigate a site. The students gained experience in contributing to the archaeological survey team by recording video of the site using the ROV.

We did not conduct a questionnaire survey in the first educational programme. Instead, we held a public meeting in Ishigaki city in the following year and arranged a presentation opportunity for the students to share their experience of underwater archaeology with Ishigaki's residents. In their presentations they mentioned their thoughts and responses: 'I was so excited when I saw the jar'; 'I didn't know that we had archaeological anchors and jars in Ishigaki Island'; and 'I think my experience will be useful for my life. If I have another chance, I want to join the educational program again.'

Figure 3 shows the high school students during the archaeological exploration; and, Figure 4 presents images of the ceramic jars and anchors as recorded by the high school students. These figures span education sessions over 2014–2016.

Second UCH education session

The second programme was conducted on 14 and 15 June 2014. Eight students from YHS, YCTHS, and Yaeyama Agricultural High School (YAHS) joined the programme. On the first day, the water conditions near the site were so rough that we could not proceed with the archaeological survey and educational session. We, therefore, had to change the location, and we instead took measurements underwater in an area of calm conditions where there were no archaeological artefacts. The students, nevertheless, operated the ROV to learn how the archaeologists took measurements

Figure 3. Local high school students participating in the educational programme.

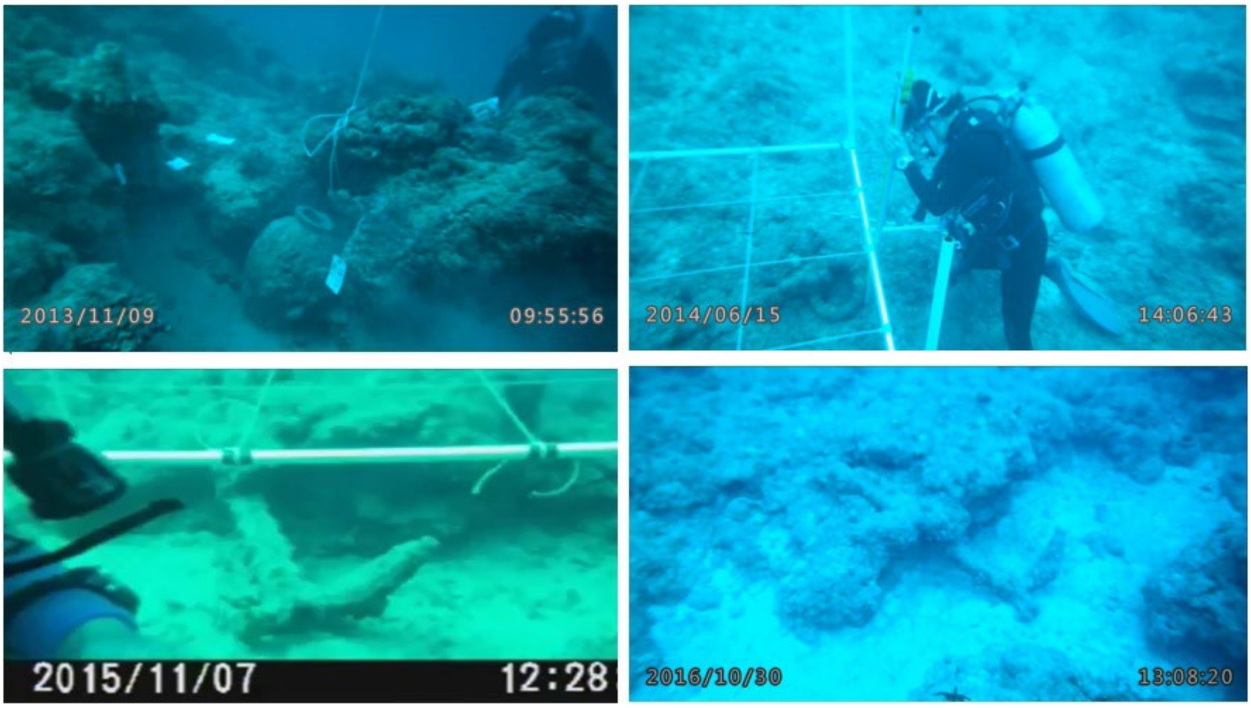

Figure 4. Captured images from ROV operations by the students.

Table 1. Outline of UCH educational program.

Students Arrival at Ishigaki Port
Safety Instruction
Leaving Ishigaki Port for UCH Site
Explanation of UCH
Beginning Questionnaire
Explanation of ROV Operation
Arrival at UCH Site
ROV Operation Practice
Lunch
ROV Operation for Exploration and Access to UCH
Leaving UCH Site for Ishigaki Port
Ending Questionnaire
Return to Ishigaki Port

of underwater artefacts. On 15 June, we took three students from YAHS to the UCH site. We conducted the educational programme as shown in Table 1. On both the days, students answered the UCH questionnaire.

Third UCH education session

On 7 November 2015 the third programme was carried out according to the outline of the educational activities. A live video stream from the Yarabuoki site was also tested, because we had planned to provide a live stream from the site into Osaka city for a public archaeology awareness effort in 2016. In 2015 we invited the three students from YHS. The educational programme was accomplished without problems, and we implemented the UCH before-and-after questionnaire survey. During the students' archaeological exploration, we tested a live stream from the site by using the operating computer and commercial WiFi. However, the network was sometimes unstable and periodically disconnected. The reason was that the computer's performance was not sufficient to operate the ROV and provide the live stream simultaneously. We therefore changed to a higher performance computer for the next public archaeology event.

Fourth UCH education session

The fourth educational programme was executed on 30 October 2016. We invited six high school students from YHS and YAHS. School teachers and heritage officers from the Board of Education provided support for the programme this year. We provided a live stream from the archaeological site in Ishigaki to Osaka city in cooperation with Osaka Electro-Communication University. The faculty member of the University facilitated the public live stream at an event room in the building Grand Front Osaka. While the students explored and viewed the Ishigaki Island site using the ROV, the operating computer's screen was shared with people in Osaka city via commercial WiFi. Afterward students completed the survey questionnaire.

Questionnaire results

The questionnaire results from 2014 through 2016 are shown in Table 2. The participants consisted of nineteen local high school students in Ishigaki Island. Before the educational programme we asked the students about their interests and why they wanted to participate in the project. Only two students were interested in history. For the reasons why they joined, their most common answer was 'no special reason' or the equivalent. Half of the students were not interested in UCH or the ROV. They were advised by high school teachers or a member of the local Board of Education to join the programme. Though the students did not have positive attitudes, it seemed that the teachers and Board of Education member gave positive evaluation to our programme. Indeed, a member of the board of education and a teacher spontaneously joined the programme with the students.

After the programme, we asked how they liked the UCH site. More than half of the students were satisfied with the programme, and they became interested in UCH. Some of the students answered 'medium' or 'not interesting' in Table 2. Reasons would be because some students could not see the archaeological site due to rough sea on 14 June 2014, and other students got seasick (all the participants had to spend more than six hours on the small ship during the educational sessions). We also asked them how they would utilise the UCH. They gave new ideas such as for tourism, education, and SCUBA diving.

Moreover, in the comment field several high school students gave their thoughts as follows: 'I didn't know the word UCH. Now I want to learn more about UCH'; 'I want to major in underwater archaeology in college'; 'I want to learn more about history'; and 'I didn't know there are also many fascinating things in the sea besides the creatures.' Thus, we received significant positive feedback from the students. The questionnaire results confirmed that this programme improved the students' knowledge about UCH.

Public outreach for UCH protection

Public understanding and involvement are essential for protecting UCH. Our educational programme would lead the residents including young people in Ishigaki Island to protect and take advantage of this UCH as cultural and tourist resources. As part of public outreach about

Table 2. Questionnaire results for the joined students.

BEFORE EDUCATIONAL PROGRAM		
Question: Why did you want to participate?	**Answer:** No special reason UCH sounded interesting ROV sounded interesting Others	 9 5 4 1
Question: What are you into these days?	**Answer:** Regional history Politics, battle sites Drum Freshwater prawn Building websites Computer Electronics Acoustic engineering Microcontroller technology Nothing No answer	 9 1 5 1 1 1 1 1 1 1 2
AFTER EDUCATIONAL PROGRAM		
Question: How did you like UCH part in the program?	**Answer:** Very interesting Interesting Medium Not much interesting Not interesting No answer	 9 2 5 0 1 2
Question: Did you have any new interests?	**Answer:** Yes No **Details of Yes:** Heritage sites, Underwater heritage. Underwater mysteries, Diving, Underwater heritage, underwater archaeology, History of Ryukyu era, Underwater robot, Robot.	 12 7
Question: How do you think the UCH should be utilized?	**Answer:** Tourism Education Scuba diving I don't know No answer	 9 2 1 1 6
Free comments: I didn't know the word of UCH before, but I now want to learn more about UCH. I want to major in underwater archeology in college. I want to know more about UCH. I want to see more UCH. Why are there 7 anchors? I didn't know there are also many fascinating things in the sea besides the creatures. I want to learn more about history.		

UCH, we exhibited educational programme posters, academic research posters, the ROV, and video footage from the ROV at Ishigaki City Yaeyama Museum in 2013, and at Okinawa Prefectural Museum in 2014–2015. During the 2017 season, we utilised digital photo imagery techniques for a 3D reconstruction of the site. In the present programme, the students can only view the archaeological site at the computer screen topside in images sent from the ROV. The synergy effect of 3D photogrammetry techniques and the ROV as an effective educational tool is under examination in our programme. The 3D image device may or may not stimulate the interest of students in understanding the archaeological objects better.

Conclusion

We have developed and conducted an on-site educational programme with a low-cost and portable ROV for UCH in Ishigaki Island, Okinawa, Japan. The on-site programme was aimed at cultivating young people's interest in local cultural heritage. The students went to the Yarabuoki underwater site with archaeologists on a research ship and operated the ROV themselves to explore and learn about the archaeological site. The results of questionnaires completed at the beginning and end of the educational programme showed that the school students became interested in archaeology, underwater archaeology, and cultural heritage; and, more than half of the students were satisfied with the programme. Because of our activities, the Yarabuoki underwater site is "also" receiving recognition from the residents "and stakeholders" of Ishigaki Island.

In 2016 we also provided a live video stream of the Yarabuoki site from Ishigaki Island to the people in Osaka city. This enabled many more people to be made aware of the UCH site. The on-site educational programme with the ROV, and the accompanying live stream event in Osaka, will be held again in 2017.

In addition, we reported in this article on other education and public outreach activities on Ishigaki Island. They include environmental education with the DIY robotic kits, archaeological education for university students, as well as the town meetings and museum exhibits in Okinawa.

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Research on the Wreck Sites, Sea Routes and the Ships in the Ryukyu Archipelago

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Abstract

The Ryukyu kingdom which ruled over the islands of the Ryukyu Archipelago, thrived during the medieval period from the transit trade that owed much to the kingdom's tributary relationship with Ming Dynasty China. During the early modern period, while subordinate to both China and Japan, the kingdom prospered with a complex culture based on the established domestic network of the islands. From the late 18th century, Western ships started to appear and the people came to have occasional contacts with these visitors through the rescue of Western ships stranded nearby.

Of the 230 identified underwater cultural heritage sites, 10% can be categorised as shipwreck sites. Ships involved in international trade with China constituted the majority during the medieval period, whilst domestic trade ships increased during the following early modern period. From the 18th century, Western shipwreck sites started to increase in number.

The distribution of wreck sites representing both international and domestic trade ships seems to correlate with the sea routes and significant ports depicted on ancient sea maps, while the distribution of Western wreck sites does not share this correlation. This research presents an analysis of the chronological transition and reason for the distributional correlation of these wreck sites and related ship routes.

Keywords

Ryukyu, Japan, shipwrecks, seventeenth-century map

Introduction

The Ryukyu Archipelago consists of 199 islands, spread across a stunning vast sea area of over 1200km between Kyushu Island—located at southern end of the Japanese Archipelago—and Taiwan. The largest island among the Ryukyu Archipelago is Okinawa Island where the present prefectural government is based. It is located almost at the centre of the archipelago (Figure 1). Unlike the Japanese Archipelago, the islands of Ryukyu have a subtropical climate, warm throughout the year. Surrounded by amazingly beautiful ocean and coral reefs, the area is also known for scuba diving and other marine sports.

We have undertaken a distributional survey of underwater cultural heritage throughout the Ryukyu Archipelago for about ten years from 2002 to 2012. As a result, we found 230 sites containing underwater cultural heritage, including wreck sites, old ports and production sites (such as quarries, stone tidal weirs, and salt works), as well as subsided sites resulting from environmental changes.

In this research, the identified wreck sites are categorised in two groups; one is shipwrecks related to trade undertaken by the Ryukyu kingdom, and the other is the Western shipwrecks unrelated to these trades. Thereafter, the characteristics of each group were analysed and collated with the history of the kingdom, as well as with the historical sea maps from the Ryukyu kingdom period. This article aims to present our analytical research on the relationship between the wreck sites and sea routes, based on comparison

Figure 1. Location of Ryukyu Archipelago.

of the wreck site locations with the old ports and sea routes depicted in the sea maps drawn in the early 17th century.

Historical background

Once there was an independent kingdom in the Ryukyu Archipelago, called the Ryukyu kingdom, which existed from AD 1429 to AD 1879. There was the capital palace, Shurijo, on Okinawa Island—the largest of the archipelago. The palace was the hub of the kingdom where the Ryukyu king lived. The Ryukyu kingdom was a maritime state which thrived during the medieval period, owing much to its special trading relationship with Ming Dynasty China. The kingdom established an international port at Naha as a centre of trading, with a good command of sea-going ships similar to Chinese junks. It greatly flourished in the transit trade connecting Japan, Korea, China and South-east Asia (Figure 2a).

The major traded commodity was Chinese pottery, which at that time had a world-wide market. Terrestrial excavations have revealed that the islands of the Ryukyu kingdom were rich in Chinese pottery.

The Ryukyu Archipelago experienced a long prehistoric period from *c.* 20,000 years ago (Nakagawa *et al.* 2010) when the first human arrived, until the latter half of the 11th century. From the 11th century, the Ryukyu Archipelago was involved in the trade network of East Asia, centering on China at that time. This lead to a

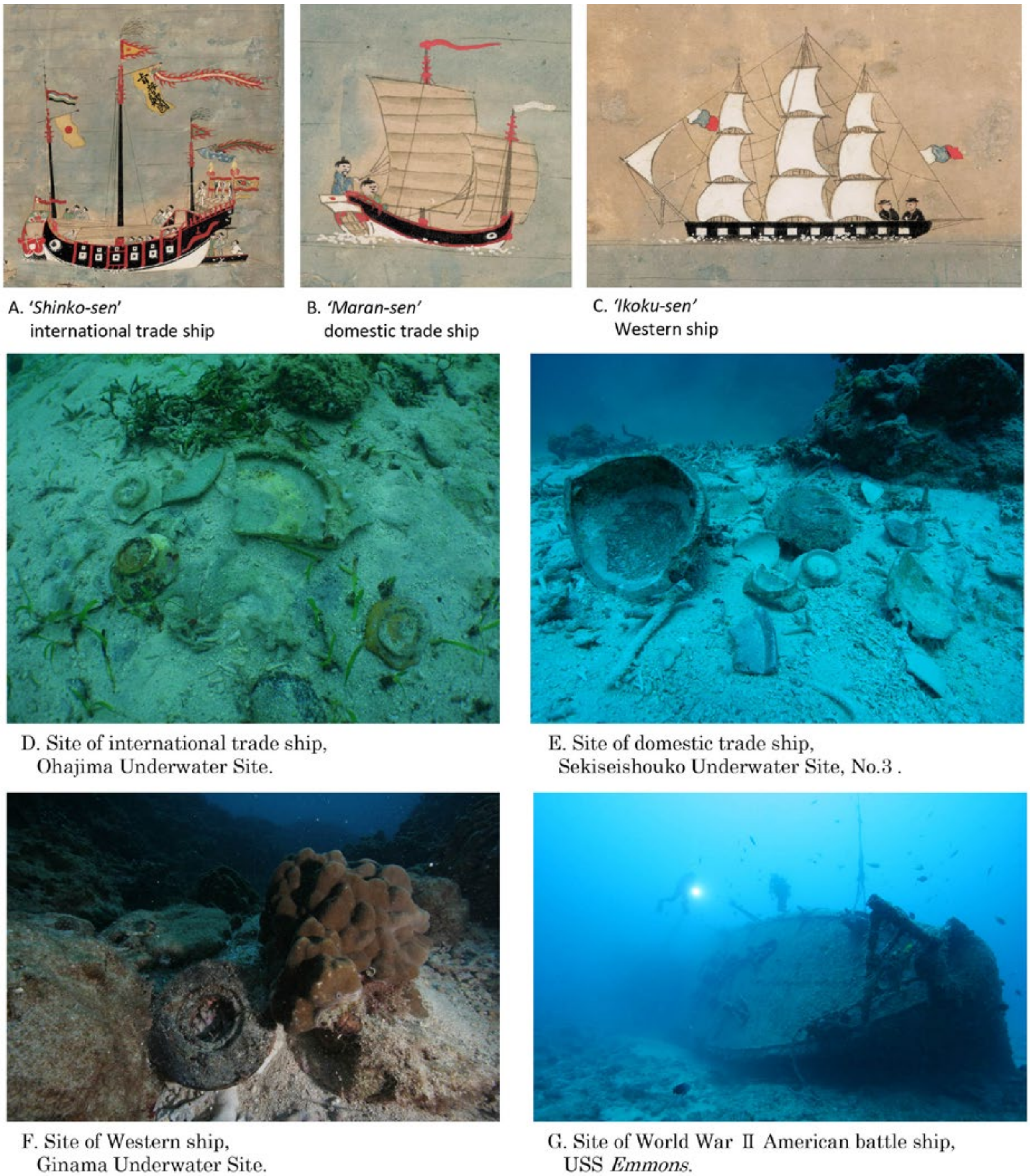


Figure 2. Ryukuan ships and a Western ship in a historic depiction and categories of shipwrecks in the Ryukyu Archipelago. (A, B and C: 'Shurinahakoezu', courtesy of Okinawa Prefectural Museum and Art Museum. F and G: Photo by Yuji Yamamoto).

dramatic and rapid increase in the flow of people and goods there. As a result, rice cultivation was introduced and a man of power emerged due to the concentration of wealth. The Ryukyu kingdom was established 400 years thereafter.

During the 16th century, the government of the Ryukyu kingdom became highly centralised and ruled over vast sea areas. Domestic trade networks among the islands within the kingdom developed through the use of *maran-sen* ships, the downsized version of sea-going international trade ships (Figure 2B). Distribution of domestic products also increased.

In the following early modern times, during the 17th to the late 19th centuries, while subordinate to both Qing

Dynasty China and Japan, the kingdom prospered with many original aspects to their complex culture, many elements of which have been passed down and survive to the present day.

From the second half of the 18th century, the ships of the great Western powers started to appear in the sea areas of the kingdom (Figure 2C). Following the rules and policies of mainland Japan, the Ryukyu kingdom had neither trade nor diplomatic relations with the Westerners. Nevertheless, the people of the kingdom were unable to avoid occasional contact with these Western ships and the Westerners on board through the rescue of some of these ships that became stranded in neighbouring seas.

In AD 1879, Japan's Meiji government invaded the kingdom, and the king was taken from Shurijo to Tokyo. At that point the history of the Ryukyu kingdom came to an end. Today, the Ryukyu Archipelago is part of Japan, and the southern half of the archipelago forms a prefecture called Okinawa Prefecture.

The Ryukyu Archipelago has played a significant role in the maritime history of Asia since the 11th century as a centre of international and domestic trade, as well as a stage for unintentional encounters with Western ships. It is therefore only natural that this ocean bears the evidence of various shipwreck sites on its seabed.

Methodology of investigation and analysis

In the Ryukyu Archipelago, we undertook a distributional survey of underwater cultural heritage from 2002 to 2012 (Katagiri 2010; Miyagi *et al.* 2002, 2003; Nansei Islands Underwater Cultural Heritage Research Group; 2012). Results of the survey made it possible to classify the sites into four categories according to their nature:

1. Shipwreck-related sites;
2. Sites formed by frequent use of the sea and coastal areas;
3. Sites resulting from production activities (quarries, stone tidal weir, salt works); and,
4. Subsided or sunken sites.

Of these, our focus was on the shipwreck sites. We further subdivided the shipwreck sites into four types according to characteristics of the ships:

a. Chinese trade ships;
b. Domestic trade ships;
c. Western ships; and,
d. Second World War wrecks.

Firstly, we calculated the proportion of each site type, taking the dates of the sites into consideration. Then, focusing on the first three types from a to c, the results were compared with the history of sea areas within the Ryukyu Kingdom. Secondly, locations of the wreck sites were plotted on a map to consider their distribution.

Lastly, the first three types of wreck sites—a, b and c—can be re-categorised into two groups according to purpose—the ones related to trade for the first two types, and the others not related to Western ships. These were then plotted on the old sea maps from the 17th century. The relationship between the location of wreck sites, old ports and sea routes depicted on the old sea maps was then analysed.

Categorisation and proportion of shipwreck sites in the Ryukyu Archipelago's underwater cultural heritage

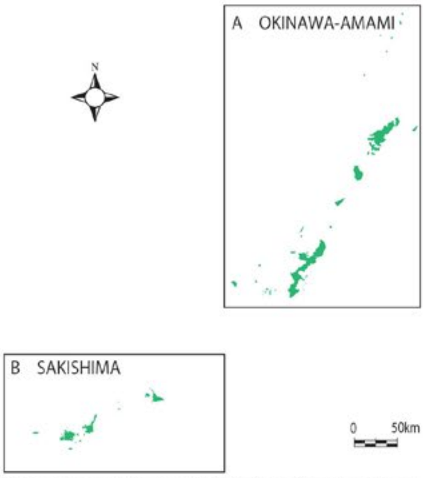
Categorisation of the shipwrecks

Our ten-year distributional survey identified 230 sites containing underwater cultural heritage. These 230 sites were categorised into four groups as mentioned above, from one to four. The shipwrecks were then subdivided into the above-mentioned four types from a to d. All of the first type, Chinese trade ships seem to have been involved in international trade with China. Large volumes of Chinese pottery and small amounts of Thai pottery are found at these sites (Figure 2D). Most are dated to the medieval period when the Ryukyu kingdom flourished on the transit trades.

For the second type of domestic trade ships, the sites yield a large volume of domestic pottery produced within the Ryukyu kingdom (Figure 2E). Most are dated to the early modern period when the Ryukyu kingdom's authority was being centralised and a distribution network among the islands by *maran-sen* ships had been developed.

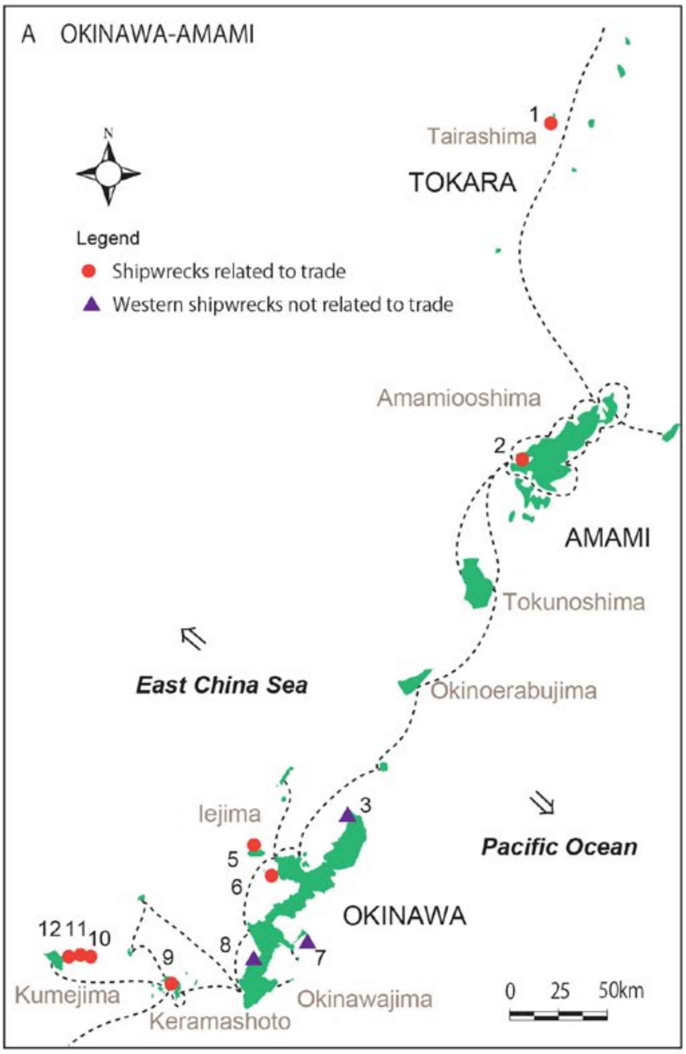
Sites of the third type relating to Western shipwrecks show part of the hull, as well as European products, Chinese products, Japanese products and the like on the seabed (Figure 2F). Most of those sites date from the latter half of the early modern period to the modern period (the late 18th century to the 19th century), when the Western great powers advanced into Asia. Unlike the trade ships, the Western ships had no connection with the trade of the Ryukyu kingdom. Those Western ships were destined for other countries, but ended up stranded or sunk in this sea area due to typhoons or similar circumstances.

The only Second World War wreck identified so far is USS *Emmons* of the US navy (Figure 2G). This was sunk by Japanese *kamikaze* attack. When it became unnavigable, the US navy sank the hulk to prevent it falling into enemy hands.



No.	Site name	Sea area	Depth	Shipwreck type	Date
1	Tairashima	Taira	- 5m	a) Chinese trade ship	Early Modern
2	Kurakizaki	Amami	- 3m	a) Chinese trade ship	Medieval (12th-13th C.)
3	Oinama	Okinawa	-10m	c) Western ship	Early Modern (1872)
4	Emmons	Kouri	-40m	d) *WW II wreck (USA)	Modern (1945)
5	Wajii	Ie	-10m	a) Chinese trade ship	Medieval (15th C.)
6	Minnajima	Minna	- 3m	a) Chinese trade ship	Medieval (15th C.)
7	Minamiukibarujima	Minamiukibaru	-17m	c) Western ship	Early Modern (19th C.)
8	Indian Oak	Okinawa	- 3m	c) Western ship	Early Modern (1840)
9	Agonoura	Zamami	-10m	b) Domestic trade ship	Early Modern
10	Nakanohama	Kume	- 3m	a) Chinese trade ship	Medieval (12th-13th C.)
11	Ohajima	Kume	- 3m	a) Chinese trade ship	Medieval (14th-15th C.)
12	Maja	Kume	-10m	b) Domestic trade ship	Early Modern
13	Yabiji, No.1	Yabiji	-13m	c) Western ship	Early Modern (1798)
14	Yabiji, No.2	Yabiji	- 3m	b) Domestic trade ship	Early Modern
15	Yabiji, No.3	Yabiji	-12m	b) Domestic trade ship	Early Modern
16	Yoshinokaigan	Miyako	- 5m	c) Western ship	Early Modern (1853)
17	Kurimajima	Kurima	- 5m	a) Chinese trade ship	Medieval (16th C.)
18	Takadakaigan	Tarama	-25m	c) Western ship	Early Modern (1857)
19	Yarabuoki	Ishigaki	-25m	b) Domestic trade ship	Early Modern
20	Nagurashitataru	Ishigaki	- 2m	a) Chinese trade ship	Medieval (15th C.)
21	Sekiseishouko, No.1	Sekiseishouko	- 3m	b) Domestic trade ship	Early Modern
22	Sekiseishouko, No.2	Sekiseishouko	- 5m	b) Domestic trade ship	Early Modern
23	Sekiseishouko, No.3	Sekiseishouko	-17m	b) Domestic trade ship	Early Modern

* WWII wreck is not included to the discussion in this paper.



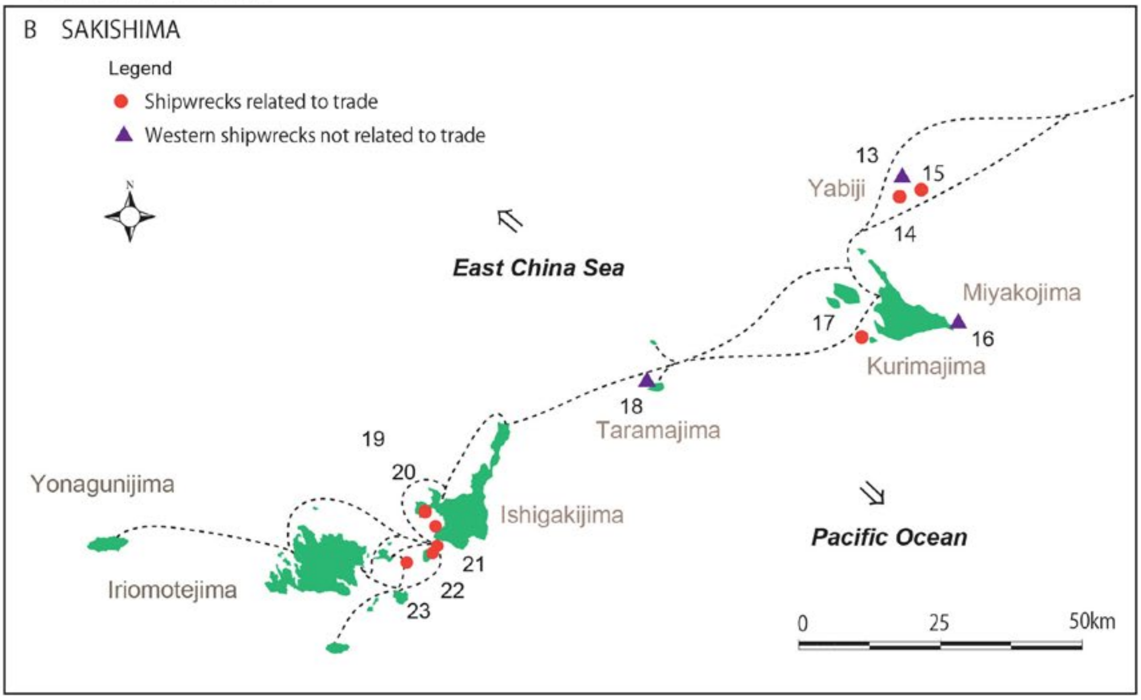


Figure 3. Table and maps of wrecks in the Ryukyu Archipelago, and sea routes depicted in 'Shoho-kuni-ezu' (4. USS Emmons is not dotted as it is excluded from discussion).

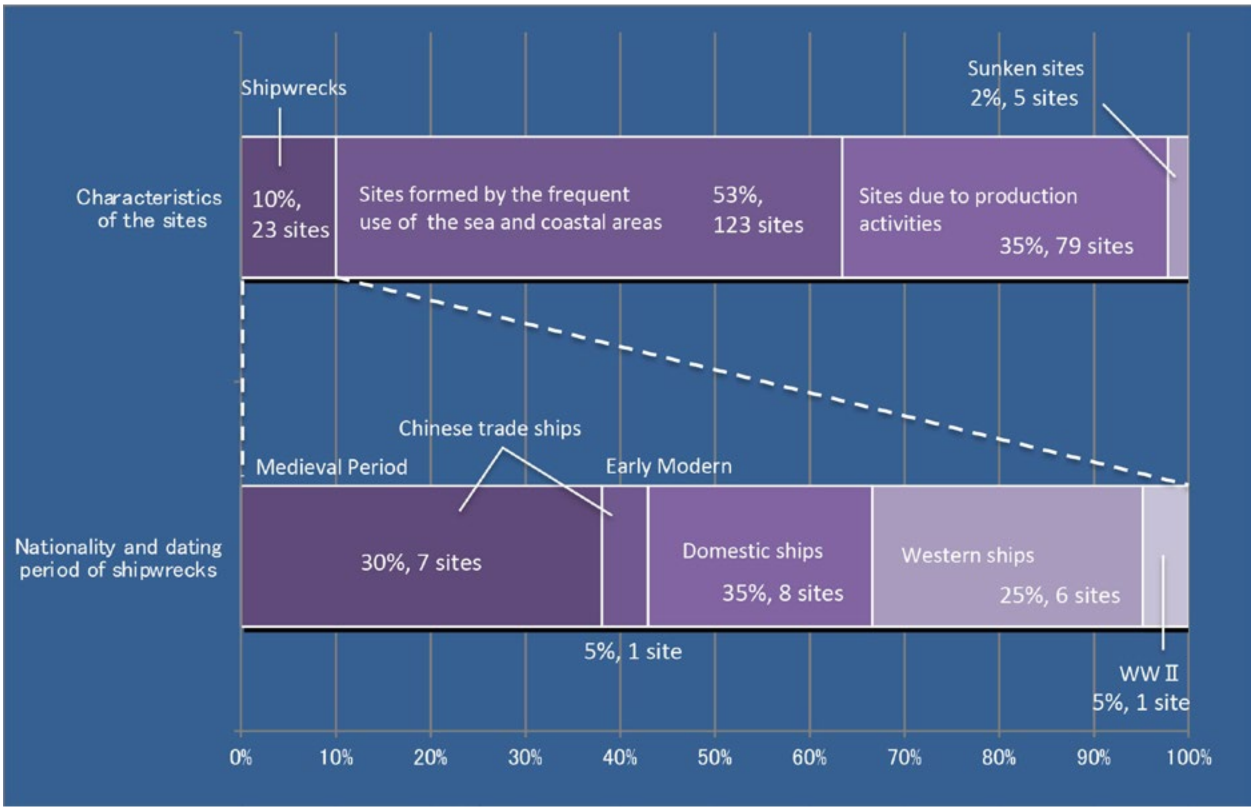


Figure 4. Shipwreck categories and percentages.

Figure 3 shows the types and outlines of the wreck sites identified within the Ryukyu Archipelago. The two oldest sites are Kurakizaki underwater site and Hatenohama underwater site dated between the end of the 12th century to the beginning of the 13th century. Both are thought to be the remains of Chinese trade ships. The most recent wreck site is USS *Emmons*, the Second World War wreck dated to 1945. Therefore, now we know that there is *c.* 800 years of history from the 13th century to the mid 20th century reflected in the shipwreck sites of the Ryukyu Archipelago.

Categorisation of wreck sites and percentages according to their nature

Figure 4 shows the proportion of underwater cultural heritage sites within the Ryukyu Archipelago that are shipwrecks, as well as the respective proportions of the three different types of shipwrecks. Among those four categories of 230 underwater cultural heritage sites, shipwreck sites number 23, comprising about 10% of the total. The proportion shows the scarcity of wreck sites amongst the numerous underwater cultural heritage sites in Okinawa.

Among those 23 shipwreck sites, there are eight Chinese trade shipwreck sites identified which constitute 35% of all the shipwrecks in the area. Seven out of eight Chinese trade shipwreck sites are dated to the medieval period, and one to the beginning of the early modern period (early 17th century). No site related to the international trade ships is dated later than that. This result reflects very well the history of international and domestic trade in the Ryukyu kingdom— the former was very active in medieval times and declined in the early modern period. Domestic trade became more active from then.

Regarding domestic trade ships within the Ryukyu kingdom, there are eight sites dated to the early modern period, which make up 35% of all shipwreck sites. This is the same proportion as the Chinese trade ships. So Chinese trade ships and domestic trade ships within the kingdom together account for 16 sites, showing that trade ship related sites make up 70% of all shipwreck sites. In contrast, Western ships neither related to trade at all nor destined for the Ryukyu Archipelago, but stranded there, account for six sites that make up 25% of the total.

These proportions reflect well the maritime history of the area and the Ryukyu kingdom. The history of international trade outside the archipelago started in the 12th century and the period supported by international trade with China lasted for about 500 years since then, particularly flourishing in the 300 years between the 14th and 16th centuries. While domestic trade was active for the 400 years from the 17th century, encounters with Western ships occurred only within the 150 years between the late 18th and 19th centuries. The length of the period in which each category of ship was active is mirrored in the respective numbers of sites; sites comprising more durable structures are discovered more often. The number of sites that are discovered and the duration of the period to which the sites belong, coincide with each other.

Of Second World War wrecks so far identified, we have only the USS *Emmons*, which is 4% of all wreck sites. Further investigation on the Second World War wrecks in future would uncover more such sites; it has not yet been adequately undertaken. Nevertheless, USS *Emmons* will be excluded from consideration related to the site locations in the following sections of this paper, as it was wrecked under very special circumstances, namely during war.

Location of wreck sites and geographical environment

Figure 3 shows the distribution of wreck sites identified in the Ryukyu Archipelago, including 16 of both the Chinese and domestic trade shipwreck sites, and six Western wreck sites with no relation to trade or intention of reaching the Ryukyu Archipelago. The locations of all 22 sites are plotted on the map.

The result indicates that the East China Sea side of the archipelago had greater significance for the Ryukyu kingdom than the other. In the Ryukyu Archipelago, the sea to the west of the archipelago, which is closer to Eurasian Continent, is the East China Sea. The sea to the east of the archipelago is the Pacific. Distribution of the wreck sites shows seventeen sites in the East China Sea, three in the Pacific, and two in locations that are difficult to pin down. Regardless of whether they are trade or Western ships, about 77% (17 out of 22 sites) are concentrated in the East China Sea.

The results coincide with what is indicated by the old sea routes depicted in the 17th-century map, which are described in detail below. According to this old map, major sea routes are mostly concentrated in the East China Sea. There is hardly any major sea route on the Pacific side. The East China Sea side is closer to China and, as mentioned above, many trade ships had to pass through the East China Sea to reach China. The route to China was the most significant sea route in the Ryukyu Archipelago. Moreover, the major sea routes to Yamato (the Japanese mainland) and for the domestic networks of the islands were also developed on the East China Sea side. Here, the distribution of the wreck sites reflects the maritime history of the Ryukyu kingdom very well—the sites show a high concentration in the sea area significant to the kingdom.

Comparison of shipwreck locations with ports and sea routes depicted on old maps

Shoho-kuni-ezu is an old map produced in the early 17th century. The map depicts the location of the ports, the anchoring capacity of each port and major sea routes at the time in the Ryukyu Archipelago. The distribution of the wreck sites is plotted on this map to compare and analyse the relationship between the location of wreck sites and depicted ports and sea routes. Figures 5 and 6 show enlarged maps of areas around major islands, taken from *Shoho-kuni-ezu*. Figure 5A shows Okinawa Island, Figure 5B Amamiooshima Island, Figure 5C Kerama-Kume Islands area, Figure 6A Miyako Island and Figure 6B Yaeyama Islands, plotted with locations of wreck sites. Trade ships are marked as ● on the maps, regardless of whether they are international or domestic trade ships; Western ships with no relation to trade are marked as ▲.

Sea area around Okinawa Island

Okinawa Island is the largest island of the Ryukyu Archipelago. The Ryukyu Kingdom was based on this island, and the Shurijo in Naha was the residential palace of the king. The trade centred on the international Naha Port (‘a’ on Figure 5A). There are three important sea routes depicted on the map—one going to Yamato (Japan) via Amamiooshima Island, another going west to China via Kerama and Kume Islands, and yet another going south to Sakishima including Miyako and Yaeyama Islands.

Five wreck sites have so far been identified in this area. Two out of five are identified as trade ships (5 and 6), while three (3, 7, and 8) are identified as Western wrecks.

Motobu Port (‘b’ on Figure 5A) had great significance as the last supply port on Okinawa Island on the sea route to Yamato. It has also served as a port of refuge until the present day. Two trade shipwrecks were found in this area near the sea route and the port, which shows a concentration of wreck sites in the area. On the other hand, the Western ships are wrecked where there is no relation to significant sea routes or ports. In particular, the Western wreck at Minamiukibaru underwater site (7) was discovered on the Pacific side where there are hardly any other shipwrecks.

Sea around Amamiooshima Island

Amamiooshima Island is located in the middle of the route from the Ryukyu Kingdom to Yamato. The ships

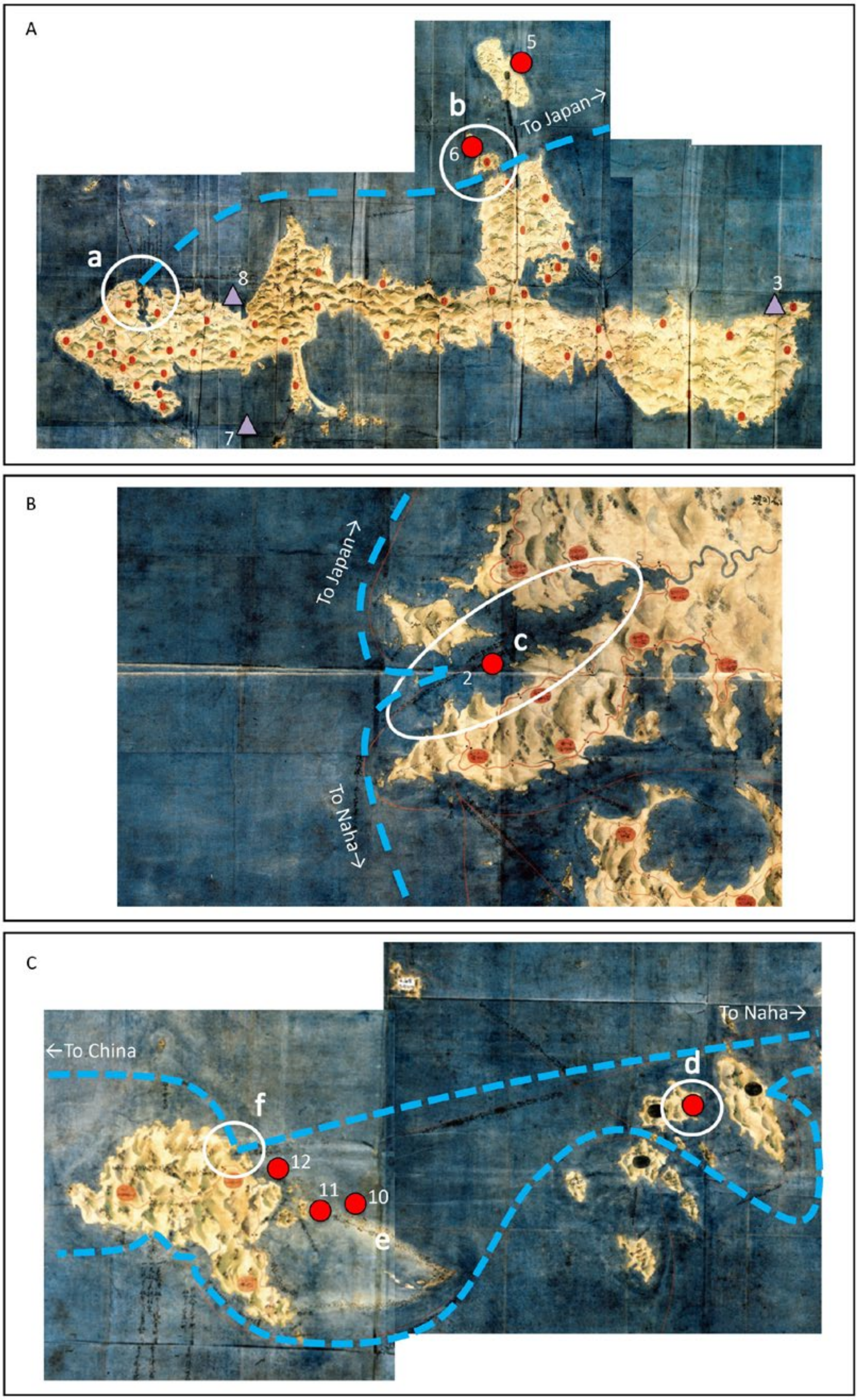
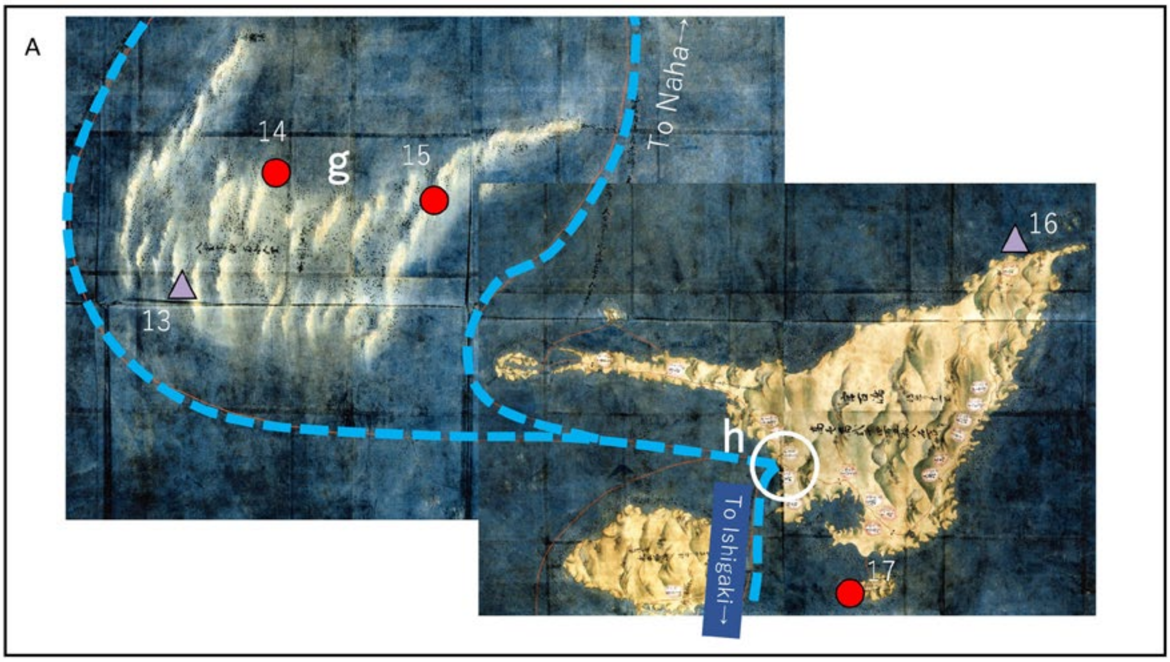


Figure 5. A) Sea around Okinawa Island; B) Amamiooshima; and C) Kerama Islands (Courtesy of Historiographical Institute The University of Tokyo).



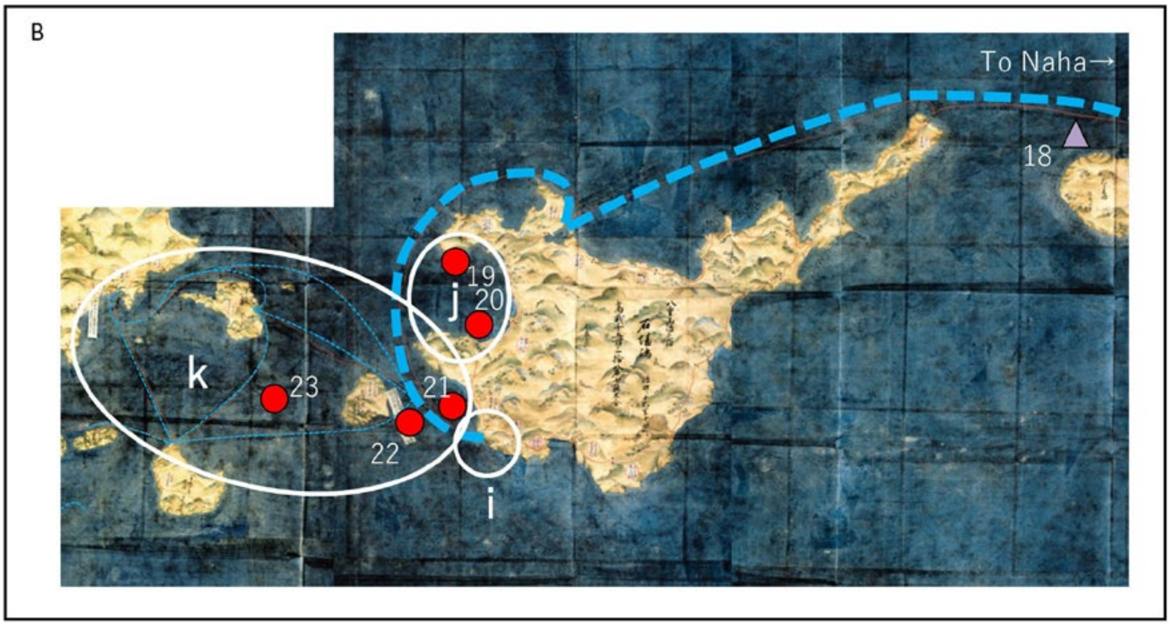


Figure 6. D) Sea around Miyako Islands, and E) Yaeyama Islands
(Courtesy of Historiographical Institute The University of Tokyo).

departed Naha Port and stopped at Motobu Port as the last port to stop at on Okinawa Island. Amamiooshima Island is located on the routes towards Yamato further north. On that island, Yakeuchi Bay ('c' on Figure 5B) has particular significance as the port with the largest anchorage capacity for ships in the whole Ryukyu Archipelago. *Shoho-kuni-ezu* describes the port as having an anchorage capacity for 200 large ships (Tsuha *et al.* 1992). At this port, a wreck site of a trade ship (2) was discovered.

Sea area around Kerama and Kume Islands

The area around Kerama and Kume Islands is on the route from Naha Port to China (Figure 5C). This is the most significant area for international trade routes for the Ryukyu kingdom. Agonoura Port of Zamami Island ('d' in Figure 5C) has historically been a very important port to wait at for the right winds; it still serves as a port of refuge. A wreck site of a domestic trade ship (9) is identified in this significant area.

Kume Island is the last supply port on the way to China. The island has two ports at its northern and southern ends. Moreover, there is a long sand bar on the east side of the island, called 'Hate-no-hama' ('e' in Figure 5C), which is a reef and shallow area very dangerous for ships. There are three trade shipwrecks identified so far around Kume Island. One (12) was near Maja Port ('f' in Figure 5C), which is the northern port of the island located in the middle of the significant sea route to China. Another two sites (10 and 11) were located close to 'Hate-no-hama'. The wreck sites are concentrated near ports and reefs.

Sea area around Miyako Islands

Miyako Islands are situated in the middle of the sea route connecting international Naha Port with the islands further south. In the north of the islands, there is an area with extensive reef shallows called 'Yabiji' ('g' in Figure 6A). To avoid this area, sea routes are parted into two directions going eastwards and westwards. Two wreck sites of trade ships (14 and 15) are identified in Yabiji. Moreover, a Western shipwreck (13) with no relation to trade is also found here. It is unsurprising that this ship encountered difficulties here as it had intended to survey the area.

Harimizu Port ('h' in Figure 6A) is the most significant port on Miyako Island. It also served as a transit port for the Sakishima route between international Naha port and Yaeyama Islands. The wreck of a trade ship (17) is found close to the sea route going from this port to Yaeyama Islands.

The wreck found off Yoshino Coast (16) is a Western shipwreck. It was stranded on the Pacific side where only a very small number of wrecks were found. This Western wreck is also off the significant port and sea routes as compared to sites found around Okinawa Island.

Sea area around Yaeyama Islands

The area is on the southern border of the Ryukyu kingdom, as well as the final destination of the Sakishima route for the trade ships. The most significant port is Ishigaki Port ('7' in Figure 6B). Nagura Bay is situated in the middle of the Sakishima routes connecting the above-mentioned Harimizu Port of Miyako Island to Ishigaki Port. It has also been historically an important port of refuge. Historical documents dated to the Ryukyu kingdom period contain records of shipping accidents ('j' in Figure 6B). There are two trade shipwreck sites (19 and 20) identified.

The sea area connecting Ishigaki Port to the islands further west is called Sekisei-shoko. A complex network of sea routes connecting to each island were developed by the Ryukyu kingdom ('k' in Figure 6B). Three trade shipwrecks (21, 22 and 23) were discovered in this area.

All five wreck sites found around Yaeyama Island are trade ships. The site distribution clearly shows a concentration around the ports and sea routes.

A Western shipwreck site has, however, been identified off the Takada coast of Tarama Island (18). The site is located near the sea route connecting Miyako Island and Ishigaki Island, which stands in contrast to other examples of Western shipwrecks not being found at such locations. It is a rare example. However, we do not see any significance in this exception; it appears to be coincidental.

Discussion

The analysis was aimed at determining if there are any historical and cultural reasons for the locations of these shipwreck sites, based on the dates and characteristics of each site. The results show that the dates and characteristics of these sites including their distribution have certain correlations to the history of the Ryukyu kingdom as a maritime nation.

As described at the beginning of this paper, there are four types of the shipwreck sites discovered: a) Chinese trade ships; b) domestic trade ships; c) Western ships; and, the exceptional d) Second World War wreck. In the trade-related ships of the first two categories, Chinese trade ships constitute the majority from the medieval period, and domestic trade ships replace them in the early modern period. The third type, Western shipwrecks, with no relation to trade, becomes apparent slightly later in the early modern period, after the late 18th century. These trends coincide with what we know of the history of the maritime kingdom.

The results also show that the proportions of sites dated to the medieval period, the early modern period and after the late 18th century correlate to the length of these respective periods. Therefore, while these maritime accidents were unpredictable, shipwreck distribution was not isolated from the history so far established through terrestrial evidence.

Furthermore, archaeological evidence from those shipwreck sites confirmed historical evidence depicting ports and sea routes. The wreck site distribution remarkably concentrates on the East China Sea side of the Ryukyu Archipelago. It is generally accepted through historically documented evidence that significant ports and sea routes are concentrated on the East China Sea side rather than the Pacific side in the Ryukyu Archipelago (Tsuha *et al.* 1992). Therefore, the archaeological evidence obtained from shipwreck sites supports the historical description that the East

China Sea has long been significant for maritime transportation in the Ryukyu kingdom.

Comparison between the locations of the respective shipwreck sites and the depictions of ports and sea routes on the historical map produced in the 17th century shows that the trade ships—international or domestic—tend to have become wrecked around the significant ports and sea routes. Maritime accidents seem to be concentrated within these areas of important ports and sea routes. In contrast, those ships with no relation to trade which accidentally drifted to the Ryukyu Archipelago, like the Western ships, tended to become shipwrecked away from significant ports and sea routes. The evidence implies that those ships wrecked away from significant ports and sea routes are highly likely to have had no relation to the frequent trade activities of the time.

Conclusion

Since unexpected shipwrecking results from accidents, it may be considered as not resulting from historical and cultural reasons. Even though the number of sites presented here is not very high, their distribution seems to suggest more than mere coincidence. The results of our analysis show that locations of shipwreck sites and associated archaeological evidence can be an index for the identification of historically and culturally significant sea areas, ports and sea routes, even if these are not mentioned in historical documents and maps. This argument needs to be further tested and verified by collecting and assessing further evidence, moving forward.

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Wreck Check's Closing in on the Fortuyn Project

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Abstract

The discoveries of four Dutch shipwrecks off the coast of Western Australia have brought great benefit to Australia, including the creation and development of the Western Australian Maritime Museum with its exhibitions and research facility, closer cultural ties between Australia and the Netherlands, and a broader sense of identity for Australians. However, the *Batavia* (1629), *Vergulde Draeck* (1656), *Zuytdorp* (1712) and *Zeewijk* (1727) were all found by 1964. Australians have had more than 50 years to sequentially explore, protect, preserve, exhibit, analyse and re-analyse these wrecks. Now, the discovery of another one or more old Dutch shipwrecks in Australian waters would arguably form the basis for a new and more contemporary maritime archaeological relationship with the Netherlands and stimulate Australian maritime archaeology for a further 50 years.

Keywords

Dutch shipwrecks, Christmas Island, Cocos (Keeling) Islands

Introduction

In 2011 Dutch Ambassador Willem Andreae called for projects relating to the 2016 Dirk Hartog 400 Years Commemoration (Centre for International Heritage Activities 2012: 2). This inspired four researchers to come together as Wreck Check Inc., to search for the still missing Dutch spice trade ships in the eastern part of the Indian Ocean (wreckcheckinc.org, https://www.facebook.com/FortuynProject, last accessed 15 March 2017). As a small, not-for-profit group, the members are conscious of their reliance on collaborative support across national boundaries between Australia, the Netherlands and Indonesia, and across the disciplinary boundaries between history, archaeology, remote sensing, and the natural sciences.

Historical background

Wreck Check members saw the unfound wrecks of the outward bound *Fortuyn* (1724) and *Aagtekerke* (1726), lost between the Cape of Good Hope and Batavia, as prime candidates for a review of the records and theories as to their locations. In 1728 survivors of the *Zeewijk* reported in Batavia that they had seen shipwreck material at the Houtman Abrolhos, and the authorities in Batavia reported that this could have been from the *Fortuyn* or *Aagtekerke*. Researchers Henderson (1978: 71), the Centre for International Heritage Activities (2014: 7) and Green (2016: 22) have cast doubt on this theory, while Edwards (2012: 4) argues that there are too many guns on the *Zeewijk* wreck site for them all to have come from the one wreck, and that the *Aagtekerke* wreck lies on the same site as the *Zeewijk* wreck. Aerial magnetometer surveys carried out in the 1970s, 2008 and 2016 have yet to provide convincing evidence of a second Dutch wreck on or near the *Zeewijk* wreck in the Southern Abrolhos.

During the 1960s another wreck, at South Cottesloe beach near Perth, was thought by some to be an early Dutch vessel because of the number and condition of its guns. Edwards (1965: 6) wrote that 'She may be one of two Dutch East India Company ships lost without trace on the WA coast—the *Aagtekerke* (1720 [*sic*]) or the *Fortuyn* (1722 [*sic*])'. Edwards noted that Perth diver Jack Sue had been given a guilder 'with a date that might have been 1701 or 1791', and added that 'it is now believed that there may be more than one wreck in the area'. Research by Henderson (1973) indicates just the

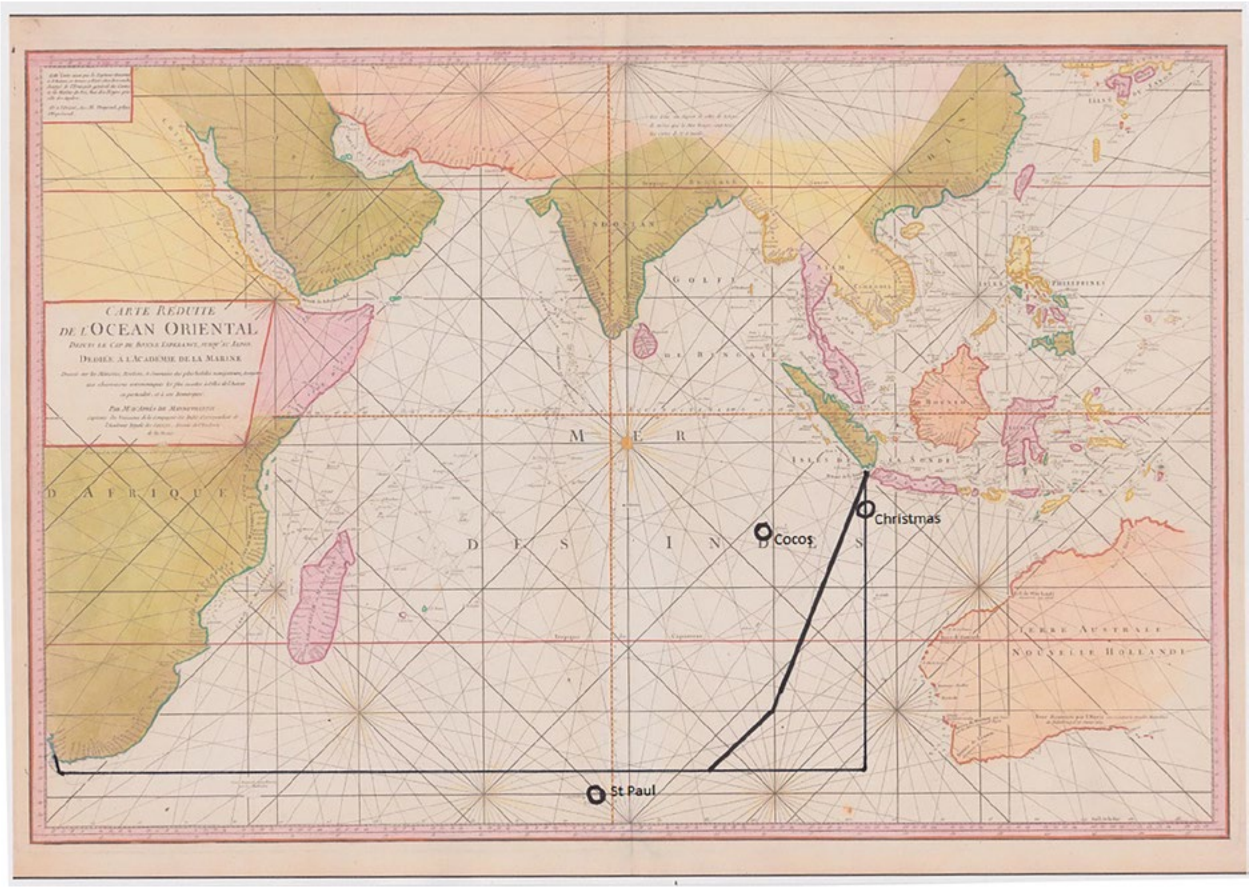

Figure 1. Route from Cape Town to Sunda Strait.

one wreck at South Cottesloe, that being the 194-ton regional trading barque *Elizabeth* lost in 1839.

For Wreck Check members, the evidence concerning the *Fortuyn* and *Aagtekerke* wrecks points elsewhere, for several reasons.

Firstly, the French cartographer Jean-Baptiste d'Apres de Mannevillette, in his atlas titled *Neptune Oriental*, wrote in 1745 that:

> ...77 leagues [400km] south of the west point of the island of Java, at 10º30' latitude lies the island that is called Christmas by the English and Moni by the Dutch. Some years ago a ship from this country touched there at night and was wrecked (D'Apres 1745: 94–95).

This description could indicate the wreck of the *Fortuyn* (1724) or the *Aagtekerke* (1726).

Secondly, in 1981, Ed Dekker, a chemistry teacher on the Cocos (Keeling) Islands, wrote to Queensland Museum curator Peter Gesner that he had found an elephant tusk on the south-west side of the main Cocos atoll (Gesner to Henderson, 19 August 1982, WA Maritime Museum Cocos Island file, MA–239.81). The *Aagtekerke* carried 214 ivory tusks before becoming lost.

Thirdly, a *c.* 1830 chart of the main Cocos atoll shows a 'Burton Point' at the south-west extremity of the atoll and, nearby, the word 'wreck' (Essex Institute Library, undated). Alexander Hare had established a slave-based settlement on the Cocos (Keeling) Islands in 1826 (Smith 44: 93). Memoirs recorded by the Clunies-Ross family, who took control of the settlement from Hare, indicate that the brig *Sir Francis Nicholas Burton* was wrecked on the south-west corner of the main atoll in December 1826 (Henderson 2007: 124). The question raised is whether 'Burton Point' and 'wreck' both mark the *Sir Francis Nicholas Burton*, or whether they mark two separate wreck events.

Fourthly, skipper Diephout of the Dutch East India Company (VOC) ship '*sGraveland*, travelling a fortnight behind the *Fortuyn* on its voyage from the Cape in 1724, told the VOC that he had seen, on 6 and 7 April, the floating wreckage of a Dutch ship at 13º20' south latitude. This latitude matches that of the Cocos (Keeling) Islands (VOC 1893, cited in Halls 1966: 6).

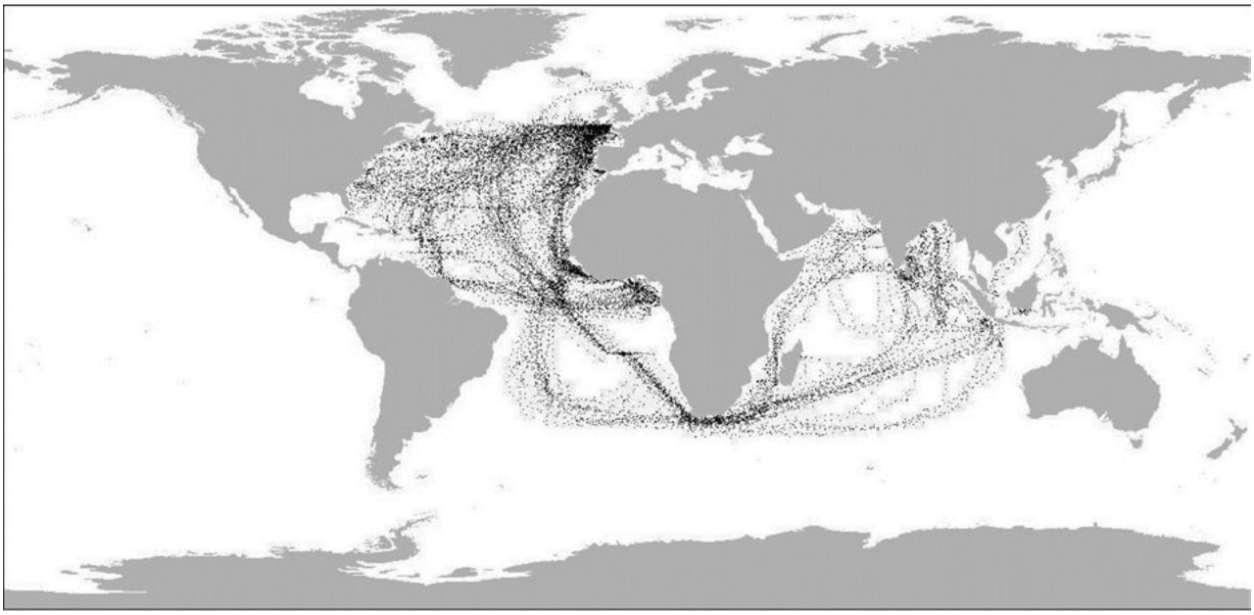

Figure 2. Sea route distribution map.

The 18th century shipping route statistics also support the likelihood of the *Fortuyn* and *Aagtekerke* being wrecked on these islands. Where do most ships get wrecked? On reefs. Which reefs? Those on major trade routes (Gibbs and McPhee 2004: 24). Where was the major outward trade route in the 18th century? It was not past the Australian coast where Hendrik Brouwer sailed in 1611, when he travelled east to the longitude of Sunda Strait and then turned north. By the 1720s ships leaving Cape Town between October and March sailed north-east after passing St Paul and Amsterdam Islands, up to 30º and then north-north-east to bring themselves west of Sunda Strait, and take advantage of the north-west monsoon (Bruijn *et al*. 1987: 71) (Figure 1).

The *Fortuyn* and the *Aagtekerke* both left the Cape in January. On this shorter route they would pass relatively close to the Cocos (Keeling) Islands or Christmas Island. The route normally taken in the 1750s, as indicated by the logbooks, is shown in the distribution map (Figure 2). If such ships struck the Cocos (Keeling) Islands or Christmas Island *en route* it may be expected that they would have encountered the south-west coasts of those islands. All of this evidence seemed to be pointing to the *Aagtekerke* and *Fortuyn* having been lost around the Cocos (Keeling) Islands or Christmas Island rather than at the Abrolhos.

Wreck Check needed someone to revisit the VOC records and Martijn Manders of the Maritime Programme in the Netherlands assigned Pablo Boorsma to the job. Boorsma found longitude information in another of the 's*Graveland* skipper's reports. Diephout told the VOC that on 6 April, in latitude 13º20' south, longitude 124º51' east, he had seen floating:

> ...several signs of a wrecked ship and among other things also the back piece of a boat with two oarlocks of which [it] was thought that the aforementioned unlucky vessel has to be the new ship the *Fortuijn* (Diephout 1724).

Accepting that Diephout was using Tenerife in the Canary Islands where 'the Dutch place their first Meridian'(Beeckman 1718: 5) as his prime meridian, his longitude measurement for the wreckage sighting can be reduced from 16º30' to 108º21', *c.* 241km east of Christmas Island. His latitude measurement for shipwreck debris in the water is *c.* 266km south of the island, consistent with the water current direction and flow rate of that time of year from Christmas Island (Tomczak and Godfrey 2003: 180). Based on this interpretation, the south-west coast of Christmas Island is the logical point of disaster for the *Fortuyn*. Alternatively, applying a correction for the effect of variation in accord with the calculations of Van Bemmelen (1895), one-time assistant director of the Royal Dutch Meteorological Institute at Utrecht, would place the floating wreckage 266km due south of Christmas Island. The distances to other obstructions in similar latitude (Cocos *c.* 1225km, or Cartier Island *c.* 1720km) are much greater. Diephout was an experienced sailor having been on four previous VOC voyages so notwithstanding the inaccuracy of longitude measurement at the time, some credence can be placed on his calculation.

Main content

With the collaboration and support of the Maritime Programme of the Cultural Heritage Agency of the Netherlands Ministry for Education, Culture and Science, the Canberra-based Embassy of The Kingdom of the Netherlands, Silentworld Foundation, Parks Australia and Thomas Creemers, Wreck Check arranged three-week seasons of remote sensing at Christmas Island and the Cocos (Keeling) Islands in 2015 (Henderson *et al.* 2015) and 2016. The Cocos Islands were included in the searches because other researchers (Halls 1966, Ariese 2011) had argued that the *Fortuyn* could have struck there, and because of the (at the time unsubstantiated) report of an elephant tusk having been found there possibly indicating the wreck of the *Aagtekerke*.

Methodology/analysis

For the 2015 season the team borrowed a proton magnetometer made for the Maritime Archaeology Association of Victoria (MAAV) in 1985. This analogue device was converted by a Labjack Pro to record a digital signal in millivolts. The instrument box gave a digital readout in nanoteslas. An electronic signal was sent from the Labjack Pro to a Motion Tablet with GPS functionality running Ozi Explorer mapping software. Anomalies were assessed and prioritised for further investigation and inspection by divers (Figure 3).

Diving was constrained to 30m for work health and safety reasons. Shallow waters were searched because the drafts of the target vessels *Fortuyn* and *Aagtekerke* were estimated to be less than 7m. Also of influence was a Coroner's report about the wreck of an asylum boat. In 2010 the asylum boat hit the Christmas Island cliffs on the north side of the island and was caught in what he described as a 'washing machine effect', sinking in 10m of water close to the cliff. In like manner, after the VOC ship *Zuytdorp* struck cliffs on the Western Australian coast in 1712, wreckage remained trapped in gutters near the cliffs.

The volcanic nature of Christmas Island (Department of Environment) meant that magnetometer signals had to be assessed against a possible high magnetic background and possible submerged outcroppings of basalt. Nevertheless, the known wrecks and anchors were clearly revealed. The magnetometer runs were primarily focused on the south-west side of Christmas Island, and the south-west side of the main Cocos atoll. Both island groups have rapidly shelving seabeds so the width of the zero to 30m-depth mark was narrow (Figure 4).

Recognising that the MAAV proton magnetometer has a much slower detection rate than modern magnetometers, which could lead to significant data gaps even at a towing speed of 4 knots, the primary instrument employed for the 2016 fieldwork season was a Geometrics G-882 caesium vapour marine magnetometer leased from Seismic Asia (see Figure 3).

Results and interpretation

During and after the 2016 season three new pieces of information modified the team's approach and understanding.

Figure 3. Magnetometer recording, 2015 season.

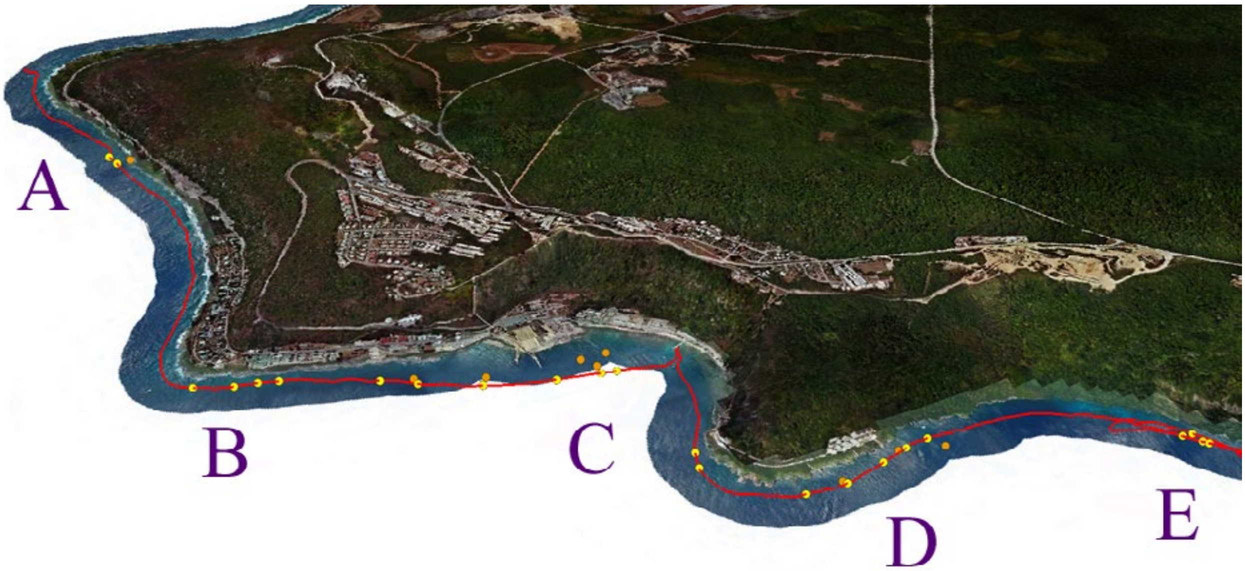

Figure 4. Christmas Island.

Firstly, Dutch researcher Thomas Creemers provided information about the 1852 wreck of the Dutch 496-ton barque *Vice Admiral Rijk*, which struck and sank on the south-west point of Christmas Island (Bennett 1853). A passing ship rescued three survivors, marooned for 57 days on the island, and they reported where their ship had gone down.

Secondly, on Christmas Island, local dive operator Teruki Hamanak (pers. comm. Feb. 2016) told the Wreck Check team that an asylum boat was deliberately scuttled as a dive site in 25m of water in Flying Fish Cove. Teruki observed that the wreck remained intact and in location for about a year after which it disappeared into water deeper than 40m. This post-deposition process observation clearly conflicts with the Coroner's observation.

With the knowledge of a known wrecking event, the team searched the south-west point of Christmas Island more intensively, without seeing any evidence of the *Vice Admiral Rijk*. The conclusion was that, like the asylum boat in Flying Fish Cove, it slid intact into water deeper than 30m.

Thirdly, more information has become available about the British 124-ton brig *Sir Francis Nicholas Burton*, wrecked on the main Cocos atoll. In 1826–27 the brig was listed in *Lloyds Shipping Register* as bound from London under the command of W. Hare to the Mexican port of Vera Cruz, a port of entry for African slaves. During the eighteenth century the Atlantic 'triangular trade' involved shipping trinkets from Europe to Africa, slaves (and on Dutch ships, ivory) to the Americas, and sugar and ivory back to Europe. The *Sir Francis Nicholas Burton* was possibly involved in trading, or, more likely, transporting, slaves. The Atlantic slave trade had been made illegal in 1807 so the owners of slave trading vessels disguised their activities and whereabouts, while owners of slaves could continue to transport slaves in ships if they wished.

English merchant Alexander Hare, (relationship to W. Hare unknown) was an infamous slave owner (Koninklijk Instituut 1860: 16) who was evicted from his household in Batavia in 1819. He settled on a farm 20km from Cape Town, before leaving to sail eastward in January 1826 to settle on the Cocos (Keeling) Islands with his harem and slaves.

By 1826 things were becoming more difficult for slave owners throughout the Atlantic. The 1834 *Slavery Abolition Act* was about to abolish slavery itself in most of the British Empire including South Africa and Mauritius. It is possible that the *Lloyds* reference to Vera Cruz was a subterfuge, and that the *Sir Francis Nicholas Burton* was always intended to sail to one of the more remote Indian Ocean islands, collecting a 'cargo' of slaves *en route* from Africa. The question is, did it also collect ivory *en route*? There is no obvious reason for the *Sir Francis Nicholas Burton* to have been carrying ivory to the Cocos (Keeling) Islands.

Discussion and conclusions

The remote sensing survey and diver ground-truthing has yielded no underwater evidence of the presence of the *Aagtekerke* at the Cocos (Keeling) Islands, or the *Fortuyn* and *Vice Admiraal Rijk* at Christmas Island. In 2016, with the caesium vapour magnetometer and excellent sea conditions, an intensive search at the south-west point of Christmas Island revealed no wreckage. The team's greater understanding of the environment there suggests that the *Vice Admiraal Rijk*,

Figure 5. Ed Dekker with elephant tusk, Cocos.

and the *Fortuyn*, will be found to lie in water deeper than the search penetrated.

At Cocos, the mysterious elephant tusk question is becoming much clearer. It can no longer be regarded as hearsay. The finder of the tusk, Ed Dekker, has been located (Figure 5). He has made the tusk available to Megan Coghlan, Michael Bunce and Zoe Richards at the Trace and Environmental DNA Laboratory, Curtin University, for analysis. Three approaches are in train.

Firstly, the DNA analysis has indicated that the ivory came from south-east Africa. In the 1720s ivory was being legally exported from Mozambique (in South-east Africa) to Cape Town. The *Aagtekerke* loaded 214 legal tusks at Cape Town so this information is consistent with the idea that the tusk found at the Cocos Islands comes from the *Aagtekerke*. Curtin University's DNA analysis of the tusk from the Southern Abrolhos *Zeewijk*/*Aagtekerke* wrecksite gave an origin of Central Africa, which does not appear to support the theory of the *Aagtekerke* having been wrecked on the Abrolhos (Green 2016: 21).

A West African, mainland Asian or Sumatran tusk origin would have supported the idea that the Cocos (Keeling) Islands wreck is the brig *Sir Francis Nicholas Burton.* However, a south-east African origin does not rule out the *Sir Francis Nicholas Burton*.

Secondly, the carbon dating was carried out. As discussed earlier, the tusk was discovered near the possible sites of two wrecks. The south-west point of the main Cocos atoll is named 'Burton Point' suggesting that the *Sir Francis Nicholas Burton* was wrecked thereabouts in 1826 (Figure 6). A carbon date leaning towards 1726 would be indicative of the *Aagtekerke* or another earlier unknown wreck, while a carbon date leaning towards 1826 would be indicative of the *Sir Francis Nicholas Burton.* The calibration curve of the rate of carbon radioactive decay between the years 1300 and 1900 is interrupted by a major fluctuation between 1726 and 1826, meaning that carbon dating may need to have a correction applied or prove not to be reliable for shipwrecks of those two dates (Michael Bunce pers. comm., 8 March, http://www.sciencecourseware.org/virtualdatingdemo/files/RC_6.html, viewed 15 March 2017). This analysis is not yet complete.

Thirdly, analysis of the coralline algae attached to the tusk includes one initial observation that it may be a form typically living on steep slopes.

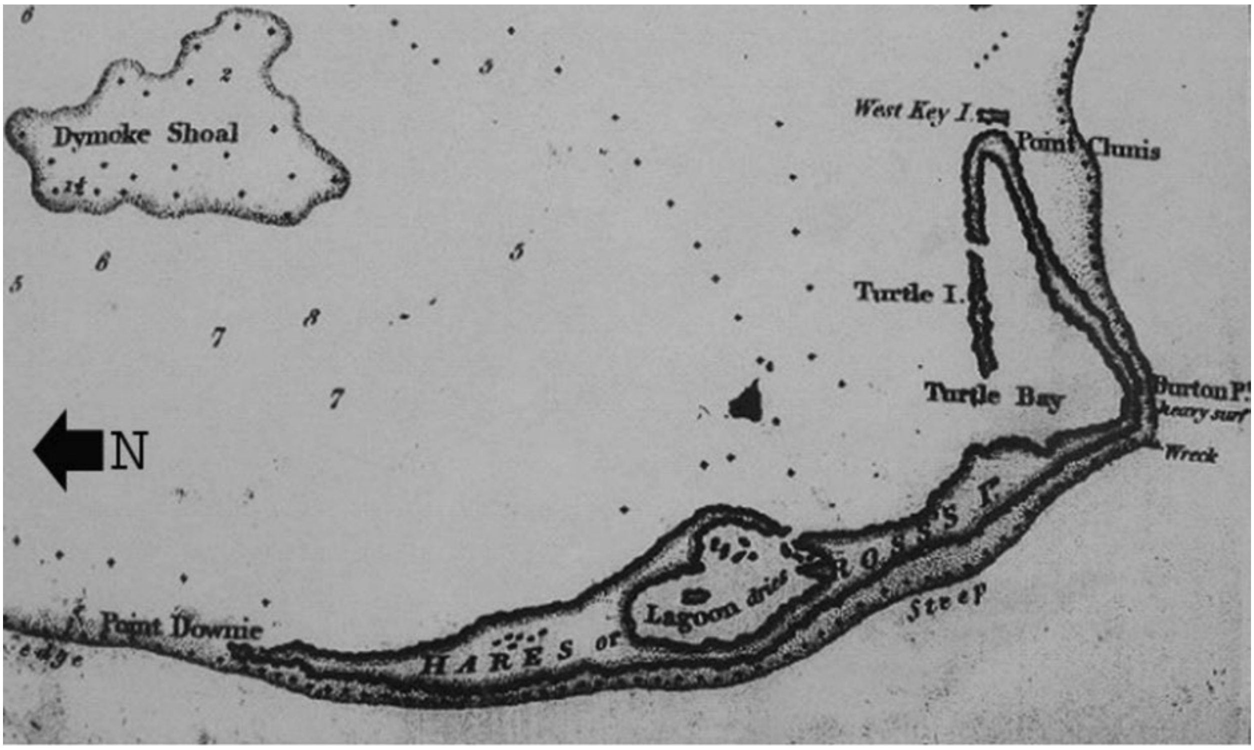

Figure 6. 'Burton Point', Cocos atoll.

So what of the future for the 'Closing in on the *Fortuyn*' project? With regards to Christmas Island, Wreck Check members are exploring the feasibility of acquiring access to an autonomous underwater vehicle for a deeper search at its south-west point for the *Vice Admiral Rijk* as a pointer to the likely depth location of the *Fortuyn* if it lies along the western or southern sides of the island. In relation to the Cocos (Keeling) Islands, the tusk analysis (if indicating the earlier date) may point to the need for a similar autonomous underwater vehicle approach combined with metal detector work, searching in the hitherto unexplored shallows shoreward of the outer reef.

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An Account of Stone Anchors Along the Northern Shoreline of the Persian Gulf

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Abstract

The northern shoreline of the Persian Gulf encompasses countless valuable archaeological sites. However, just as in many other areas, the Iranian side of the Gulf is undergoing continuous, rapid urban and industrial development, which results in the destruction and loss of many archaeological sites and artefacts. Limited systematic maritime studies have been conducted on the underwater and coastal cultural heritage in these areas. This article presents an inventory of the historical stone anchors and weights observed along the northern shoreline in the areas between Bushehr and Hormozgan Provinces. This collection was put together as a result of site observation, archival studies, sporadic interviews with local people, and findings during construction excavations—either underwater or along the shoreline by locals. No archaeological excavations were conducted; most finds are surface objects that were collected during site visits and considered to be in danger of destruction or loss. The locations of the objects were registered using Global Positioning System. Recordings were conducted of their weights and sizes, and they were photographed and drawn. Following an inventory of all the stone anchors and weights, a classification system is suggested. The results of this research have the potential to lead to further in-depth studies about seafaring and maritime history within the Persian Gulf.

Keywords

Stone anchors, stone weights, Persian Gulf

Stone anchors

Stone anchors are made of a stone shank in a variety of shapes and are known from different parts of the world (Frost *et al.* 1993; Tripati *et al.* 2005 and 1998). They have varying numbers and shapes of holes; some anchors have flukes and some do not. A stone anchor can be just a heavy stone with only one hole for its cable, which relies on weight alone. Stone anchors can also represent a wide range of shapes and sizes of stone with several piercings for wooden or iron arms that dig into the seafloor, and one hole for the cable (Frost *et al.* 1993: 449). Stone weights are smaller than stone anchors, and have traditionally been used for fishing and pearl hunting (Carter 2005: 140; Lorimer 1915: 2229; Potts 1998: 148). Studying stone anchors is important for understanding different types of ancient ships, their sizes, functions, and location of origin, as well as for the geographical passage and anchorage of ships in the history of navigation (Frost 1963: 2).

Background to Iranian maritime studies and stone anchors

Present-day Iran, which historically was part of the larger Persian empire, has approximately 5000km of shoreline including its bordering seas, islands and lakes, more than 989km of shoreline along the Persian Gulf, and 784km along the Oman Sea, as well as more than 800km along the Caspian Sea (Dibajnia *et al.* 2012:1; IHO 1953: 20–21). According to historical sources and studies, Persian seafaring dates back at least to the Sassanid era (AD 224–651) (Agius 2008:75; Hourani, 1950: 36-46; LeBaron and Le Strange 1966: 257–69 and 295–98; Whitehouse and Williamson 1973: 29–49). Despite an extensive Persian maritime history, only a few attempts to write exclusively about Persian naval history, such as Hasan (*A History of Persian Navigation* 1928) and Raeen (*Daryanavardiye Iranian*: Iranian Navigation 1971) have been published. Some background studies about Persian maritime history can be found in Greek literature (Herodotus 1920; Diodorus Siculus 1946), travellers' accounts (Ferrand 1922: 7, 26 and 53–58; Freeman-Grenville 1982: 63–70) and artworks. However, maritime archaeological study in Iran has been overlooked in the past few decades. This article attempts to contribute to the study of Iranian maritime history, through offering an inventory of stone anchors and stone weights, which were observed and recorded in a number of historic ports and villages along the shoreline of Bushehr. Although several studies on the typology of anchors in the Persian Gulf have been published (LeBaron 1957; Vosmer 1999, 2000), no study has exclusively focused on the stone anchors found in Iran.

Throughout the maritime history of the Persian Gulf, stone anchors and stone weights were in regular use. The Persian glossary, *Miftah-ul fuzala*, compiled during the second half of the 15th century at Mandu (Malwa), defines *langar* (anchor) as the 'stone of a *kishti*' (boat) (Hourani 1951; Qaisar and Verma 2002: 20; Tripati *et al.* 2005: 131–37). Among sporadic documentation of stone anchors in Iran, three were reported by Whitehouse (1970: 141), found at terrestrial archaeological sites in Siraf; two were recorded in the 2012 investigations in Siraf (Khakzad *et al.* 2014); and one single-holed, round-shaped anchor was reported at the port of Ganaveh, about 100km north-west of Bushehr (Tofighian 2014: 127). Since there is no focused study on the stone anchors of Iran, and international literature mentions Iranian stone anchors only sporadically, for classification of stones anchors in Iran, this work relies on studies from other parts of the world, such as India and the southern shorelines of the Persian Gulf.

Types of stone anchors in neighbouring countries

Studies conducted on the Arabian side of the Persian Gulf in Qatar, Oman and United Arab Emirates (UAE) recorded a number of stone anchors including different types of Indo-Arabian, *al-sinn* and three-holed stone anchors (e.g. Qalhat anchor) (Vosmer 1999: 250–52). Indo-Arabian types are the plinth type with a round hole at the smaller end and two perpendicularly opposed rectangular holes at the larger end. Indo-Arabian stone anchors are recorded in the western Indian Ocean and Arabian Sea (Vosmer 1999: 251). *Al-sinn* is a rectangular-shaped anchor, mostly recorded with one hole on the flat face and another on the side, described since the early 16th century (Agius 2008: 144–46; Badger 1863: 59–60; de Ruyter 2014: 126–27; Pilcher *et al.* 2003: 38). According to previous studies, *al-sinn* anchors indicate the passage or wreck of an Arab or Persian fishing or pearling vessel in the Gulf (Agius 2012: 182; de Ruyter 2014: 128). LeBaron Bowen (1957: 293) stated that *al-sinn* stone anchors located on the Iranian littoral are possibly indigenous to that coast. This study introduces evidence that confirms that this type of anchor was made locally in Iran.

Recording and documentation methods

For the present study, data was collected by observing coastal cultural heritage and archaeological sites, and visiting construction sites. The artefacts were surface finds and no archaeological excavations were conducted. As is the case with some surviving examples of *al-sinn* anchors, such as those in the museums of the UAE (Sharjah Maritime Museum and Dubai), the Iranian *al-sinn* anchors were found on land with other archaeological remains, or at local peoples' houses and shipyards (Blau 1995: 120–24; Carter 2005: 168). Several stone shanks and anchors were also found underwater. The ones reported from buried contexts are the result of digging for foundations of new buildings and road construction. These artefacts have mainly been found at sites that are threatened by, and/or have already undergone, urban and industrial development. Some data was collected through communicating with locals and fishermen who have stone anchors and stone weights in their possession through generations, or by finding them on their properties while digging foundations or wells.

Recording methodology consists of drawings, photographs, collecting size and weight measurements, describing form and materials, dating the stone, and interpreting the holes and their directions. According to Frost, size and weight are the two most important measurements to record because these two measurements can usually imply the size of the ship that carried the anchor (Frost 1997: 122). In the present study, the location and GPS coordinates of the artefacts were recorded through site observation. Artefacts in danger of destruction or loss were transported to museums for documenting and archiving. Anchors in the possession of private individuals were photographed, weighed and their find location, if known by the owner, recorded.

In addition, the process of recording and documenting was a training opportunity for locals. Through talking to local people and local non-government organisations (NGOs) about the importance of archaeological sites and, in this case, stone anchors and stone weights, they are now more aware of the cultural values of these artefacts, and they are more likely to share their findings and the location of other discoveries with archaeologists. In total more than 300 stone anchors and stone weights were recorded. The following sections present the analysis of these stone anchors and weights.

Study areas and findings

The study focuses on the shoreline of Bushehr Province. Historically, several important ports and traditional fishing villages were located along Bushehr's coastline. Case studies for the present research were selected from among important archaeological and historical sites in danger of destruction or loss of archaeological artefacts. Some stone anchors and weights were also reported from a few nearby sites in Hormozgan Province by locals. These are included in the present research.

Rishahr

According to the literature and archaeological reports, one of the major ports in the Persian Gulf was Rishahr, now located within the city of Bushehr. Rishahr (Rev Ardeshir) was an Elamite city and an important port during the reign of King Ardeshir (AD 180–242) (Daryaee 2008: 2; Kazeruni 2015: 60; Massoudi 2013: 146). At present, the remains of Rishahr are located in and around a large extended cliff, which varies in height along the shoreline and, in some locations, reaches 10m. The site includes the remains of a collapsed well and human skeletons, in addition to several types of carved stones and stone blocks within different layers of the cliff and on the shoreline. Based on previous archaeological studies such as Whitehouse and Williamson (1973) and Ataie (2005: 86), the remains of an ancient pier or wave-break appear to be present, extending from the shoreline to the sea. Among the remains, several stone shanks and anchor types were documented. Some peculiar stone objects whose functions have yet to be identified were also noted (Figure 1).

Hezar-Mardan

In the areas around Bushehr are sites and villages with evidence of historic fishing and pearling. Hezar-Mardan is one of many old fishing villages in this area where 15 stone weights have so far been recorded. These weights are purposefully carved stones of different shapes, with a small hole usually in the middle, weighing between less than 100g up to 260g, for use in pearl diving and fishing.

Bibi-Khatoon

Bibi-Khatoon is another fishing village and one of this project's case studies where 32 stone weights were recorded. These weights are more diverse in terms of their shape, and where some have holes and some do not; and, some are flat, oval- or egg-shaped stones with evidence of rope tied around them. Their weights vary—some as light as 45g, several of them around 500–700g, and the heaviest ones approximately 1.625kg—and might be considered small anchors.

South-east along the coast to Siraf, locals reported a few more anchors. A rare example reported is a composite, three-holed anchor from the archaeological site of Bardu in Bardestan. This is a very common type in the Mediterranean and examples have been found on the Arabian side of the Persian Gulf (Frost 1993: 452; Raban 2000: 260). The only three-holed composite anchor known so far from Iran is the one reported from Bardestan.

Siraf

The historically important port of Siraf is well-known by national and international archaeologists. Major archaeological excavations and studies were conducted by Whitehouse and the British Institute for Persian Studies in the 1970s (Whitehouse, 1968, 1969, 1970, 1971, 1972) and later by Iranian archaeologists with the Iran Archaeological Institute (Masoumi 2004) at several terrestrial sites. In addition, a pilot underwater and coastal cultural heritage study was conducted in 2012 (Khakzad *et al.* 2014). As a result of these studies, three Indo-Arabian anchors were reported by Whitehouse (1970: 14–15), and three single-holed anchors were observed (two documented) during the 2012 studies. Among those recorded during the 2012 project, one was possibly a single-holed ring-stone, observed underwater, which was badly eroded; one was a pear-shaped, single-holed anchor, recorded underwater and left *in situ*; and the last one was half of a broken single-holed, pear-shaped anchor found among debris on the beach. In addition, several millstones were observed along the shoreline that could have been used as mooring buoys.

Nayband

Another site, about 60km south-east of Siraf, is Nayband, which has remains of a wave-break and historic ruins, some identified by archaeologists as trade and storage areas, and a customs building along the coast (Esmaili Jelodar and Ebrahimi 2012: 40–41). Nayband is mentioned in historical records, and travellers and historians such as Yaqout, Al-Muqaddasi and Ibn Hawqal described this city as a port and a good anchorage area for ships around the 9th to 11th centuries. Terrestrial archaeological studies (Esmaili Jelodar and Ebrahimi 2012) have been conducted on this site and there is no doubt about its archaeological value. However, the remains are threatened by erosion and urban development. More than 200 stone anchors and stone weights have been documented. Most of these artefacts were observed in terrestrial sites among the rubble. Only one anchor was recorded in the tidal area. Underwater excavations and studies have not been conducted yet, and more anchors likely will be found underwater in the bay. Several stone anchors were documented on land, and Figure 2 shows three stone artefacts that seem to be incomplete.

Bostano

Bostano is presently a fishing village in Hormozgan Province, neighbouring Boushehr Province, with residents who have been engaged in fishing for many generations. The present buildings are not historical but there are archaeological remains beneath and around the village. Although the study areas were mainly in Bushehr Province, some local people from Bostano shared their stone anchors with us. These artefacts were found by locals digging wells or foundations for new buildings. These anchors are larger in size (*c.*

Figure 1. Different stone artefacts in the area around the cliff and the possible ancient pier; some may have been anchors. The three artefacts at the bottom are classified as stone anchors recovered from Rishahr close to the potential ancient pier/wave-break, and on the beach along the bay. Picture by author (© Bushehr Museum of Naval Trade).

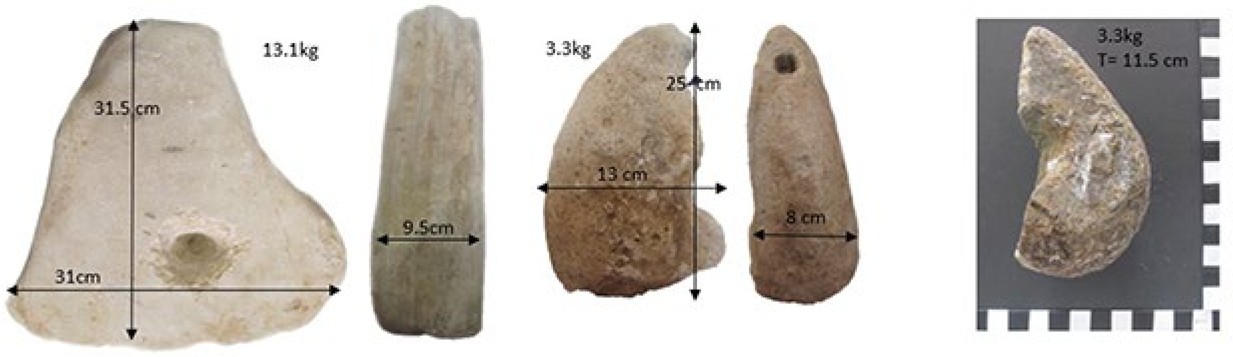

Figure 2. Unfinished/incomplete stone anchors, documented at Nayband Site.
Pictures by author (© Bushehr Museum of Naval Trade).

60–75cm high) than those found in Nayband and Siraf (maximum 50cm) and are similar to the *al-sinn* type. Among them is one anchor that is slightly different from others—this is the only one that has been recorded with three holes on the surface. The upper part is broken, so it is not possible to determine anything about its side-hole (Figure 3). It was donated to the Bushehr Museum by a local who found it while digging a well at his property at a depth of about one metre. In addition, a brief observation of the area around Bostano reveals several sites and fishing villages, such as Javadol-Aemmeh, Beloghreh (Borogla) and Ziarat, with surface archaeological remains, including many stone weights and anchors. The archaeological importance of these locations is mentioned in some historical accounts (Stein 1937: 199). These sites are in danger of destruction by new development and road construction and it is recommended that survey and documentation of the sites and their artefacts be carried out before the archaeological resources are lost.

Through our observations, findings and local reports, we documented three anchors in Rishahr, 15 weights in Hezar Mardan, 32 weights and anchors in Bibi-Khatoon, more than 200 in Nayband (and still counting), five anchors in Siraf, six reported in Bostano by locals and we observed 19 weights in Javado'l Aemeh, 12 in Beloghreh and 17 in Zyarat. The ones in Bushehr Province, which were in danger of loss and destruction, in addition to the ones that were donated by locals, were transferred to the Museum of Maritime Trade in Bushehr.

Typology of stone weights and stone anchors

As mentioned before, different criteria for stone anchor classification have been suggested (Frost 1997). To classify our artefacts, we used characteristics that could be accurately and precisely recorded such as weight, size and number of holes. Several types and forms of stone anchors with different weights, and number and shape of holes, were identified. One aspect that we are still studying is the type of stone. Some stones were identified by local geologists as sandstone, limestone and corals. All these types of stone exist locally in the mountains and rocks along the coast. However, not all the anchor stones were specifically identified.

The results of our classification are presented in the following section, and drawings based on this classification are presented in Figures 4–6.

Results: Typology and classification

1. Large al-sinn *type:*

The first group of similar stone anchors is the large *al-sinn* type reported by local people in Bostano. Heights range from 50 to 70cm, and weights between 45 to 75kg. They all have one hole on the surface and one hole on the side (the form of the side-holes was not recorded, just the location was noted). Among these anchors, one is exceptional with three holes on the surface. We called this one "Persian-Bostano Type." One large *al-sinn* type from Nayband is lighter in weight than the ones from Bostano. Therefore, due to its shape and weight, it is classified under the category of small *al-sinn* type.

2. Small al-sinn *type:*

These anchors vary in size (their height varies from 15 to 40 cm), weight (from 2kg to 18kg), thickness (between 5.5 and 11.4cm), and carving style (flat, pointed or curved bottom). Some of these anchors are badly damaged, broken or eroded, therefore, the exact location of the side-hole and its form is unclear. Amongst this type, one was found to be incomplete (see Figure 2–1). These types were recorded in Nayband.

3. Pear-shaped type:

A number of pear-shaped stone anchors, with one hole on the side and one hole on the surface or only

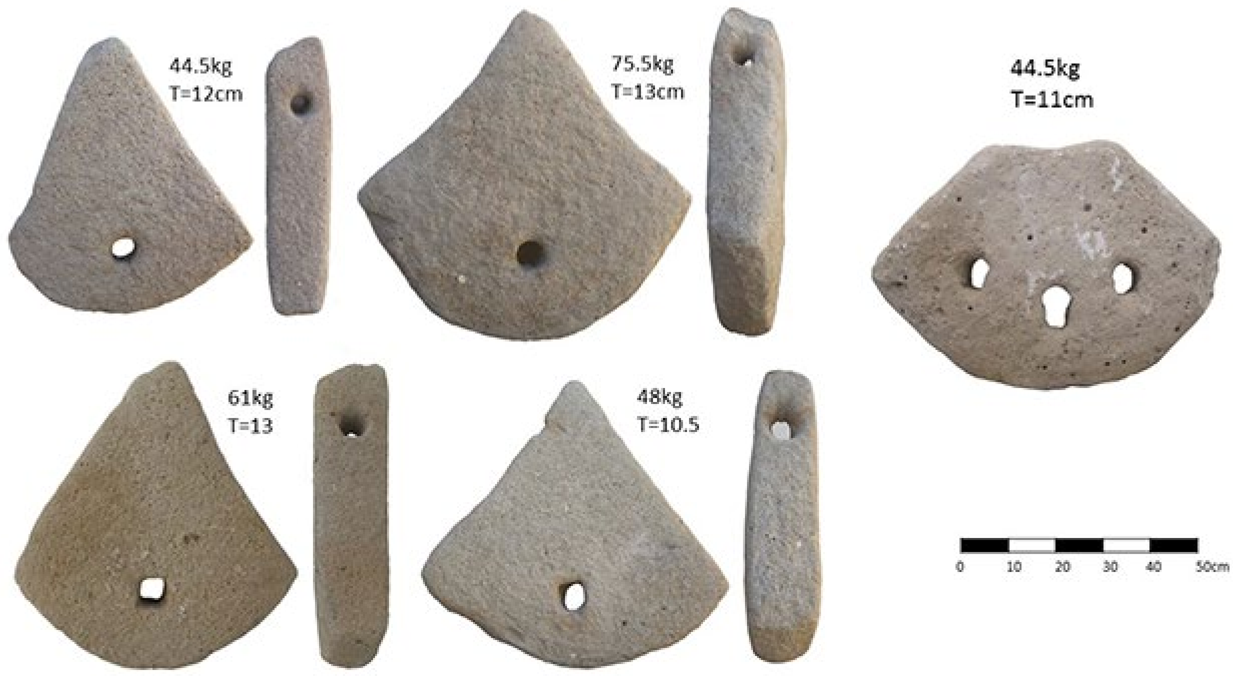

Figure 3. Anchors documented in Bostano are similar to the type called *al-sinn*. Four of this type are reported to be in good shape (shown here, and one broken). Pictures by authors (© Bushehr Museum of Naval Trade).

one hole on the surface, were recorded in Nayband and Siraf. However, their forms vary to some extent, and the shapes of their surface holes are different as well. Their heights vary from 20 to 50cm, and they weigh between 2.5 and 5kg. The Siraf anchor is larger than the ones from Nayband. The ones from Nayband can be classified as large weights.

4. Two-holed type:

Four two-holed anchors, different in form, were recorded in Nayband. The two holes are on their surface. Their heights are between 20 and 30cm, and weights between 4 and 5.5kg. However, they are eroded and their original weights and shapes are not completely identifiable. Their thickness varies between 6 and 13cm.

5. Single-holed:

Several single-holed anchors, in a variety of shapes, were recorded from Nayband and Rishahr. We put them in the single-holed group with uncategorised shape. Their sizes, weights and thicknesses vary.

6. Three-holed type:

Three-holed composite anchors, also known as Byzantine-Arab, are the triangular- or trapezoidal-shaped stone anchors with three holes on the surface, used for sandy and rocky seabeds (Frost 1963). Only one of these types was recorded during our investigations, found by locals in the archaeological site of Bardu in Bardestan Port, about 40km north-west of Siraf. It weighs about 21kg.

7. Stone weights:

The smaller stones were classified as weights. However, we found varieties of weights, from a simple rock with evidence of a rope wrapped around it, to more sophisticated and carved stones, either flat or bulky, and with or without a hole in the middle. They were categorised based on the existence of holes, and the side that a rope was tied around. These stone weights were recorded at many sites such as Nayband, Rishahr, Bostano and all the fishing villages.

8. Unfinished stone anchors:

Among our findings are at least three stone anchors identified as unfinished (incomplete). They appear to be of *al-sinn* and pear-shaped types. These unfinished artefacts are evidence that these types of anchors were made locally.

Discussion and conclusion

In addition to the anchors presented in this study, more than 300 stone anchors and weights had previously been

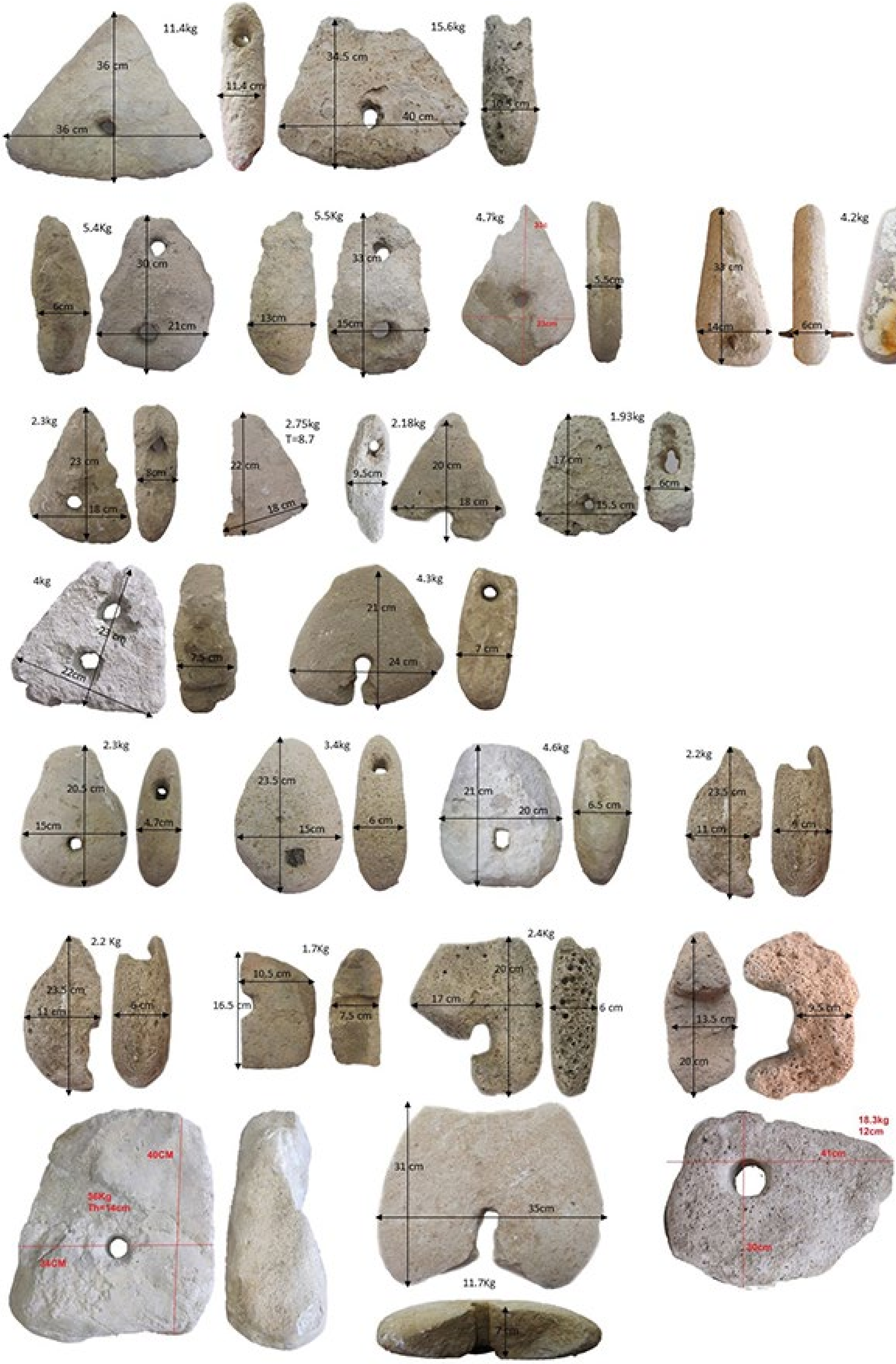

Figure 4. Some examples of stone anchors documented at Nayband Site; they vary in size and shape. Some are badly eroded while some are in better condition; one was recorded with its iron fluke still intact.
Pictures by authors (© Bushehr Museum of Naval Trade).

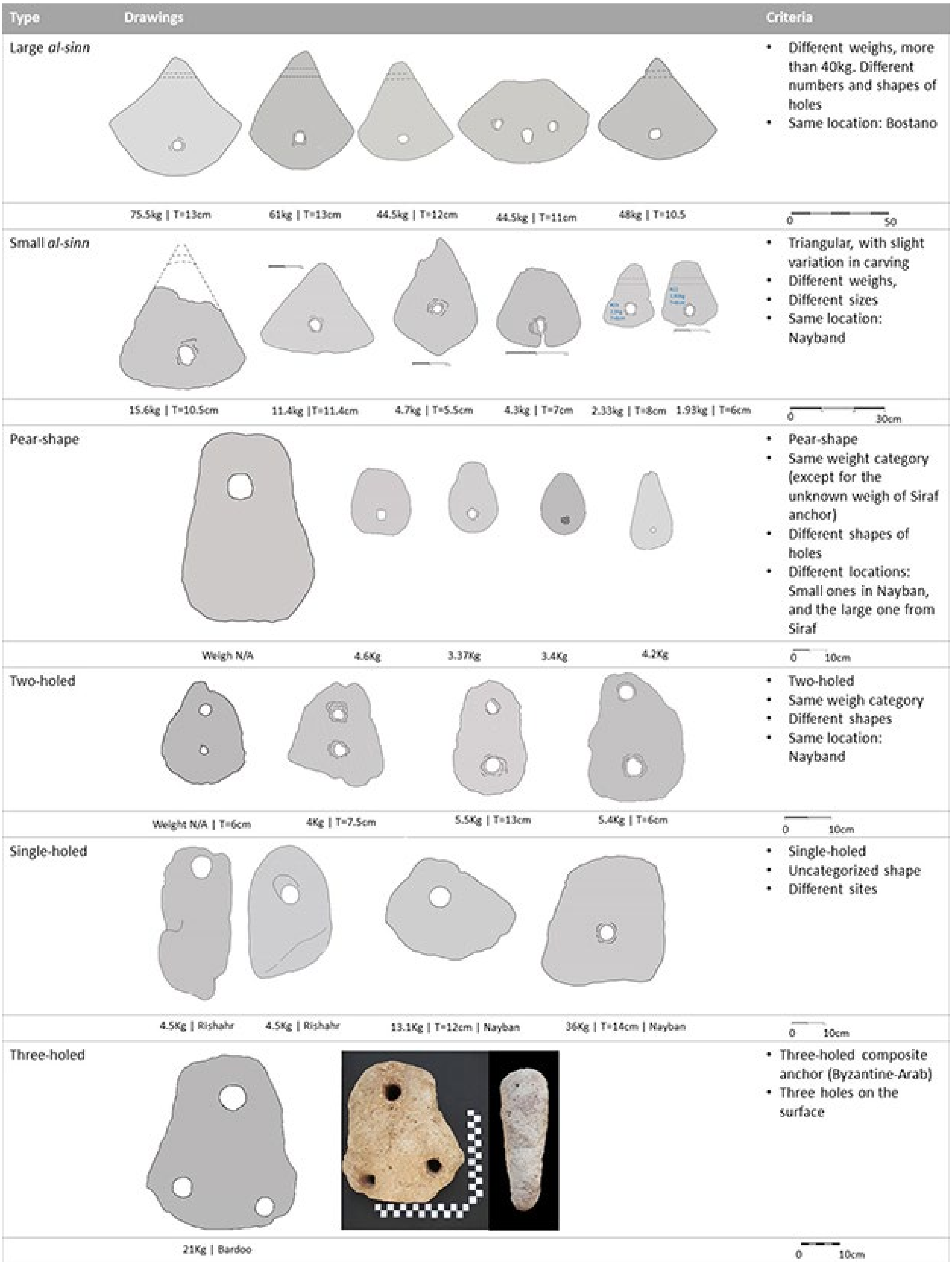

Figure 5. Classification of stone anchors based on weight, size, shape, number of holes and location of finding. Drawings by authors (© Bushehr Museum of Naval Trade).

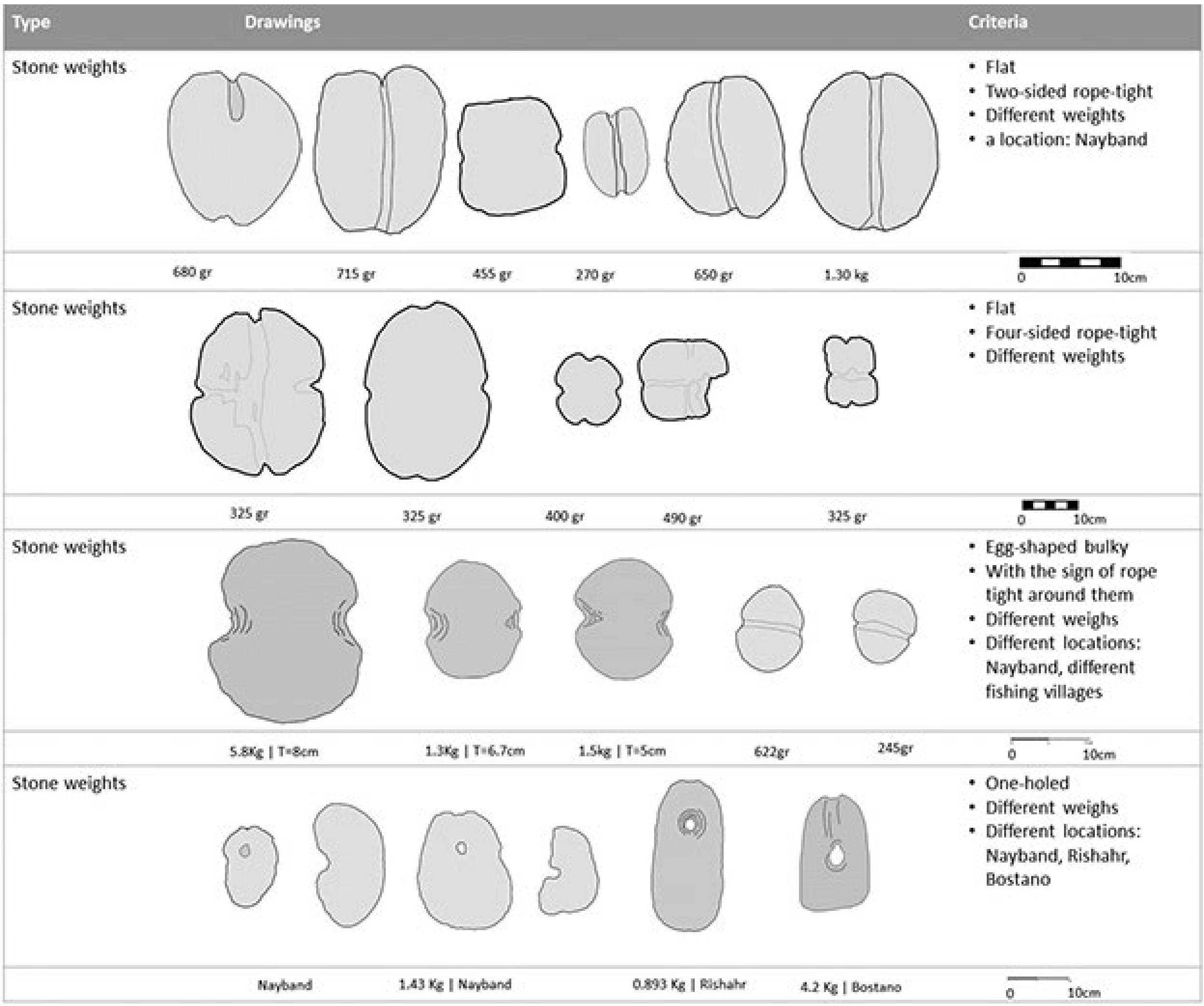

Figure 6. Classification of stone weights based on their shapes, way of wrapping the rope, and existence of holes. Drawings by authors (© Bushehr Museum of Naval Trade).

documented. Based on their shapes, weights, number of holes and find locations, we tried to classify some of them for analysis. Classification was not a simple task, however, because some types are exceptional, while others are similar in some ways but not in others. Our observations and analysis conclude as follows.

Firstly, anchor types and weights from towns and ports appear to be very specific to those areas, and we have not observed many similar types in other ports, villages or towns in our study samples. This indicates that the use of some of these was possibly localised such as for fishing, pearl-hunting or small-scale trade. The concentration of a specific type of stone weight in Bibi-Khatun or Hezar-Mardan may indicate different uses for stone weights. The *al-sinn* type, from Bostano may also indicate a concentration of pearl-hunting in this area. However, more archaeological evidence should be collected to substantiate these hypotheses.

Secondly, unfinished anchors of different types, possibly *al-sinn* and pear-shaped, were documented. This indicates that these types of anchors were made in those locations. This is an important issue when it comes to the production of *al-sinn* anchors, and suggests the Iranian side of the Persian Gulf was engaged in wider maritime activities and seafaring trade with other countries. In addition, the types of stone and rock used for anchor and weight production are similar to local stone from surrounding mountains, such as limestone and granite.

Thirdly, the concentration of many stone anchors and weights in Nayband can shed more light on the importance of this port. Its closeness to Siraf is peculiar in the sense that it raises questions about the function of Siraf as a major port. Nayband has a more protected bay, and a better anchorage area. A hypothesis can be made regarding whether Nayband and Siraf were working together, and whether Nayband was used as an anchorage instead of Siraf for trade and sheltering ships. This question requires further investigation.

Through raising awareness amongst local people about the historical importance of these anchors and weights, with additional site observation, we received many reports of stone anchors and weights. Therefore, the documentation of weights and anchors is an ongoing process. In addition, awareness-raising helped to encourage local NGOs and cultural heritage offices to organise exhibitions and set up local museum exhibits to display these artefacts.

The inventory this study conducted provides opportunities for further research on stone anchors and stone artefacts observed at different historical ports and archaeological sites. This inventory can be used to develop a database for future comparative analysis with such artefacts from other locations around the world. Moreover, our findings, from sites such as Rishahr and Nayband raised new questions about a range of artefacts, their functions, and the location of important ports and anchorage areas.

Future work should include the preservation of the finds and presentation of the results to researchers and the public. More studies underwater, close to the historical ports, may reveal more stone anchors and additional cultural heritage. These studies should be incorporated into the larger body of maritime history studies in Iran. Comparison of anchor/weight typology with their locations can help us to understand seafaring and maritime trade between different ports within as well as outside of the Persian Gulf.

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The Social Context of Boats and Maritime Trade in Late Medieval Norway: Case Studies from Northern and Southern Peripheries

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Abstract

In this paper, boat remains from two widely separated regions of Norway provide a point of departure for exploring the social context of maritime trade in the late medieval period (AD 1350–1550). The wrecks of two 15th-century cargo vessels from adjacent offshore islands near the Arctic Circle, built of southern Norwegian timber, provide insights into the extensive stockfish (dried cod) trade. Diverse small finds illuminate social aspects of communities participating in a flourishing international maritime trade network. Due to urban expansion in Oslo, ongoing mitigation archaeology in the in-filled former harbour at Bjørvika has revealed more than 30 wrecks from the medieval period up until 1624 when the main port was relocated following a massive fire. The Barcode 17 wreck, dated to the mid-14th century, illustrates the role of maritime trade in Oslo, which, despite being a central urban port, was also a European commercial backwater. Although northern Norway may have been on the periphery relative to Oslo, both locations were marginal when viewed from a European economic perspective. The cases presented here demonstrate the potential for going beyond nautical technology to an understanding of the maritime cultural contexts in which watercraft performed.

Keywords

Maritime trade, late medieval wrecks, cargo vessels, northern Norway, Oslo harbour

Introduction

In keeping with the theme of the session 'Boats in context', this paper illustrates the importance of going beyond the description of nautical technology to a more holistic understanding of maritime social contexts in which vessels performed as a central component in a variety of 'scapes' (e.g. seascapes, islandscapes, harbourscapes) essential to an archaeology of the sea. In this case, we will be examining the social context of maritime trade during the late medieval period in Norway (AD 1350–1550). Our presentation is based on case studies of individual wrecks from two geographically and culturally distinct regions of Norway that, despite differences, share common overarching elements of form and function within the sphere of maritime trade. The study locations are also comparable in terms of economic marginality both within Norway, where Bergen was the most important maritime trade centre, and a broader European economic context.

The case studies from northern Norway include two wrecks of clinker-built 15th-century cargo vessels from adjacent offshore islands in the Helgeland region near the Arctic Circle recently discussed by Wickler (2016a). It is argued that both vessels were involved in the stockfish trade with Bergen, the preeminent maritime commercial centre of medieval Norway, and abandoned after becoming unseaworthy. The Husøy wreck is a broad-hulled ship more than 20m long built of pine from West Norway and the Lovund wreck is a large open boat *c.* 12m long built of oak from South Norway. The third case is the Barcode 17 wreck from Bjørvika, the medieval harbour of Oslo that went out of use in the 1600s and has since been extensively in-filled. This is a cargo boat built of Baltic and Scandinavian timber that likely sank at anchor while awaiting cargo or repairs around AD 1400. This vessel was a coastal trader potentially owned and used by Hanseatic merchants from Rostock.

Presentation of the individual wrecks as case studies below enables broader discussion of socio-cultural contexts within the sphere of maritime trade employing a bottom-up approach.

A contextual approach

As archaeological objects, the remains of boats and ships have long been subjected to the perceived need for classification through the establishment of both

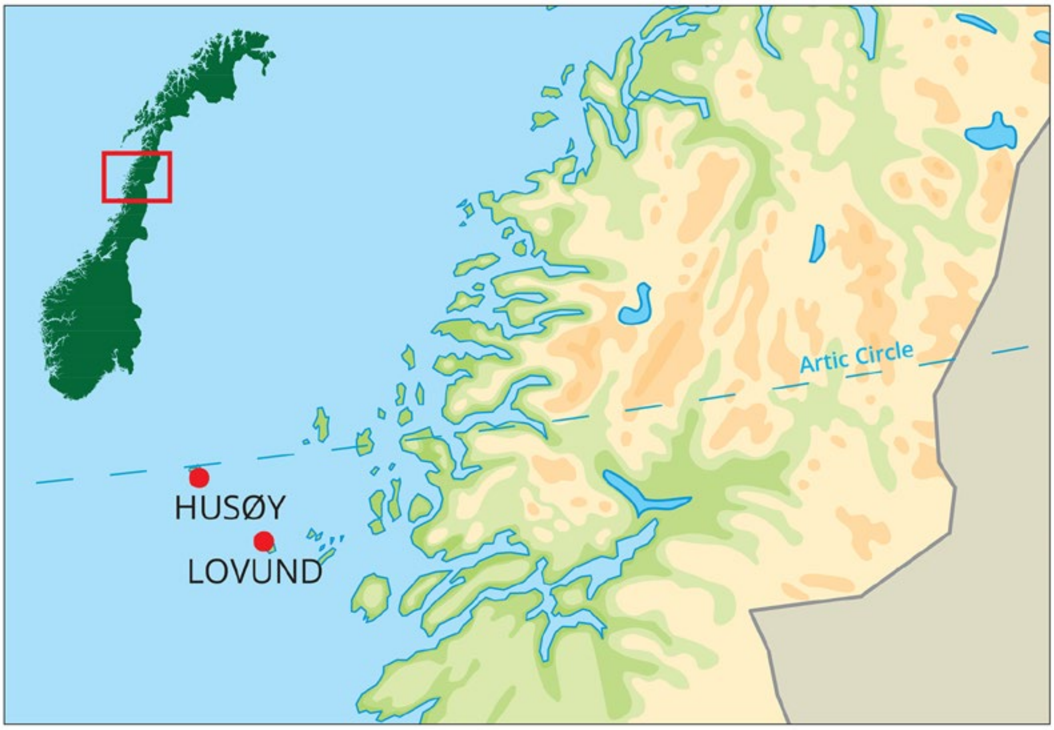

Figure 1. Map showing the northern Norwegian wreck locations mentioned in the text (A. Icagic, Arctic University Museum of Norway).

simple and complex types with spatial and temporal connotations. The problems attendant on this exercise have been pointed out on numerous occasions and vessel studies have amply demonstrated the complexity of entities existing in a state of constant flux. Despite this concern, the typological approach has maintained a central position within nautical and maritime archaeology. Although all vessels have a point of origin that defines their original character, subsequent modifications (repair, rebuilding, refitting, etc.) can substantially alter both form and function. This highlights the necessity of grounding documentation and interpretation of individual cases within specific socio-cultural, economic, functional and environmental contexts.

A significant problem with typology is uncertainty regarding the relevance and applicability of boat types for those who built and used the vessels. This is especially true when attempting to apply the more rigid classification system that characterised 19th-century Norwegian, and Nordic, traditional boats to medieval vessels. By taking a more contextual approach, we are free to explore variability rather than forcing vessels into predefined types. The wreck contexts discussed here exemplify the necessity of accommodating the inherent diversity of late medieval nautical activity. Two of the wrecks are open boats that, despite general similarities in form and function, operated in dramatically different settings with contrasting life histories. Both represented smaller trading vessels that are difficult to classify by 'type'.

The Helgeland wrecks (Træna and Lovund)

The only two known medieval shipwrecks in northern Norway are both located on smaller offshore islands in the northern Helgeland region of southern Nordland County close to the Arctic Circle (Figure 1) (Wickler 2004). The first was reported to Tromsø Museum (henceforth TM) in 1955 by residents on Husøy in Træna, 40km from the mainland, and the second was discovered during mechanised sand excavation in 1976 on Lovund, located 28km from the mainland and *c.* 17km to the south-east of Husøy. There are similarities between the two wrecks in terms of identity, function and cultural context. Both are interpreted as cargo vessels involved in maritime trade during the 15th century that focused on the transport of dried cod (stockfish) from northern Norway to the urban port of Bergen.

Træna wreck

A partially exposed intertidal wreck in a shallow inlet on the small island of Husøy (Figure 2) was reported to TM in 1955. The wreck was partially excavated by archaeologists from TM and the Norwegian Maritime

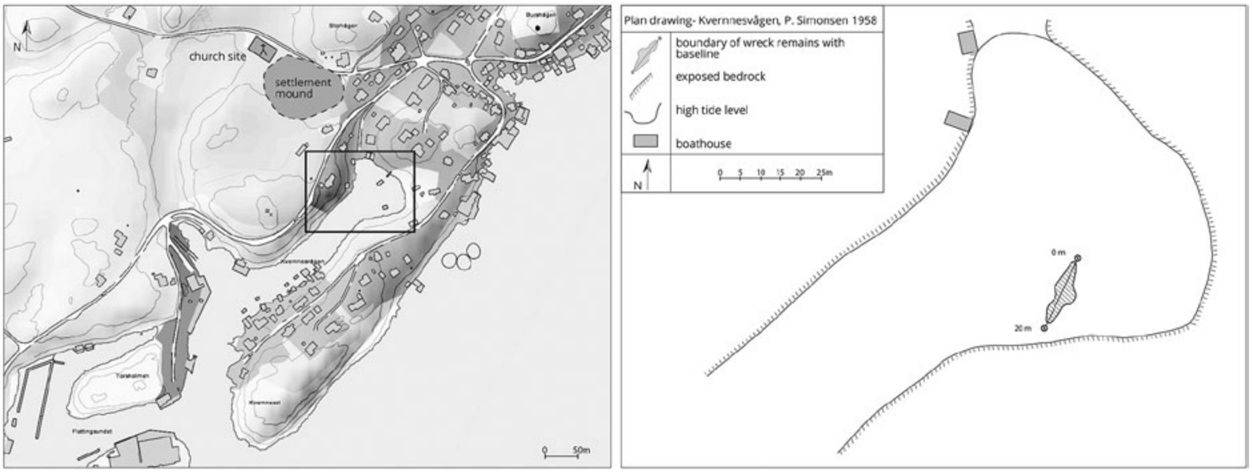

Figure 2. Overview map and plan of the Husøy wreck location.

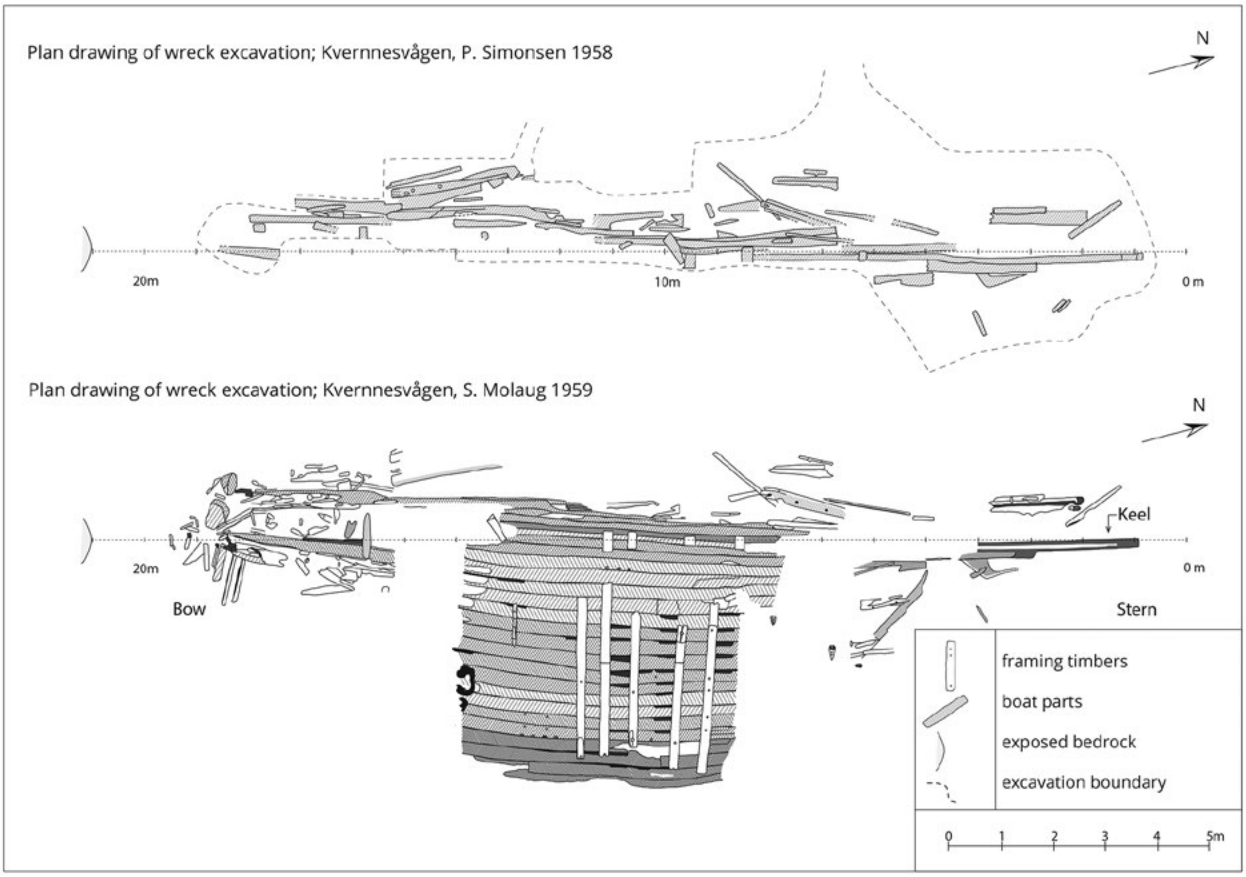

Figure 3. Plan drawings of the Husøy wreck, redrawn from P. Simonsen's field notes and Molaug 1960: 12–13 (A. Icagic, Arctic University Museum of Norway).

Museum (NMM) in 1958 and 1959, representing the earliest wreck excavation in Norway (Molaug 1960; Simonsen 1960). Sections of the keel and the portside amidships section were exposed (Figure 3). The wreck was a broad-hulled clinker-built cargo ship constructed of pine originally and more than 20m in length with a stern rudder and an estimated beam of *c.* 7–8m.

Small finds and animal bone refuse were concentrated in the bottom of the hull. In addition to rigging, ship-related items and clothing, less common objects included bone flutes, gaming pieces of walrus ivory, a carved wooden figure, and objects of whalebone and soapstone. Most finds likely represent personal belongings of the crew overlooked or discarded when the vessel was abandoned. The wreck remains were removed by dredging in 1984 except for a salvaged frame timber shown by dendrochronological analysis to have originated from a pine in West Norway felled *c.* AD 1400 (Kirchhefer 2013).

Both the identity and life history of the Husøy ship remain uncertain. However, the importance of Træna as a source of dried cod suggests involvement in the stockfish trade with Bergen. It is also plausible to suggest that the ship was purchased in West Norway by Træna fishermen in exchange for stockfish. When the vessel was no longer seaworthy, as indicated by attempts to patch leaks in the hull with pitch/tar, it was abandoned in the intertidal zone. The wreck's location was a natural harbour for the island's medieval population centre where a 15th-century farm mound and church site have been documented.

Lovund wreck

The Lovund wreck is located in what was formerly a narrow sound between the mainland and an islet along the north-eastern shoreline of Lovund Island (Figure 4). A mechanical excavator significantly damaged the wreck in 1976. Subsequent inspection by TM (Simonsen 1976) determined that the vessel was a clinker-built oak vessel that lay upright and perpendicular to the shoreline beneath a 50–70cm layer of fine sand. A radiocarbon date from a wreck timber in 1977 produced an age range of cal AD 1398–1530 at two sigma. Dendrochronological analysis of two oak planks (Bonde 2012) confirmed that the vessel was built after 1441 but incomplete outer sapwood hindered a more precise age determination. The oak was sourced to Agder in the Sørland region of southern Norway.

Lovund wreck excavation in 2016

There has been considerable local interest in excavating and exhibiting the Lovund wreck since its discovery. A consortium of Lovund businesses first contacted TM in 1995 regarding wreck excavation and intermittent contact occurred in the following years. Contact was renewed in 2015 from a local interest group organised to support the excavation and exhibition of the Lovund wreck. At this point TM and the NMM decided to collaborate in conducting a preliminary study of the wreck financed by the interest group.

Over a three-day period in April-May 2016, the wreck was documented by maritime archaeologists from the NMM and TM (Falck *et al.* 2016). A recently constructed sea barrier wall enabled the wreck locality to be drained and kept dry with pumps during excavation. The sand layer overlying the wreck was removed mechanically and the main boat timbers exposed by hand excavation to record the extent and construction details of the vessel. Documentation with close range digital photogrammetry (Agisoft Photoscan) enabled 3D model generation and a reliable estimate of timber volume (Figure 4). The vessel was originally 11–12m in length with 12 strakes and a set of *c.* 20 frames (Figure 5). It was an open cargo boat with a probable curved stem and straight stern, sternpost rudder, and plank sheer on the sheer strake interior. No evidence of a keelson, mast-step or mast was observed. The planking joints were caulked with a combination of woollen textile strips and twisted animal hair soaked in tar. The presence of pitch mixed with animal hair pressed into the planking joints and a tarry layer spread over the interior of the lower strakes is suggestive of maintenance necessary to prevent leakage in an older vessel. This lends support to a scenario in which the boat was abandoned, further strengthened by the absence of cargo and concentration of large angular rocks (not ballast stones) in the hull suggesting that the vessel was scuttled.

Small finds recovered from the sand layer within the hull included leather footwear, treenails and a hand whetstone. Additional *in situ* finds were recorded directly above the lower strakes and keel, including a stationary rectangular 50 x 10cm whetstone 1.3m from the stern end of the keel. The whetstone was resting on two different types of front-lace leather shoes above a concentration of wood shavings, charcoal and small fish bones. A piece of parchment was also recovered (K. Gebremarian: pers. comm.).

Although the boat is not complete, with some parts damaged and others in poor condition, it will still be possible to conserve, reconstruct and exhibit the find. The Lovund interest group has guaranteed financing of a complete wreck excavation in 2017 and 1:1 scale digital 3D documentation of the individual timbers as the basis for the construction of a scale model followed by conservation and reconstruction for exhibition.

Bjørvika, Oslo harbour

The two wreck locations described above stand out as examples of rural harbourscapes in a late medieval context. In contrast, Oslo was an urban harbour and economic centre with added importance as the seat of royal and ecclesiastical control (Nedkvitne and Norseng 2000). This urban harbour setting appears far removed from the remote Helgeland coast considered economically and environmentally distant from both the south-eastern coast of Norway and continental Europe. At the same time, the maritime link between Bergen and northern Norway through the stockfish trade, calls into question the notion of remoteness and marginality. Oslo must also be considered a remote European harbour, and is, compared to the importance

Figure 4. Location map and 2016 plan drawing of the Lovund wreck
(S. Ahrens, Norwegian Maritime Museum).

and size of Bergen, a minor town throughout the medieval period. Still, Oslo is undoubtedly urban in character. In this paper, it is also Oslo's urban harbourscape qualities that will aid us in comparing and discussing the two contexts. What stories can these shipwrecks tell, and what behavioural and social inferences can be extrapolated from the material shipwreck evidence?

The medieval and post-medieval harbour of Oslo has undergone numerous phases of modification during the last century, but with the extensive redesign of the industrial harbour since 2000, large parts of the material remains of the old harbour have been removed. The Barcode project that revealed thirteen shipwrecks (Gundersen 2012; Vangstad 2012) mainly covers the post-medieval harbour but the eastern part

Figure 5. View facing north of the Lovund wreck following excavation in 2016 (S. Wickler).

of this project also includes structures and cultural layers from medieval Oslo. This is where the Barcode 17 wreck was found (Figure 6), and what makes it a useful link to understanding harbour development during the transition between the medieval and early modern period.

The waterfront at around AD 1300 consisted of timber caissons for storehouses (*sjøbod*) and wharves (Molaug 2015: 350). Despite substantial economic and demographic setbacks following the mid-century plague pandemic, the harbour layout remained essentially the same in the late 1300s. Many boats must have been moored at these wharfs, or anchored nearby, at least during the summer season. Molaug (2015) estimates that the AD 1300 shoreline with warehouses covered a distance of 400m. The economic foundation for late medieval Oslo lies in its hinterland and a favourable location in inner Oslo fjord (Iversen 2015). International trade was partially governed by Hanseatic merchants, many of whom had direct links to Baltic towns such as Rostock. The trade still represented cargo that could be transported in smaller coastal traders, and the significant shift towards timber as the major commodity for international trade did not occur until the late 1300s to early 1400s.

Barcode 17 wreck

It was during the excavations conducted by the Norwegian Institute for Cultural Heritage Research (NIKU) in 2013, that the remains of a boat were discovered (Figure 6). The Museum of Cultural History, University of Oslo (Bill and Engen in prep.) conducted the excavation, while the post-excavation documentation of the ship timbers was undertaken by the NMM (Rodum in prep.). The reports are still preliminary. Despite the incomplete status of reconstruction, the main measurements and construction features are known, making it possible to compare this wreck with the two vessels from northern Norway.

The Barcode 17 is a lapstrake vessel that can be classified as a large open boat. The dendrochronological dating points towards construction shortly after 1350 (Daly 2016), and the suggested depositional date is around 1400 (Bill and Engen in prep.). It was built using an eclectic combination of oak (Baltic) and pine (Scandinavian). The reconstructed hull dimensions indicate a length of 12m and width of 4–4.5m (Rodum in prep). It is constructed on a ‘log shaped’ keel with a curved stem and a raked sternpost with rabbets for the strakes. The hull has 12 strakes on each side, but the gunwale is only preserved as a fragment on the starboard side. The boat has twenty frames, all made from pine, and the distance between the frames varies from 35-55cm. The planks are mainly held together by clinker nails with square roves. A well-preserved 429cm-long keelson made of oak, reveals that the mast was placed slightly fore of amidships. The boat was waterproofed using plant fibres, animal hair, tar and textiles. There is considerable evidence of wear and tear with extensive repairs undertaken to keep the boat afloat.

A comparative wreck assessment

Although displaying general similarities in terms of their function as cargo vessels and relative age, the three wrecks exhibit a significant degree of variability and distinctiveness that points to differences in use and life histories within a broader Norwegian and European maritime trade context. The lack of direct parallels in the existing corpus of Norwegian medieval wreck evidence increases the difficulty of characterising the vessels but also presents an opportunity to enhance our knowledge of trading vessels from the period.

The three wrecks were cargo vessels but none contained cargo or ballast. The removal of cargo and other inventory prior to sinking strongly suggests that

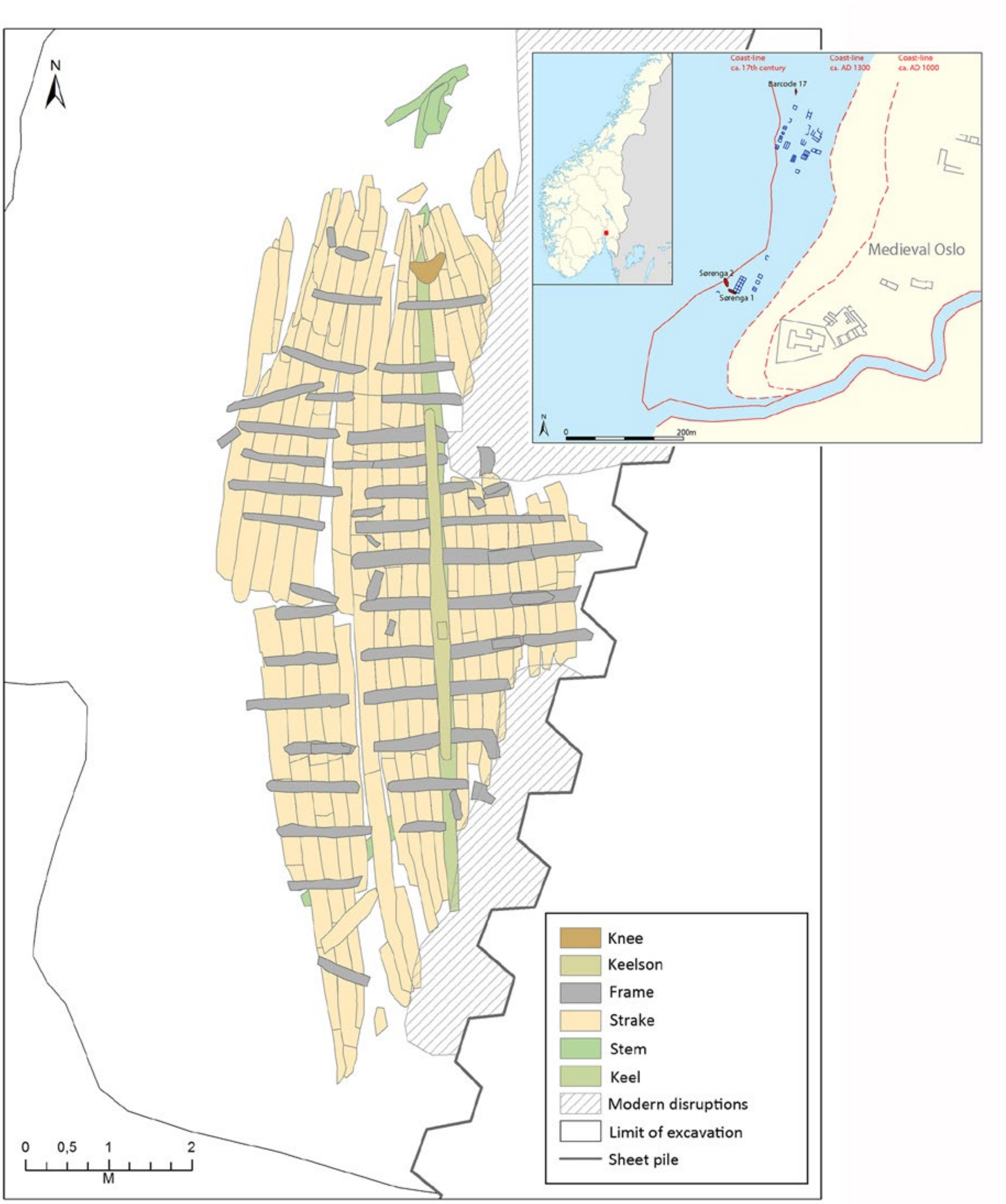

Figure 6. Location map and plan of the Barcode 17 wreck in Bjørvika, Oslo harbour, showing contemporary timber caissons and changing waterfront.
(Plan drawing Museum of Cultural history, University of Oslo, map inset: S. Ahrens, Norwegian Maritime Museum).

the vessels were abandoned rather than being wrecked. Evidence for maintenance activity with the application of tar to the planking joints and strakes on the Helgeland wrecks further indicates that the vessels were showing signs of age and reduced seaworthiness. The wrecks are open, clinker-built wooden vessels with sails associated with the 'Nordic' boat-building tradition, although the Barcode wreck was partly built of Baltic timber while the Helgeland vessels from Træna and Lovund were built of pine from West Norway and oak from South Norway, respectively.

Contrasts between the three wrecks are most evident with regard to overall size, dimensions, and the type and source of timber utilised. Although built from timbers originating from, and most likely constructed in, the southern part of Norway, the use of oak timbers in the Lovund boat provide a different set of construction parameters than the pine timbers of the Husøy ship. However, it should be added that the analysis of the Lovund boat is still at an early stage. Construction with Baltic timber (oak) combined with Scandinavian pine also distinguishes the Barcode 17 vessel from the others.

The Lovund boat is significantly smaller than the Husøy ship with an estimated length of 11–12m and only twelve strakes in comparison with a length in excess of 20m and at least nineteen strakes in the Husøy ship. The Lovund vessel also has less massive construction features such as frame dimensions of *c.* 15cm compared with frames having sided dimensions up to 22cm from the Husøy ship and average plank widths of 25.5cm vs. 29cm. Although both vessels had stern rudders, the Husøy ship had an angled scarf at the stern end of the keel for a sternpost while the Lovund boat has a *c.* 12cm-long rectangular mortise-and-tenon joint hole in the stern end of the keel. Both vessels were undoubtedly sailed although direct evidence is lacking.

The stockfish trade and the Helgeland wrecks

The account of Venetian merchant Pietro Quirini from 1432 (Wold 1991), a unique first-hand record of medieval life in coastal northern Norway, provides insights of relevance to the Træna and Lovund finds. Quirini was shipwrecked on Røst in the Lofoten archipelago and later taken to Bergen in a ship loaded with stockfish. This is the first record of direct transport stockfish to Bergen by a local maritime community representing an organizational model, known as *bygdefar* in Norwegian, which continued to characterize the stockfish trade into the 19th century.

The late medieval period from *c.* 1350 through to the end of the 15th century was the golden age of the stockfish trade with the price for stockfish reaching a peak in the mid-1400s when fishermen received three times as much flour for their fish as during the century prior to the plague (Nedkvitne 2016: 53). The price of stockfish dropped appreciably in the 16th century and never approached the same level in the following centuries. Both of the Helgeland wrecks are from this golden age in which local fishermen were able to achieve a degree of affluence that would have made possible the purchase of cargo vessels from the south in exchange for stockfish.

Hanseatic trade and the Barcode 17 wreck

The Barcode 17 wreck was found just to the north of where the Bishop's Commons (*Bispeallmenningen*) met the waterfront (Bill and Engen in prep.), and south-east of the river Hovin. While many of the shipwrecks in Oslo are found in direct relation to wharfs (timber caissons) (Gundersen 2012: 76), and even some partly underneath them, there is no evidence for this in the case of the Barcode 17. An anchor found in the immediate vicinity of the boat is interpreted as having been used to moor the vessel a short distance from the waterfront. The boat may have been drawn away from the wharves, in anticipation of loading, repair or for other reasons. We know that the amount of time that a ship could be moored at the wharves in Oslo was first regulated in the 13th century (Magnus Lagabøtes Bylov 1923: 35). The anchor has a mark carved into it, suggesting ownership of the anchor and/or the boat to which it was attached. Furthermore, the Barcode 17 has extensive evidence of wear and tear with cracks repaired by strips and cramps and cask staves with textiles covering other severe cracks. We also believe that the boat had at least two building phases (Rodum in prep.).

The physical remains shed light on the life history of the boat, including its crew and the merchants who benefited or suffered losses from the trade in which it was involved. During the 14th and 15th centuries, trade over longer distances was organised from the large Hansa towns. The known historical dominance of Hanseatic merchants from Rostock in late medieval Oslo, combined with the fact that the oak timber in the Barcode 17 was originally cut in the southern Baltic, supports the contention that the Barcode 17 was used in this traffic, and was owned by the Hansa. Although much of the trade connecting Oslo to the international market was conducted by Hanseatic merchants, Oslo was not considered a proper Hansa town, such as Bergen. This has mainly to do with the rights the merchants had in the town when they traded. On the other hand, the Hansa merchants in Oslo were more socially integrated than in Bergen although those in Bergen had greater commercial and political power (Bull 1922).

The ships that sailed between Rostock and Oslo were mainly small coastal traders and in written sources, the somewhat generic name *skute* is cited (Nedkvitne and Norseng 2000: 358). In sources from 1367–68, sizes between 12-20 *lester* are mentioned, but Mortenssøn (1995: 105) also refers to sizes as low as 1.5 *lester*. By comparison, the Hanseatic trade in Bergen during the late medieval period utilised ships of about 40 *lester*. In Christlieb (1934), cited in Nedkvitne and Norseng (2000: 451), a medieval *lest* equals one register ton or 2.83m^3. A *skute* of 12 *lester* could then be said to have a capacity of 34m^3. The term *skute* fits well for the size and features of the Barcode 17 (and the Lovund boat), and there are other finds from medieval Oslo of similar size (Molaug 2012: 224). It also fits the descriptions presented by Mortenssøn (1995: 104) (concerning the Renaissance), where he confirms that *skuter* were common in Sweden, Denmark and South Norway, and that the lively Baltic maritime traffic was conducted mainly by *skuter* with one mast and a square sail. Other features common to the *skute* include a proper keel, a straight stern and a curved stem. This short discussion on types and sizes illustrates that much (overseas) trade was done on small coastal traders that are less visible in written sources than large ships. As shown by the Barcode 17, studying the physical remains of this trade reveals considerable variability, even between boats of similar size and function.

The distance between Warnemünde (the shipping port of Rostock) and Oslo is 366nm (measured using Google Maps). By comparison, the sailing distance between Bergen and Lovund is about 457nm, and in a more demanding rough sea. Sources from 1599 report that a ship from Rostock took on average eighteen days from Rostock to Oslo (Nedkvitne and Norseng 2000: 359). With good wind, the trip could be reduced to only 6–7 days. Nearly the entire voyage was made in relatively sheltered waters, quite the opposite of the situation sailors between Bergen and northern Norway experienced, although a lack of wind would often delay travel. The crew only lost sight of land during the first stretch from Warnemünde to Falster (Nedkvitne and Norseng 2000).

In the season when the Oslo fjord was free of ice, mainly from March to November (Nedkvitne and Norseng 2000: 358), attractive goods like flour, beer, malt and hops would be shipped northward. Luxury items such as fine textiles from other parts of Europe came on the same vessels. The captain and his crew would be met at the wharves in Oslo by the (Hansa) merchants to pick up the cargo from their commissioners in Rostock. The cargo was marked with an owner's mark comparable to the one on the anchor found next to the Barcode 17. The items and barrels would then be cleared through customs and eventually sold (engross). The transactions were heavily regulated, concerning who they could sell to, and how much time they were allowed to remain in the harbour (Bull 1922: 129).

We have sufficient evidence to create a picture of practical aspects of travel between the Baltic and Oslo in the late medieval period. From a social perspective, the role of the captain and crew is of considerable interest but difficult to examine from available sources. How many trips across the Baltic did a single boat make each year? Did it stay in Oslo to engage in other assignments? Who owned the vessel; the commissioner, the merchant in Oslo, or the captain? How did the crew interact with the residents of Oslo? We know that the captain received payment for the transport, including a bonus for bringing the cargo safely to the market (Nedkvitne and Norseng 2000: 359). The captain also had to pay a designated ship tax, perhaps indicating that he himself had official responsibilities with regard to the ship and itinerary, in addition to ensuring safe passage from port to port.

From wrecks to people: exploring the social context of maritime trade

As discussed, the identity, function and social context of the 15th-century vessels that came to rest on the offshore islands of Træna and Lovund are likely to have been directly linked to maritime trade between northern and southern Norway. The wrecks provide us with valuable insights into the stockfish trade from the perspective of source communities rather than the Hanseatic and Norwegian merchants in Bergen who received the goods for further distribution or the European consumers of the commodity.

Apart from the account by Quirini from Røst, this perspective is poorly documented in historical documents from the late medieval period. The abundant small finds from the Husøy wreck, while neither extravagant nor costly, reveal a sophisticated inventory of personal possessions potentially owned by crew members from the local community. While not as numerous, the objects recovered from the Lovund wreck are similar in terms of function and source. The collective finds also illustrate the broad range of contacts to which ordinary members of islander society were exposed through maritime trade. These individuals were members of outward-looking, dynamic maritime communities actively linked to impulses and influences from the burgeoning urban centres of Europe. Thus, small islands in northern Norway commonly perceived as 'marginal' locations today were neither isolated nor detached from society but functioned as essential nodes in networks of maritime interaction at the intraregional, interregional, and transnational level (Wickler 2016b). The maritime communities of northern Norway also possessed a highly developed nautical technology coupled with seamanship skills developed since the Early Iron Age where the sea was viewed as a highway rather than a barrier.

Despite a reduction of *c.* 63% in the overall population of Norway following the plague pandemic, the latter part of the 14th century and most of the 15th century witnessed considerable growth in the coastal economy of northern Norway driven by favourable prices for stockfish and reduced competition for resources between fewer people (Nedkvitne 2016; Nielssen 2014: 309–10). This fuelled increased production of dried cod and infrastructural investment related to the stockfish trade including cargo ships suitable for long-distance open-sea voyages. The Helgeland wrecks provide archaeological evidence supporting historical documentation for direct trade with Bergen, and other potential maritime commercial centres in the south, during the 15th century. Although difficult to confirm, the possibility that both vessels may have been obtained in Bergen in conjunction with the sale of stockfish illustrates the extensive nature of maritime trade during the late medieval period. Although Oslo is better documented in historical sources, the study of vessel remains from both northern and southern Norway reveals new aspects of maritime trade that includes information on social contexts and the lives of those involved.

Concluding thoughts

In this paper, we have taken an explicitly contextual approach to maritime trade in late medieval Norway by evaluating and comparing three wreck case studies from widely separated northern and southern peripheries. Although two wrecks are situated on remote offshore islands near the Arctic Circle and the third is from the urban port of Oslo, each was situated on the medieval Norwegian and European periphery. Despite sharing general similarities in form and function, the vessels from north and south operated in dramatically different economical settings and seascapes and each had a unique life history that remains only partially understood.

Even though the evidence gleaned from the physical remains is fragmentary, it has been possible to reconstruct key contextual aspects of the vessels relating to form, function, and socio-economic variables. Each vessel provides insights into the nature of Norwegian maritime trade during the late medieval period in which the Hansa merchants had a central role. In the case of the Helgeland wrecks, this represents the stockfish trade as viewed from the perspective of coastal fisher communities. The Barcode 17 boat provides tantalizing clues from the Hanseatic trade between Rostock and Oslo and its importance for the port of Oslo prior to the shift from smaller cargo to bulk cargo in the 16th century.

By turning our attention from defining vessels as predetermined types to exploring variability within broader categories, it has been possible to gain additional insights into the nature of trade during the transition from the late medieval to early modern period. However, there remain numerous unanswered questions that await additional clarification. What factors contributed to abandonment of the vessels apart from diminished seaworthiness? Who were the owners and users of the vessels throughout their life histories? How accurately do the vessels reflect late medieval trade along the Norwegian coast?

Acknowledgements

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Logboat Ižanska I (SI-81) from Ljubljana: New Evidence of Iron Age Transportation on the Ljubljana Marshes, Slovenia

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Abstract

During archaeological excavations undertaken prior to a building project, an archaeologist unexpectedly came across some timbers. On closer inspection, these were found to be the bottom of an upturned logboat. Radiometric dating showed that it dated to the 8th century BC. Judging from the excavated section, the logboat was 90cm wide with an estimated length of 10–12m.

The Ljubljana Marshes, with 76 attested logboats, is the most important historical location in the region. Evidence of 18 dated logboats indicates that this form of transport has been in continuous use from the Neolithic to the modern age. We have two Iron Age logboats from the Ljubljana Marshes: one from Matena, currently on display in the National Museum, and another from Zakotek. A few are older: one from the Bronze Age and three from Neolithic times.

In the 8th century BC, an era marked by the use of iron began. At the transition from the Bronze to the Iron Age, Slovenia witnessed a change in its settlement pattern, evident from the abandonment of old settlements and the springing up of new ones on higher ground. They were surrounded by extensive barrow cemeteries and iron-working areas. Near those defended upland settlements were many smaller protected settlements and lowland settlements.

Some of the settlements near the excavated area are situated to the north: one on Castle Hill and another directly under the steep slope of the hill at the Tribuna site. The others are situated to the east on the Gradišče na Rudniku site and the better-known hill-fort of Molnik above Orle and are surrounded by burial grounds.

Keywords

Logboat, Ljubljana Marshes, radiocarbon dating, Iron Age, Slovenia

Introduction and background

Data on vessels in the Ljubljana Marshes has been collected for nearly two centuries. As a result of detailed documentation and dating, many of these finds reveal patterns that can be used to understand changes in the environment and human adaptations. If we observe the type of wood used, documented for 30 vessels, it appears to be dominated by oak (*Quercus* sp.) in 18 cases and spruce (*Picea Abies* sp.) in 11 cases. The use of beech (*Fagus silvatica*) for the logboat from Božje polje (SI-77) is unusual. Although only 18 of the *c.* 80 recorded vessels on the Ljubljana Marshes have been dated, it is evident that all logboats older than 2000 years are carved from oak, but more recent logboats are mostly spruce (Table 1).

Palaeo-environmental research in the Ljubljana Marshes has shown that these two species were readily available locally over recent millennia. The change from using oak up until the Roman Age to pine in later periods must have been due to a conscious selection made by the logboat makers. However, it is not entirely clear if the change of preferred wood is associated with technological innovations that arrived with the Romans, since the techniques of carving logboats and their dimensions remained similar.

Radiocarbon and dendrochronological dating conducted on the Ljubljana Marshes in the past showed that logboats originate from different periods ranging from the Neolithic to modern times. Carving and building tradition and strategy did not change significantly in this environment, judging from data which spans almost 6000 years. Here is the reason why the Ljubljana Marshes are so important for understanding the past. The preserved remains show that technological tradition in terms of evolutionary technical development hardly changed at all. We are faced with a good example of discontinuous balances. Introduced technology, probably present since the Mesolithic period, enabled the intensive use of the

Table 1. List of dated logboats from the Ljubljana Marshes. Logboats No. 1 and 2, Stare Gmajne II and Stare Gmajne III were dated using dendrochronology by Katarina Čufar from Chair of Wood Science of Department of Wood Science and Technology, University of Ljubljana (Velušček *et al.* 2009). All other references of finds and dates are listed in the article by Miran Erič (2009).

No.	Logboat	Year	ID	Conventional age	Calibrated age 1σ	Species	Length (cm)	Width (cm)
1	Stare gmajne II	2002	SI-75		3211±12 BC (D)	Quercus sp	120+	90
2	Stare gmajne III	2002	SI-76		3134±12 BC (D)	Quercus sp	300+	90
3	Veliki mah	1996	SI-08	4210±40 BP	2808 - 2756 BC	Quercus sp	100+	50+
4	Za strugo	1989	SI-09	3190±130 BP	1622 - 1369 BC	Quercus sp	800+	100
5	Matena	1927	SI-03	2700±35 BP	855 - 813 BC	Quercus sp	930	87
6	Ižanska I	2016	SI-81	2500±30 BP	768 - 739 BC	Quercus sp	700+	90
7	Zakotek	1990	SI-07	2350±130 BP	564 - 354 BC	Quercus sp	900+	100+
8	Jelovšek	1892	SI-02	2125±30 BP	200 - 106 BC	Quercus sp	1200	100
9	Krtine II	1996	SI-05	2050±40 BP	111 BC - 2 AD	Quercus sp	630	70
10	Vrhnika I	2001	SI-60	1995±55 BP	51 BC - 70 AD	Quercus sp	1500+	130+
		2008	SI-60	1930±40 BP	48 - 125 AD			
11	Žitnik	1978	SI-06	1940±80 BP	46 BC - 140 AD	Quercus sp	1240	90
12	Krtine I	1992	SI-04	1800±35 BP	139 - 198 AD	Picea abies sp	540	70
13	Pri Juriju II	2001	SI-58	820±80 BP	1154 - 1277 AD	Quercus sp	237+	59
14	Kamin II	2001	SI-66	710±40 BP	1262 - 1299 AD	Picea abies sp	465+	45
15	Šivčev graben I	2002	SI-59	380±80 BP	1446 - 1524 AD	Picea abies sp	174+	61
16	Podpeč I	1999	SI-18	290±80 BP	1485 - 1666 AD	Picea abies sp	760+	82

complex accessible environment and remained efficient and unchanged until a new era changed the method of exploitation (Erič and Kavur 2012). In the early 19th century, trade and farming completely changed and the logboat slowly disappeared from the set of tools necessary for agriculture, transport, commerce and life in the marshes. But the spatial distribution of the vessels is also interesting.

All the medieval and early modern logboats were discovered in the Ljubljanica River itself, but older vessels are dispersed over the whole of the Ljubljana Marshes with several earlier vessels in its western part. A third of all logboats were found in the northern part of the Ljubljanica River in the area between the Podlipščica stream to the west and Drobtinka stream to the east side (Figure 1: a). The other high concentration of ten known logboats is in the wider area of Zakotek between Goričica and Kamnik under Krim (Figure 1: b). The third area consists of the marshes at the northern edge of the Ig alluvial fan with 16 (Figure 1: c). In the area of the village of Črna vas, from about a mile south of the Ljubljanica River from Kosler's farm and continuing almost to the banks of the hill of Debeli hrib on the east, there also exists a narrow zone of 12 identified vessels (Figure 1: d). All of the above logboats were discovered at altitudes between 285m and 290m asl. Their distribution is most likely related to the probable extent of the water surface at the time of the abandonment or sinking of each logboat. The increased number of finds is probably due to this area remaining an axis of communication at a time when a lake or floodwater was drying up, or streambeds of former watercourses surviving here (Erič, Gaspari and Kavur 2012).

Fieldwork

Prior to the housing construction, the Institute for the Protection of Cultural Heritage of Slovenia (IPCH) ordered that a preliminary protected archaeological investigation should take place. This was undertaken by the mechanical excavation of three test trenches of 3 x 1.5m to determine the depth and nature of any archaeological stratigraphy. The research area was located within the heritage area Ljubljana—pile dwellings Ilovica. An ArheoVed company conducted archaeological research on 24 July 2015, with guidance from Pavla Peterle Udovič (Figure 2) and professional supervision carried out by Mija Topličanec from IPCH. The weather conditions were stable, mostly cloudy with summer humidity and temperatures between 25ºC and 31ºC and this affected the speed and working conditions during the execution of works. Due to the discovery of a logboat in one of the test trenches, it was decided to increase the number and size of the

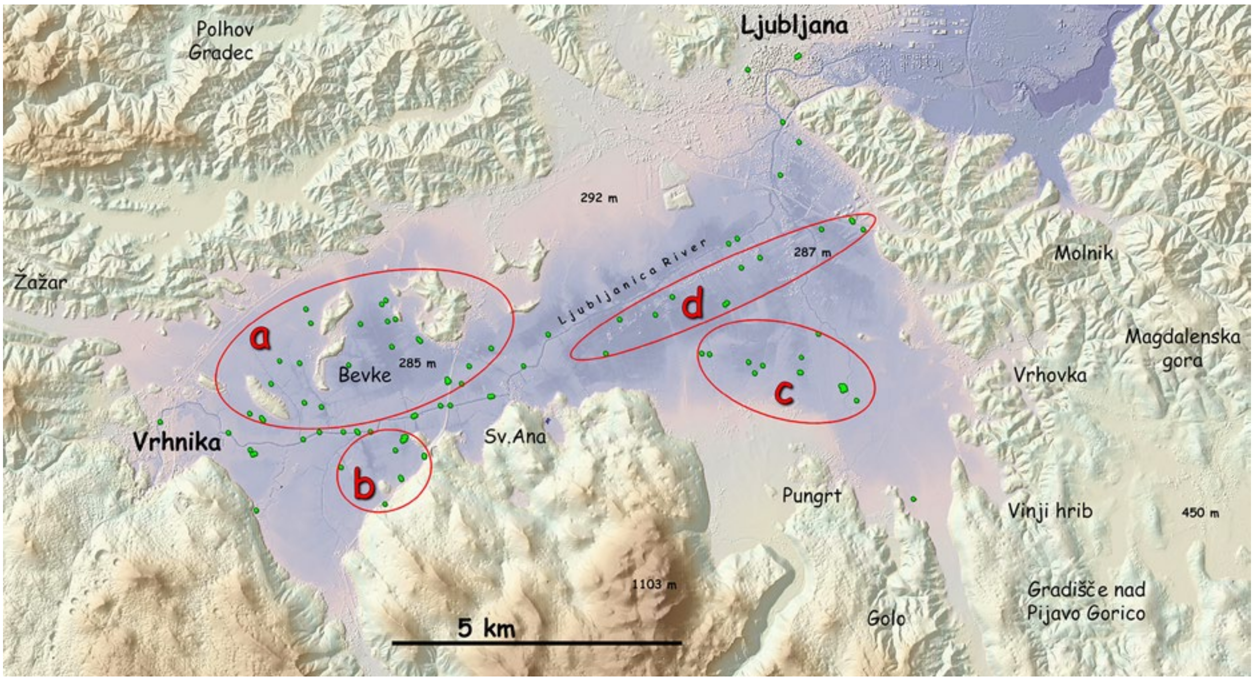


Figure 1. Medieval and early modern logboats discovered in the Ljubljanica River, including older vessels dispersed across the Marshes.

trenches in agreement with the supervisor. The aim of these changes was to determine the approximate length of the logboat. When the four test trenches were excavated, a single, straightforward stratigraphy of this area was identified.

The first trench had a size of 1.80m x 1.20m and was 1.13m deep. Three strata were documented. The geological base represents lake deposits, half of grey to olive-grey and half of light olive-grey sandy silt with crushed snails (lake deposit). Above it is a very dark grey layer of silt and coarse sand with a large amount of organic material, which could be a layer of alluvium or deposited by the Ljubljanica River. The upper stratum consists of a very dark grey sandy silt mixed with coarse sand, rubble, gravel and stones. It also contains fragments of modern pottery and pieces of modern bricks. This layer represents the former material of a ploughed field that during investigation was overgrown with grass turf.

The second trench was 2.90m x 2.70m in size with a depth of one metre. At a depth of 0.85m from the surface of today's sterile lake, a deposit base was identified. Above it lay an alluvial layer of black clay silt with organic material (leaves, branches, grass) and crushed snails. The logboat was deposited partly in this layer and was later covered by the alluvial layer of black silt with coarse sand and organic material. Above it is arable land, overgrown with grass turf. In the upper layers, fragments of modern ceramics—porcelain plates and pieces of modern bricks—were identified. The logboat was located at a depth of between 0.40m and 0.45m, and oriented in the direction north-east and south-west; 0.90m wide and 0.29m high, it was carved from oak.[1] The top of the boat-side is about 1.1cm thick. In contrast to the all other logboat finds from the Ljubljana Marshes, the Ižanska I logboat was deposited upside down. Since the surface of the logboat was quite rotted and abraded, traces of the carving tool on the surface had not been preserved. Due to this unexpected find, we decided to continue with the excavation of two more trenches. They were placed 2.80m north-east and 2.30m south-west of the excavated area. The purpose of these examinations was to detect the stern and bow of the logboat and determine its total length. Unfortunately, these trenches did not locate the extremities of the boat so we can only guess that its length was originally from ten to 12 metres. A length of 2.85m was therefore recorded (Figure 2).

The next trench was 3.10 x 1.23m in size, at a depth of 0.68m and located north-east of the previous trench. The stratigraphy was quite similar to that of the first trench. At the bottom of the pit we came upon a sterile base, which also represents lake deposit as in other trenches; this is covered by an alluvial layer of mostly organic material. The most recent layer is a layer of arable land, today overgrown with grass turf and containing fragments of modern bricks.

[1] Identification of the wood was done by dendrochronologist associate professor Dr Tom Levanič, Head of the Department of Forest Yield and Silviculture, Slovenian Forestry Institute.

Figure 2. The Ljubljana Marshes is a karstic field situated in Central Europe between the North Adriatic Sea to the west, the Dinarides to the south, the Pannonian Basin to the east and the Alps to the north (Image based on blind maps of the Institute of Archaeology, Slovenian Academy of Science and Art). Fieldwork and the extended excavated trench with part of the logboat. View to the north (Igor Buser). Closer view of discovered logboat (Nataša Buser). The trench was documented by multi- image photogrammetry (3D model by Žiga Stopinšek, Computer Vision Laboratory of Faculty of Computer and Information Science, University of Ljubljana).

The last trench, 2.08m x 1.19m in size and 0.62m deep, was excavated south-west of the second trench. Therein we documented four strata, similar to the other trenches. The geological base is a lake deposit, with an alluvial layer of dark olive-grey clay silt with organic material, coarse sand and crushed snails above. The most recent deposits of this layer constitute black silt with organic material and crushed snails. The alluvium is covered with arable land, overgrown with grass turf.

Radiocarbon dating result

In examining the logboat we had limited possibilities for radiocarbon dating the timber due to the authorities deciding to preserve the logboat *in situ*. This meant that it would be impossible to excavate the area surrounding the logboat, which could potentially have enabled a precise and wiggle-matching method of sampling the logboat. However, we only had the opportunity to take a sample from the exposed upper edge of the logboat. The sample was treated according to standard protocol and sent to the BETA Analytic Laboratory, and we received the conventional result of 2500±30 BP (BETA-427161).

Narrow context of Iron Age transport across the Ljubljana Marshes

Logboats were for thousands of years the basic water transport, and one of the main cultural features, of the Ljubljana Marshes during the Bronze and Stone Ages. Bearing in mind the many archaeological finds reported from the first half of the 19th century onwards, the logboat today could be considered the emblem of this increasingly endangered landscape. With new discoveries in the last twenty years, this observation only reinforces the importance of dating, which was previously the exception rather than the rule, as we unveil new time horizons.

The earliest mention of logboats as archaeological finds is encountered in a book by Franz Hochenwart *Die Entsumpfung des Laibacher Morastes*, which describes a small oak-wood logboat, discovered in 1827 during the dredging of the Galjevec channel (Hohenwarth 1838). In the following decades, Karl Deschmann (Dežman 1858) and Alfons Müllner (Müllner 1892; 1894; 1897) discussed archaeological finds of logboats, increasing the number of logboats known to 19 at the end of the 19th century. The Roman cargo ship from the Lipe (discovered in 1890) and the plank ship under Medvednica on the hill of Plešivica should also be included. Next Anton Melik reported almost 17 new vessels in 1946 (Melik 1946: 72, footnote 122). In fifty years, Josip Korošec also investigated this issue (Korošec J. 1953; 1954; 1955a; 1955b; 1963; Korošec and Korošec 1969). An impressive and detailed inventory of 18 new logboats discovered after WWII and all older ones was prepared by Davorin Vuga (Curk *et al.* 1981). From 1977 to 1982, Vuga in his fieldwork recorded a total of 22 vessels - mostly logboats (Vuga 1977; 1980; 1981; 1982). In the eighties, four new logboats were reported by colleagues at the Institute of Archaeology of the Slovenian Academy of Science and Art and by the Department of Archaeology, Faculty of Arts, University of Ljubljana (Dirjec 1990). Up to 1990 in the Ljubljana Marshes, two ships and 51 logboats were recorded. After 1990, we discovered 21 new logboats and three new ships (Erič 1998; 2009) (Figure 3: top).

The logboat described in this article, Ižanska I (SI-81), is not the only one dated to the Iron Age. In the period of ±200 years (between 2700 to 2300 by radiocarbon conventional BP date), we should mention two of them. Matena I logboat (SI-03) made of oak with a length of 9.30m and width of 0.87m was discovered in 1927 at Matena near the village of Iška loka (Mal 1926), south of Ljubljana and afterwards moved to the National Museum of Slovenia (NMS). The logboat has, however, been known since 1892 with its location described by Alfons Müllner. Today the logboat is on permanent display at the NMS (Figure 3: middle; Table 1: No. 6). The logboat is dated to the Early Iron Age (Trampuž Orel and Erič 2014; see list on Figure 9, No. 6). The second logboat dating to this period is the Zakotek I logboat (SI-07) made of oak with a length of 9m and width of 1m, discovered in 1987 at Zakotek near the village of Prevalje pod Krimom, south-west of Ljubljana, by the City Museum of Ljubljana's researcher (Figure 3: bottom; Table 1: No. 7). The logboat was preserved *in situ*, and it is dated to the Iron Age by dendrochronological correction (Dirjec 1990). Both logboats, Matena I and Zakotek I, have related shapes and constructional details. The solution to the bow was the same, which is elegantly narrowed on end, no more than 20cm wide, with the square hollowed out rope-hole.

The spread of Iron-Age logboats in Europe

The database of all logboats ever discovered in Europe includes more than 3500 noted finds as well as recognised traces.[2] The oldest is the well-known 8200-year-old logboat from Pesse, and the logboat database also contains the most recent one from the early 20th century. More than 1800 logboats have been dated either by radiocarbon or dendrochronology. The database was started at the beginning of 19th century based on chance finds such as the one in the book *Die Entsumpfung des Laibacher Morastes* by Franz Hochenwart (1938: 75). Hochenwart describes that in the years from 1826 to 28 as a result of the extension of the Galjevec water channel, a small boat was discovered at a depth of

[2] The authors of this article would like to thanks to our colleagues Dr. Lars Kröger from Deutsches Schiffahrts Museum who while collecting data and preparing the list of Iron Age European logboats helped us with his extensive knowledge and revised the final result.

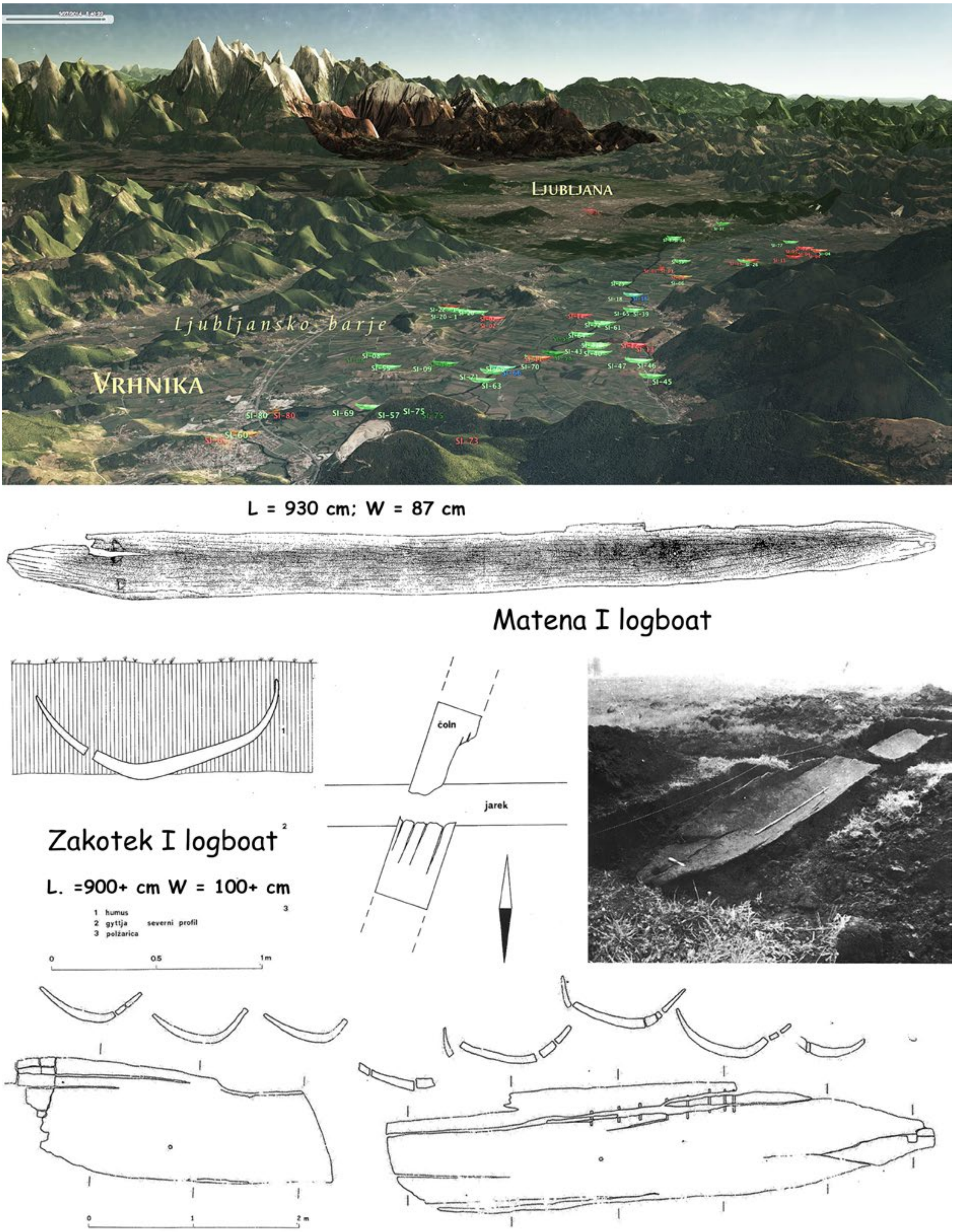
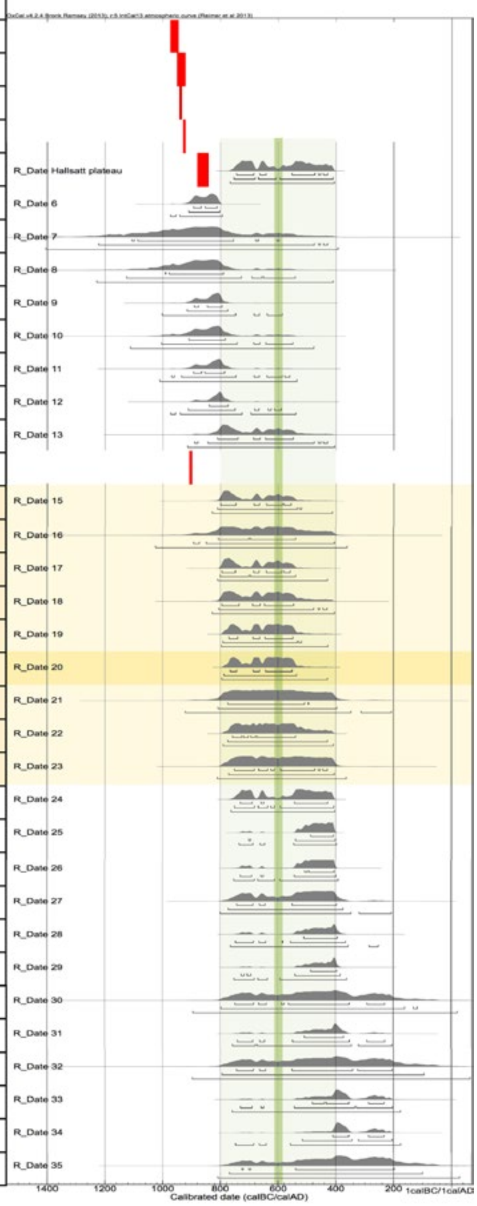


Figure 3. Distribution of logboats on the Ljubljana Marshes between Vrhnika and Ljubljana (Image based on Google Earth Pro Slovenian Logboat Database). **Middle:** Drawing of Matena (SI-03) logboat (by Davorin Vuga). **Bottom:** Drawing of Zakotek I (SI-07) logboat (by Janez Dirjec).

Table 2. List of logboats across Europe dated to between 2,700 and 2,300 with the period from 2,550 to 2,450 (yellow lines). Conventionally measured dates were calibrated by refreshed OxCal 4.2 application. Green column is the frame of *Hallstatt plateau* radiocarbon dating between ^{14}C 2500–2400 BP. *Que - Quercus*; *Pin - Pinus*. However, it is clearly evidenced from the list of European logboats in that time that all except two of are made from oak, as we can observe on the Ljubljana Marshes over more than 2,000 years. **It is not clear about the use of logboat-like shape*.

No.	Logboat	State ID	Conventional age	Calibrated age 1σ (D) - Dendrochronology	Species	Database
1	Hauterive-Champréveyres	CH-78		990-960 BC (D)	*Que*	B. Arnold
2	Douane-Vingrave	CH-59		970-940 BC (D)	*Que*	B. Arnold
3	Chalain-Marigny	FR-10		959 BC (D)	*Que*	B. Arnold
4	Chabrey-Montbec	CH-36		957 BC (D)	*Que*	B. Arnold
5	Auvernier	CH-09		880-850 BC (D)	*Pin*	B. Arnold
6	Matena I	SI-03	2700±35 BP	855 - 813 BC	*Que*	A. Melik, M. Erič
7	Sevrier-Cret de Chatillon	FR	2700±140 BP	1088 - 756 BC	*Que*	B. Arnold
8	Furbara	IT	2695±100 BP	980 - 791 BC	*Que?*	C. Hirte, J. Lanting
9	Sanguinet lo forét 9	FR	2660±50 BP	847 - 796 BC	*Que*	B. Arnold
10	Chalon Saint-Marcel 5	FR	2660±75 BP	910 - 786 BC	*Que?*	J. Lanting
11	Bevaix	CH-18	2645±60 BP	856 - 787 BC	*Que*	B. Arnold
12	Sanguinet Put Blanc 5	FR	2630±50 BP	840 - 775 BC	*Pin*	B. Arnold
13	Roseninsel (Feldafing)	DE	2570±70 BP	811 - 741 BC	*Que*	B. Arnold
14	Roseninsel (Feldafing)	DE		900 (D)	*Que*	B. Arnold
15/1	Blae Tarn	GB-14	2550±50 BP	800 - 748 BC	*Que*	J. Lanting
16/2	Hasholme	GB	2550±100 BP	808 - 702 BC	*Que?*	B. Arnold
17/3	Peterborough	GB-108	2535±40 BP	794 - 748 BC	*Que*	J. Lanting
18/4	Lathen	DE	2530±60 BP	648 - 547 BC	*Que*	C. Hirte
19/5	Terbregge	NL	2505±35 BP	771 - 741 BC	*Que?*	J. Lanting
20/6	Ižanska I	SI-81	2500±30 BP	768 - 739 BC (?)	*Que*	P. Peterle, M. Erič
21/7	Skäggered	SE	2485±100 BP	775 - 509 BC	*Que?*	J. Lanting
22/8	Nijeveen	NL	2480±40 BP	673 - 541 BC	*Que?*	J. Lanting
23/9	Fiskeby	SE	2455±72 BP	592 - 474 BC	*Que?*	O. T. Kastholm
24	Voorsterbos Kodoelerveld	NL	2440±30 BP	544 - 430 BC	*Que*	T. J. Maarleveld
25	Kilraughts. Co. Antrim*	IR	2405±20 BP	488 - 409 BC	*Que?*	N. Gregory
26	Lees Island 5	IR	2400±30 BP	493 - 406 BC	*Que?*	K. Brady
27	Vastersø Lemvig	DK	2400±75 BP	551 -397 BC	*Que?*	K. Bork-Pedersen
28	Saint Germain du plan	FR	2370±45 BP	511 - 394 BC	*Que*	A. Dumont
29	Martebo myr	SE	2370±35 BP	487 - 396 BC	*Que?*	O. T. Kastholm
30	Zakotek I	SI-07	2350±130 BP	749 - 684 BC	*Que*	B. Dirjec, M. Erič
31	Mechelen-Nekkerspoel	BE	2345±50 BP	509 - 373 BC	*Que?*	J. Lanting
32	Sisak I	HR	2330±140 BP	552 - 343 BC	*Que*	I. Radič-Rossi
33	Oudon-L'ile Neuve	FR	2320±60 BP	434 - 356 BC	*Que?*	B. Arnold
34	Clifton 1	GB	2310±50 BP	434 - 356 BC	*Que*	S. McGrail
35	Shapwick	GB	2305±120 BP	541 - 199 BC	*Que*	S. McGrail



1.5m at the bottom of a channel (SI-62). After the vessel was exposed, the oak crumbled.

Over the last 180 years or so, thanks to many researchers around Europe, and especially those working in recent decades,[3] we have a more comprehensive and complex picture of early watercraft, through all of the history of transport on the European continent. Particularly valuable is the database of dated logboats, because it helps us to understand human activities in narrow time windows. We can discern the transporting activities in Europe between 2700 to 2300 BP, and more narrowly between 2550 to 2450 BP.

Radiocarbon dating controversy

It is not our intention here to open high-level discussions on the radiocarbon dating methodology or to question the methodology. However, it is necessary to show in one simple case of logboat radiocarbon

[3] Béat Arnold, Jan Lanting, Christian Hirte, Sean McGrail, Waldemar Ossowski, Lars Kröger, Niall Gregory, Karl Brady, Ole Kastholm, Thijs Maarleveld, Davorin Vuga and many others.

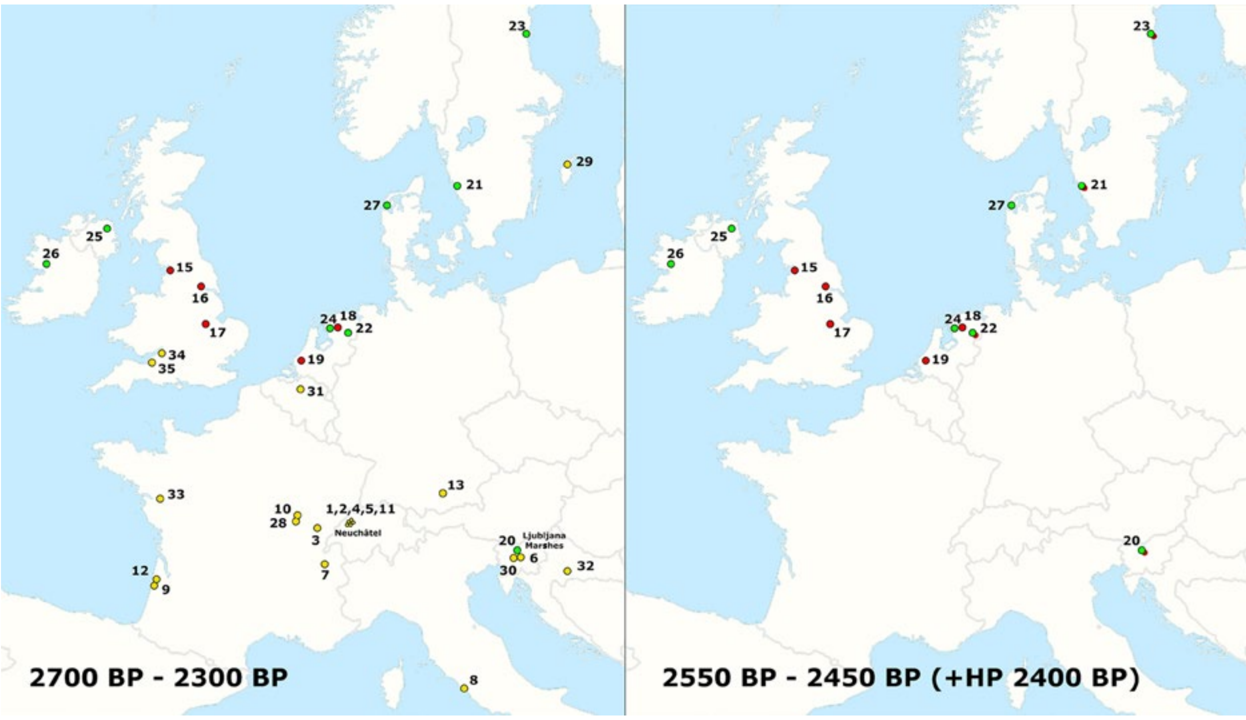


Figure 4. Distribution of logboats over Europe from the list on Table 2 connected by number. **Green** dots show logboats in frame of Hallstatt plateau and **red** dots show logboats in frame of ±50 years of 2500 (Image: M. Erič).

dating how important it is to know the possibilities of interpretation before we come to a final conclusion about date.

Vrhnika I logboat (SI-60) was first investigated in 2001 by the Slovenian Underwater Archaeology Division. At that time, part of the logboat was documented as being 11.50m long and was exposed at the bottom of the river (see Kavkler and Erič in this publication: Figure 1). We estimate the logboat to have been longer by a few metres as sediments covered part of it. A sample of wood for radiocarbon dating was at that time taken from the part of logboat which had been exposed in the water flow for an unknown period. Results of gas radiocarbon dating methods were 1995±55 BP (Z-3294). When the logboat was prepared for excavation and removal from the Ljubljanica River later in 2008, it was sampled again to confirm (or not) the previous results. It was again sampled from the water-exposed part of the logboat, and the results of AMS radiocarbon dating were similar: 1930±40 BP (Beta-250375).

During the logboat excavation in 2015 (Gaspari 2017), eight samples were taken from the bow of the logboat, which had been covered in deep sediment. These samples were dated using wiggle-matching dating (WMD). Such an exact method of dating samples from the part of the logboat that had been covered by sediment and never exposed to freshwater surprisingly shows us how big the differences in measurements could be. Two WMD pairs of samples, the first from the pith and the bordered tree-ring boundary, and the second in the middle of the tree on a closer distance, allow us to assume that the beginning of the logboat's use is from around the beginning of the first century BC. This dates it at least 200 years earlier than the earliest dates from 2001 and 2008.

It is, therefore, necessary to be aware of this fact and also take into account the measured difference in the understanding of former radiocarbon measurements made in the last decades, especially in those countries which use a similar procedure. Researchers are informed about the discovery of a logboat, visit the site to examine the artefact, rarely take more than one sample without a controlled part of the sample position in the wood structure (whether it is from the pith or bordered sapwood, or the cambial part of the trunk cross-section). In many cases this is taken without information on ecological or environmental conditions. Many radiocarbon dates originate from post-sampling methods of old museum artefacts which have been exposed in museum conditions for decades. We must assume that such radiocarbon dating is surely infected by new carbon particles and consequently leads to so-called 'false' results, which are more recent than the real age of the wood.

The second controversy is the Hallstatt plateau in Iron Age radiocarbon dates, where the dates, however precisely they are analysed, should be interpreted as a being of a calibrated date of 800–400 CalBC (Van der

Plicht 2004; Reimer *et al*. 2004). More research is needed on the accuracy of the border of the Hallstatt plateau. Is the year 2500 the beginning of this phenomenon or could it also be 2505?

If we examine both controversies together, we can assess what exactly we can deduce about the Matena I logboat (SI-03). As was mentioned above, the logboat was exposed to air in 1927 and removed to the NMS. After it was brought to the NMS the logboat was preserved with a solution of glue. However, a review of the logboats in the NMS by Davorin Vuga (1980) showed that it had substantially shrunk, with more than 5% in the longitudinal axis of the logboat entirely lost from its original shape. Because of this, shortly afterwards in 1982, the logboat was preserved again by Ivo Nemec from the Restoration Centre of Slovenia. The work was carried out in the hallway on the first floor of the National Museum. We had an opportunity to sample the logboat, and in 1994 Jan Lanting reported a radiocarbon date of 2700±35 (GrN-20811).[4] To summarise, that logboat was exposed to air for 67 years and it was two times partly saturated with fresh substances such as glue. The Vrhnika I logboat's story of radiocarbon dating shows that its real age could be significantly older than the samples which were infected with recent carbon. This scenario forces us to rethink all older radiocarbon dates. The argument concerning the age of the Vrhnika I logboat gives us a reason to take the age of the Matena I logboat as a *terminus ante quem* with a reasonable assumption that it could have been used during the Iron Age.

Regional Iron Age archaeological context

At the beginning of the first millennium BC, an area in central Slovenia was colonised by people of the so-called Ljubljana Urnfield culture. This included a significant part of the Dolenjska and Bela Krajina regions. Among the sites here is the best-studied cemetery in Ljubljana (Puš 1971; 1982), which was in use from the end of the second millennium BC to the third/second centuries BC. Urn burials are a feature of the first cultural phase. A significant change in material culture is apparent in the next phase (Gabrovec 1973: 338). One of these changes is the appearance of iron, which is first encountered sporadically in Phase IIa. In Phase IIb, jewellery and dress accessories (brooches, bracelets, necklaces, needles) are commonly made from iron. Iron jewellery is used during Phase IIIa, but gradually disappears. Within central Slovenia, iron began to be used in the 8th century BC. At that time substantial changes in settlement patterns also began. Old Bronze Age settlements located on low-lying terrain were in decline and new settlements were constructed on hills. These were continuously inhabited throughout the Early Iron Age. Compared to the Late Bronze Age hill forts they are fewer in number, but the living area is several times bigger in the Early Iron Age settlements (Dular and Tecco Hvala 2007: 137).

The earliest known settlements in the region of the Ljubljana Gateway have been dated to the end of the second millennium BC. During the transition from the Late Bronze Age to the Early Iron Age, these settlements were occupied and this continues to the 1st century BC. However, a series of hill settlements persists on the eastern outskirts of the Ljubljana Marshes during the Bronze and Iron Ages, but these have not been precisely dated, except the site at Prule (Tribuna; Teržan and Črešnar 2014: 696). The residents of the hill settlements would have had significant overview and control over the Ljubljana Marshes to the west (Figure 5: top).

Meanwhile, south-east of the Ljubljana Gateway several settlements have been identified including the hill of Gradišče above the village of Rudnik (Šašel 1975a: 191), Molnik Hill near Podmolnik (Šašel 1975b: 195; Puš 1984: 134; Puš 1991; Dular and Tecco Hvala 2007: 162, fig. 90 and 155), Vrhovka on the hill of Mali vrh near the village of Šmarje (Gabrovec 1975: 201), Vinji hrib near the village of Vino (Puš 1975: 195; Dular and Tecco Hvala 2007: 268, fig. 166) and at the village of Gradišče above Pijava Gorica (Truhlar 1975: 200; Dular and Tecco Hvala 2007: 268, fig. 168). On the southern outskirts of the eastern part of the Marshes settlements continued to be occupied at Golo Hill (Šašel 1975c: 180; Vuga and Šmid 1977: 328), at Pungert near Ig (Šašel 1975d: 180), along with two supposed settlements at Grad hill above the village of Iška vas and on Srobotnik hill above the village of Tomišelj.

The Ižanska I logboat (SI-81) dates from the 8th-century transition from Bronze to Early Iron Age. This logboat remains *in situ* and is located around 230m east of the present riverbed of the Ljubljanica River and 400m north-east of the confluence of the Ljubljanica River and Ižica River. The nearest settlements are at Prule (see above) 2km to the north, near the Ljubljana Gateway, and Gradišče to the east (Figure 5: bottom).

In the area close to the logboat, three settlements from the end of the Bronze Age and Early Iron Age have so far been documented. All are located on the right side of the Ljubljanica River: a hill fort on the hill of Grajski grič (Vičič 1990: 178; Horvat 1991: 232–33; Puš 1992: 18; Vojakovič 2013: 341–44); a lowland settlement at Prule (Tribuna) under the southern foothills of Grajski grič; and, on the northern foothills of Grajski grič a limited village complex was recognised (Draksler *et al*. 2011; Vojakovič 2013: 351–52). A nearby cemetery in the yard of the Slovene Academy, SAZU (Slovenska akademija znanosti in umetnosti), NUK II archaeological site and

[4] Unpublished report of radiocarbon dating analysis sent to the National Museum of Slovenia by Jan Lanting.

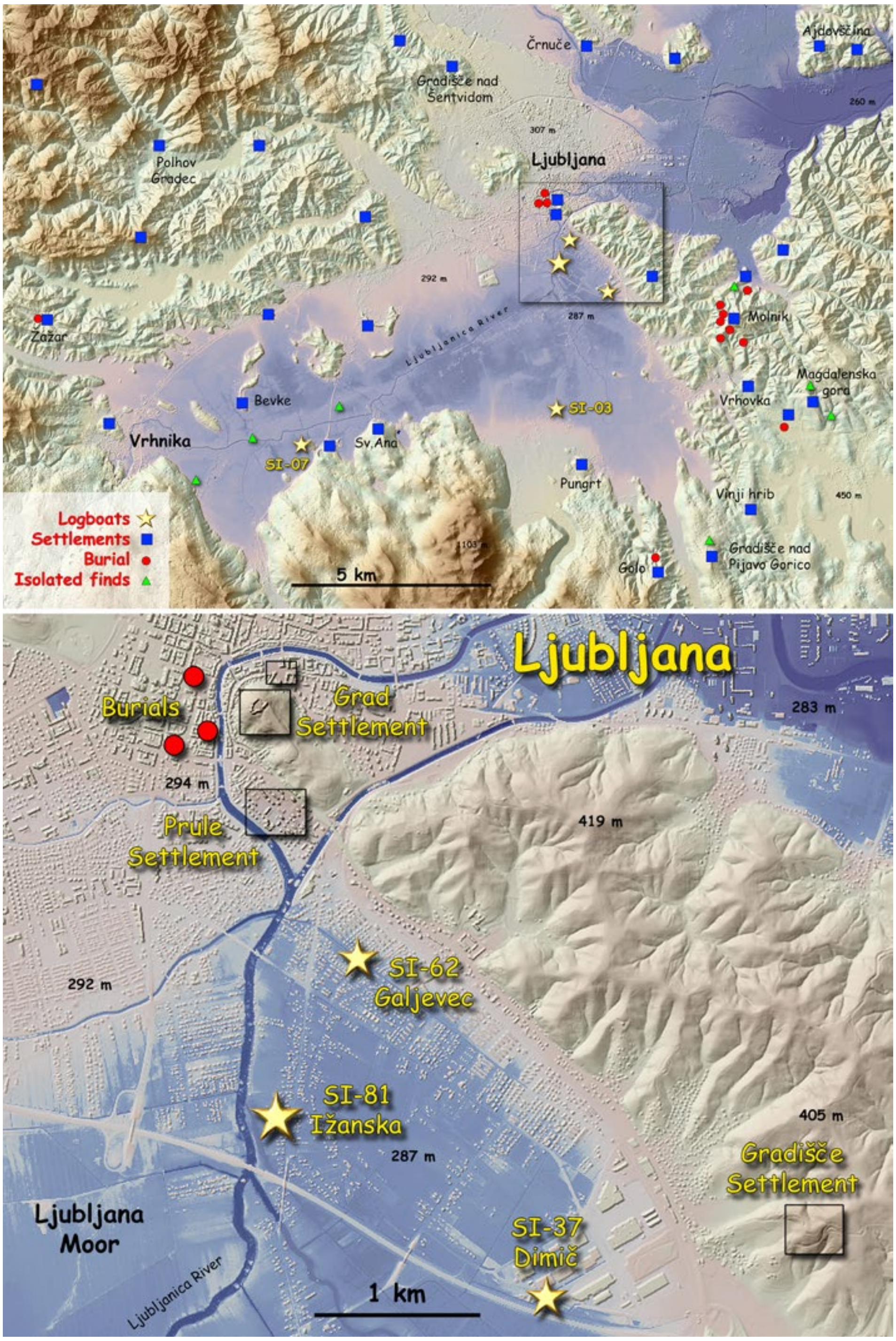


Figure 5. The wider area of Ljubljana Marshes through the Iron Age shows us frequent activity on the eastern part of marshes. Also included are Matena I logboat (SI-03) and Zakotek I logboat (SI-07) positioned (ALS credit by GURS; image: M. Erič). **Bottom:** Closer area of Iron Age settlements, where burial and other logboats are situated (ALS credit by GURS, image by M. Erič).

burial in Congress Square, supplements our knowledge of this area. All this area is on the left bank of the Ljubljanica River.

The settlement of Prule (Tribuna) mentioned above was archaeologically well excavated in 2008/2009. The remains of wooden buildings as well as gravel and paved streets were identified. Houses were placed in rows along the streets, orientated on a north-east and south-west axis with a slight deviation to the north or south. Houses were rebuilt and restored frequently. The settlement lay on an at least occasionally active riverbed, which flowed out of Grajski grič. Buildings north of the stream are thought to have been used for economic activity with the residential part of the settlement to the south, judging by the assemblage of artefacts. Deposits probably made by inhabitants of the largest settlement are spread out on the land between the Ljubljanica River and Grajski grič (Vojakovič 2013; Gaspari, 2014: 85).

Vojakovič (2013: 340) assumes that this area is probably the industrial part of the principal settlement centred on a residential area, which is conjectured to be situated on Grajski grič. The excavated fort covered approximately the same area as today and encompasses Ljubljana Castle on Grajski grič. Its construction almost entirely displaced the remains of a prehistoric settlement. Protected archaeological excavations of the eastern part of the district have shown that the settlement was inhabited during the 8th and 7th centuries BC (Vičič 1990: 178).

The Ižanska I logboat (SI-81) belongs to a group of discoveries that challenges researchers and raises interesting new questions. It is well known that logboats were used for farming, fishing, hunting, transport and trading. Can the location of logboats aid the recognition of the economic space of the settlement? Can isolated logboat finds complement a better understanding of the use of space outside settlements and graves or graveyards? Will they help us to understand the transition from the Late Bronze to the Early Iron Age? Did communication between the forts also take place along the waterways? Did a network of forts on the outskirts of the Ljubljana Marshes exploit these marshy waterways?

Finally, we should mention two logboats found nearby which are relevant to our research even though they have not been dated. First is the previously mentioned disintegrated and never-dated oak logboat from Galjevec (SI-62), which is reported to have been discovered at a depth of 1.5m beneath the surface. The second is the oak logboat Dimič (SI-37) that is described as having been discovered during the digging of a new stream channel. They are reported as being *in situ* but this seems doubtful as in the 1990s this area was entirely built up with the South Ljubljana Rudnik trading zone. However, it should be emphasised that both are made of oak and both were more than 1m below the surface, at a greater depth than the Ižanska I logboat (Figure 5: bottom).

The discovery of the Ižanska I logboat certainly confirms that the Ljubljanica River was one of the channels used for communicating with other communities, and for the economic use of the wider area (farming, fishing, hunting, gathering, etc.).

Discussion and conclusion

During the last 200 years, the Ljubljana Marshes have been exposed to extensive interventions in the marshland in the course of which were discovered numerous archaeological remains of organic materials. Attention is attracted mainly by the largest, the logboats and ships, which are difficult to overlook. The vast majority of these have been detected in isolated circumstances, reportedly at the site of abandonment or foundering. Only a few of the logboats were identified as part of the settlement sites (Dežman 1878; Velušček, Veranič and Čufar 2009) or other areas of multiple activities (Velušček 2005: 203).

The Ljubljana Marshes is a perfect example of an anthropogenic environment. Their hydrogeological nature preserves objects made from organic materials very well. Conclusions can be drawn from these finds about historical material culture further afield. In other words, if a wooden bow was discovered in the marshes, it can reasonably be deduced that such bows were a part of a broader contemporary culture. If a hatchet from the marshes has a wooden haft it can be deduced that all hatchets of that period had wooden hafts. As a wooden wheel with an axle was discovered in the marshes, it is assumed that they were also more widely known and that wagons were used in the region. Across the Ljubljana Marshes numerous remains of logboats have been recorded, including the Ižanska I logboat. As presented above, a great number of logboats have been recorded around Europe and logboats from many periods have fortunately been preserved throughout the whole of the Ljubljana Marshes. However, logboats are not the only artefacts important for cultural history to be preserved in the marshlands, and heritage protection should take into account the fact that marsh environments can give us unique insight into the extent and longevity of common material culture of which logboats are a unique constituent.

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'Know the Ropes'—Boat Representation on 17th and 18th-Century Portuguese Tin-Glaze Ware

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Abstract

Portuguese tin-glaze ware decorated in blue and/or purple on white has been made in Portugal from at least 1570 using traditional methods up until the late 18th century. During this time, these ceramics were decorated with many different motifs with boats or ships being among the less frequent representations. These are shown in many different ways, most of the time illustrated while sailing. Several types of vessels have been recorded, from the small fishing boat associated with the fisherman to large vessels believed to correspond to ships, *pataxos, naus* or even galleons along with other types of vessels known in the 17th and 18th centuries. The purpose of this paper is to demonstrate the importance of this iconographic source, depicting diverse types of boats and how those relate to the ships from different flags that pottery makers would observe daily entering the Portuguese ports, considering their economic, social and symbolic importance.

Keywords

Portuguese faience, ships, boats

Introduction

Portuguese faience as a plain tin-glaze ware started to be manufactured in the early 16th century though it was only around 1570/1580 that it was transformed into a highly decorated material with a varied repertoire of motifs painted over a white surface with new shapes inspired by European and Eastern, namely Chinese, objects. The decoration, although a novelty, combines Portuguese themes with different European medieval, Islamic and Renaissance values going back to classical Greek and Roman cultures. Together with these European and Near Eastern influences, the Discoveries brought a new oriental and exotic world that was to be a constant presence in these wares not only in the use of colour but above all in the decorations with the representation of different people, animals, plants, buildings and objects or phytomorphic and geometric patterns.

The iconography on 17th and 18th-century Portuguese faience can be grouped into different categories such as anthropomorphic and zoomorphic representations, phytomorphic and geometric motifs, letters, artefacts, buildings and constructions, landscapes and patterns. Boats are usually considered to belong to the class of constructions (Gomes and Casimiro 2016).

The decorations are multiple and it is possible to divide them into several categories. Ship representations are among those decorations although one has to bear in mind the presence on the pottery of human figures, buildings or even phytomorphic motifs, among many other things. Portuguese faience is a palimpsest of cultures where every representation has a specific meaning (Casimiro, Gomes and Gomes 2015; Gomes and Casimiro 2016).

Production was not consistent from the mid-16th century up to the late 18th century. These Portuguese ceramics underwent different stages of production and consumption. When they started to be produced, they seem to have supplied mostly the internal market and Portuguese colonies. They were manufactured in three production centres—Lisbon, Coimbra and Vila Nova (near Oporto), each one presenting their own style and characteristics. These ceramics are related to very wealthy archaeological contexts in the late 16th and early 17th centuries. In fact, one has to wait until the mid-1600s to see faience being used by less wealthy sections of the population in a democratisation of consumption. Despite becoming more widespread, faience was still quite frequent in aristocratic and bourgeois houses, enriched by international trade, but was also in daily use in religious houses, hospitals, military compounds and middle-class houses.

The changes in production and decoration around the late 16th century made it one of the most desirable European ceramic products and largely exported to other countries. In this sense a large majority of the ceramic objects found in archaeological excavations and kept in museums were in fact discovered in England, the Low Countries, Germany, Sweden, among many others (Bartels 2013, 2016; Casimiro 2011; Jaspers and Ostkamp 2016; Martens 2012). However, this was a commodity demanded by European populations across the globe making them common finds in European colonies from North America to Brazil and Argentina, Africa and even the Eastern Portuguese colonies of India and Macau, though in smaller quantities due to the massive presence of porcelain from China.

The reasons for this demand can actually be related to many different factors though the originality, novelty and exotic aspect of these ceramics contributed to the wide international distribution. Different volumes of these ceramics are found depending on the period though it is possible to state that between 1580 and 1660 this was in fact one of the most global ceramic productions (Casimiro, Gomes and Gomes 2015).

Ship and boat representations

More than two-dozen vessel representations are known in Portuguese faience, presenting a huge polymorphism, from very small fishing boats to large ships. This paper looks at 29 objects with vessel representations (16 plates, six cylindrical drug jars, five bottles, one pot and one pitcher). Many others may exist in private collections. Twenty-five of these objects are kept in museums or private collections in Portugal or abroad while four were found in archaeological excavations, one of them in Portugal (Figure 6A), two in the Low Countries (Figures 1D, 4C) and one in Brazil (Figure 3B).

It is not always easy to classity the type of boats especially due to their very stylised representations where sometimes only the ship's silhouette is recognisable. In this regard, the differences in the parts of the ships that actually permit defining what type of boat it is are not always easily identifiable.

All the ceramics presented in this paper were either produced in Lisbon or Coimbra, so one should assume that ceramic painters while crossing or entering the River Tagus or the river Mondego saw the majority of these ships. It is curious that the Coimbra plates only reveal small sailing vessels, possibly for fishing or river crossing, while the larger ships are represented in Lisbon productions. Every 16th–18th century representation of Lisbon, either in paintings, tiles or engravings reveals that this river and the Lisbon port were reached by hundreds of different ships, small and huge, from different nationalities.

Vessels, depending on their size and function, can be depicted while sailing, with the wind blowing their sails or with furled sails, possibly when they were anchored. In spite of these difficulties, several types of ships were recognised, as stated below:

Very small fishing boats, without sails

With one man and moved by paddles, as can be seen in five painted decorations on the ceramics, namely on the drug jar with the Portuguese coat of arms dated 1641 (Figure 1A). The typology of these boats is difficult to define though some of them present similar characteristics and are usually defined in Portuguese as *barcas* or *batéis*. All of them are represented in perspective from the forepart where the bow is always drawn with two equidistant circles or eyes. The representation of eyes, as two circles or in a more naturalistic way in boats' bows has its beginning in Ancient Egypt (in the Horus hawk's eye) and from there reached Europe and Asia, the Pacific Ocean as well as the Canadian Coast (British Columbia). These seem to be apotropaic elements, used against the evil eye and bad luck, able to protect the famously superstitious maritime populations (Hornell 1923). The hull is always represented on the left side and in all cases one single occupant is depicted. In two examples the man is fishing and in the others propelling the boat with paddles. Almost all of these occupants are wearing wealthy noble garments. Boats such as these are frequently represented in 17th and 18th-century tiles or in book illustrations such as the boats represented in the *Livro das Plantas da Casa de Cadaval* (Arquivo Nacional da Torre do Tombo) (Lencastre and Távora 1993: 13, fig. 10).

Small fishing boats without sails

A small boat with two pairs of paddles and another with three people occupying the vessel, with three pairs of paddles, which seems to be fishing, considering the presence of a fishnet, can both be seen on a bottle (Pais 2013: 249, no. 34) (Figure 7B). In some examples the boats could be moved by only one paddle as seen for example in the drug jar kept at the Carmona and Costa Foundation (Pais and Monteiro 2003: 46–47, no. 2) (Figure 1B), or in another plate with polychromic decoration (Figure 2B). These should be one of the most frequent boats in Portugal at the time, used mainly in fishing activities, on rivers or near the coast. In one of the cases the boat occupant, also dressed as a nobleman, holds a bird on his right hand, possibly a tamed cormorant (*Phalacrocorax carbo hanedae*, *Phalacrocorax cappilatus* or *Phalacrocorax carbo sinensis*), used as a fishing technique in the Far East, China, Japan and India, mentioned in several texts since the 7th century (Merino 1991: 291–94). Cormorant fishing is supposed to have been introduced in Europe by the Dutch as a noble sport in the 17th century, brought from China (Beike, 2014). However, recent research indicates that a similar species already existed in Germany and

Venice in the 16th century. In fact, the first description of cormorant fishing ever to reach Europe was the account of Galeote Pereira and his China travels in the mid-16th century so the practice should have been known in Portugal (Beike 2012: 13) (Figure 1D). Such boats are also frequently found in tiles, paintings and illustrations. The aforementioned *Livro das Plantas da Casa de Cadaval* (A.N.T.T.), shows a boat with three occupants and fishing nets (Lancastre and Távora 1993: 13, fig. 11).

Very small boats with one main master and a sail

The sail, when opened can be triangular or square; something we believe can be related to a traditional type of navigation. Sometimes, one single occupant was depicted. Some of these vessels are represented while sailing (Figures 3A, 3C, 4B, 4C), with the wind blowing the sails' canvas. There are only two examples where the sails are twisted to the mizzenmast. In one of these boats a man is actually holding cables or ropes that are tied to the sails (Figure 4B) though on a second one the state of fragmentation hinders understanding the activity of this individual on board (Figure 4C). On the top of the main master there are pennants, with two or three points, although in these cases it is not possible to actually recognise any nationality. These could in fact also be used as fishing boats and small coasters, though it is possible that these were also used for connecting the two sides of a river such as the Tagus or the Mondego. Since the Middle Ages, these crossing vessels have been called *batéis* (Bellec 1993: 34–35, 82, figs 39, 41, 86; Oliveira 1993: 97, 114, figs 98, 112).

The origin of the triangular sail has been the subject of much discussion. According to L. Casson it may have originated in Ancient Egypt (1994: 97–98, 117–18, 152–53, fig. 90) spreading through the Mediterranean around the 2nd century in small boats. This idea is based on a small tombstone found in at Piraeus port, kept at the Athens National Archaeology Museum, dating from that period. However, V. Christides (1988: 88) mentions the hypothesis that triangular sails were a Chinese invention and were transmitted to the Mediterranean through the Muslim world. Several authors who believe that these sails were widely disseminated by large Byzantine boats earlier than the fifth century (Late Antiquity) contested these assumptions. Such vessels can be seen on a mosaic found in Kelenderis, in Southern Turkey (*c.* 500) and on a graffito in Corinth, dating from the 5th or 6th century and in another representation at the Kellia monastery (Alexandria, Egypt) (Pomey 2006: figs 1–3; Whitewright 2009: 98–99). In the High Middle Ages these boats appear in Byzantine illuminated manuscripts from the late ninth century, namely in a Greek manuscript illustrating St Gregory of Nazianzus's homilies from *c.* 880 AD (National Library of France 510: ff. 3, 367), or in a graffito scratched on a ninth-century wine amphora found in Theodosius Port, in Yenikapi (Turkey) (Günsenin and Rieth 2012). Some still believe that it had its origin in the Indian Ocean and it reached the Mediterranean from that part of the world by Mozambique reaching Morocco and the Iberian Peninsula through the Muslim expansion (Hourani 1995: 100–04). Nevertheless, some authors such as Campbell (1995: 4, 10, 18) believe in a simultaneous invention in the western Indian Ocean, Pacific Ocean (South-east Asia) and the Mediterranean where the Copts passed it to the Muslims.

Ships of medium-sized dimensions, with two large sails

These vessels are represented in plates produced in Lisbon and Coimbra with the ledge decorated with *aranhões* (a type of decoration resembling spiders), peaches and chrysanthemums. The five known examples, four from private collections (Figures 5A, 5B, 5C, 6B) and one from the archaeological site of São João de Tarouca (Sebastian 2015) (Figure 6A), all represent boats with similar hulls and with two square or two triangular sails or one triangular and the other square. It is possible that these may correspond to the traditional boats that would have been used to transport people and cargo up and down the rivers or along the seashore.

One must be aware that, for example, although Coimbra was a large city in the early modern period with several international connections, the River Mondego constitutes its main access. So large ships, destined to cross the oceans could not reach its port, and ships coming from Northern Europe or the New World would stop in Figueira da Foz, a seaport, and loaded or unloaded there (Rocha 1954). In this sense smaller ships, possibly such as the ones represented here, were sailing towards Coimbra. The Tagus estuary was also crossed by dozens of medium-sized boats, which could sail up the river all the way to Toledo accessing the Iberian hinterland. This navigation was possible in some areas due to the several changes in the riverbed from the 16th century onwards (López Gómez 1998). These ships with triangular sails are quite similar to the River Tagus frigates or *muletas*, or the modern river Sado galleons (Cabeçadas 2008: 91, 97).

Larger ships with two masts and two big sails

They are in fact more rarely found on the ceramics and only two examples are known with a mainmast and a foremast and their respective yards, possibly depicting a Portuguese *barinel* or *barca*, a vessel used in long-distance travelling (Oliveira 1993: 110–14). In an 18th-century Coimbra plate (Figure 8A), a man with a scourge on his right hand, is standing on top of the bowsprit, while two others take care of the sails and four other figures are depicted inside the deck. It is the only ship representation where the rudder was in fact painted. The sea was represented with sea-birds and sea-serpents and it is possible that the vessel corresponds to a slave boat. This plate was produced before 1761 when new slaves are forbidden to enter Portugal where in 1773 slavery by birth was abolished. However, slavery in African overseas Portuguese territories was only abolished in 1869.

***Large ships named** caravelas*

A Lisbon-made plate from first half of the 17th century (Figure 8B) shows a ship close to a city where large towers and walls represent the city walls (Matos and Monteiro 1994: 63, fig. 9). Two birds fly on each side of the ship, possibly representing the Lisbon city emblem, which is a caravel, with two crows flying overhead. The word *caravela* can derive from the Arab of Hebrew *qārib / qawārib* or from *carabus*, the name given to some boats in Egypt, Syria, and Mesopotamia or from the Greek *karabós*. It was used in Portugal from the 12th century to name fishing boats using a Latin sail and, from the 15th century onwards, to designate larger vessels with two Latin sails (Barata 1987: 166–67; Barker 2001: 214,–15; Gomes 2016: 40).

Very large ships named** naus **or galleons

They are represented with large hulls and high forecastles where one can see the main mast, the fore mast and even the mizzenmast, as well as the bowsprit (Figures 9A, 9B, 9C, 9D). Each of these ships has six sails: the main sail, the main topsail, the fore sail, the fore topsail, the flying jib and the spanker sail. The hull is bigger than the previous representations (*caravelas*) and allows distinction of the poop, the quarterdeck and the main deck. It is not easy to actually define what type of ship this was though if we look at some 16th and 17th-century books that were actually manuals for the constructions of ships, such as the *Livro de Traças de Carpintaria*, these representations are quite similar to *naus* or *patachos* that would cross the oceans. One of the pots where these ships appear has the date 1651 beneath the boat representation and it is the same where one can in fact distinguish the Portuguese nationality of the flag on top of the mainmast (Santos 1960: 90). This large boat, in this case what seems to be a galleon, is flanked by two crows, and despite not resembling a caravel, may be related to the Lisbon City coat of arms.

In one of the plates only a part of a ship is represented (Figure 9E) inside a coat of arms. Although it is not possible to determine what family it was associated with, only the top of the main master is depicted with the crow's nest and parts of the shrouds.

Discussion

Ship representations either in paintings, tiles or ceramics appear frequently in early modern Portuguese productions. The sea, as one of the main elements that connected the widespread Portuguese empire, was always an inspiration for artists. This was particularly the case for faience craftsmen since eastern porcelain models arriving daily by the waterfront in fact inspired a large portion of their pottery and a substantial portion of that production was exported.

Ship representations can inform us about the type of vessels that were crossing the waters using Portuguese flags, some of them connecting the Far East to Europe and Europe to the New World. These were described above and in fact represent several categories from small fishing boats that could not carry more than one single occupant, to large ships transporting hundreds of people and large cargos, which would connect continents. However, the attribution of a specific name to early modern vessels is quite difficult. Written evidence contains various designations for diverse types of vessels and sometimes the same name is given to different types of vessels.

It is possible that potters used models, namely engravings, when decorating faience. This can, in fact, be observed in the representations of small boats since almost all of them are depicted the same way. Were these representations also faithful to the ships that were built or arrived in Portugal from foreign countries? We believe so, since these are quite similar to the type of ships observed in construction manuals or paintings and mainly in engravings.

Nevertheless, these representations cannot be assumed to be straightforward. They are included on objects which had specific meanings in Portuguese history. Faience is, in fact, one of the most widespread productions in Portugal at this time and recognisable around the globe (Gomes and Casimiro 2013). This pottery and its decoration were highly symbolic and cannot be separated from the social, cultural and economic environment where they were produced.

Notice for example the cylindrical drug jar that has the Royal Portuguese coat of arms on one of the sides, dated 1641, just a few months after Portuguese Independence from Spain, and a fisherman inside a boat on the other side. This is not a regular fisherman and the fact that he is dressed as a nobleman should not be interpreted as a recreational activity but rather a possible metaphor addressing the new king João IV. As a fisherman catches fishes, the king was catching people for his cause.

Some of these vessels (Figures 4B; 8B; 9A) have two birds associated with the scene flying over the boat. The

Table 1. Main types of vessels depicted in Portuguese faience objects from the 17th and 18th centuries.

	(XVII-XVIII)	(XVII)	(XVII)	(XVII)	(XVII)	
	3	3				6
				2		
	5	1		1		7
	1					1
	1					1
	4	2		1		7
	1					1
	1					1
			1	1	1	3
	16	6	1	5	1	29

presence of birds around boats is not difficult to account for since some boats could in fact carry fresh fish, and seagulls would definitely be a frequent presence trying to get their next meal. However, one should consider different interpretations. It is possible that these birds, especially when flying over larger ships, may in fact represent albatrosses, the bird believed to carry the soul of dead sailors, but also a sign of good fortune as one can read in the late 18th-century poem by Samuel Taylor Colerige, *The Rime of the Ancient Mariner* (Eyres 2011). These existed in Portugal in the 17th century and had that connotation while at sea. On the other hand, one should not forget that birds, as aforementioned can, in fact, be associated with local symbols. The large pot dated 1651 where one can see a large ship with a Portuguese flag may, in fact, correspond to the arms of the city of Lisbon where a caravel is always represented with two crows. Crows have a particular meaning in the history of Lisbon since the 12th century when it is said that they protected the body of the martyr Saint Vincent the patron saint of Portugal's capital (Tavares 2001: 146). It is likely that these birds were represented in artistic productions made in the city.

Although fish are the most frequent animals associated with ships, one should not ignore the plate where several sea animals are depicted (Figure 8A). A man is standing on the bowsprit with a scourge and, as mentioned above, can be interpreted as a reference to the abolition of slavery in Portugal (1761).

Some Portuguese faience objects tell different stories. A small boat with a single occupant is represented on the ledge of a large plate (Figure 2B). At the central bottom there is the main scene where a group of Portuguese soldiers faces a group of indigenous people. This may correspond to the battle of Ambuilla where the Portuguese troops opposed D. António I (Nuita-a-Nkanga), king of Congo, supported by the Spanish and some renegades in 1665 (Cruz and Lucena 1998: 270–71; Dias 1942; Thornton 1998).

Ships are commonly depicted on other types of artefact. One of the most similar to faience was tiles (Almeida, Gomes and Castro 2017). Some of them are well known such as that of the view of Lisbon of around 1700 that were made for the palace of the Tentugal counts but are nowadays at the Museu Nacional do Azulejo. It depicts the waterfront of this city where dozens of ships of different sizes are anchored. In front of the area of Santos, where curiously the pottery kilns were located, there are several ships and boats on the Tagus River. These are actually quite similar to the ones depicted on the objects covered in this paper. One should not forget that faience painters were sometimes also tile painters since both were made in the same workshops. We know of other tiles with vessel representations especially in late 17th and 18th centuries when figurative tiles were the main product of some of the Lisbon workshops. The interesting aspect of tile representation is that they permit more detailed images than plates as there is more space to draw on. Thus, the anatomy of the vessels is easier to recognise. Single figure tiles from late 17th century and 18th-century productions have ships, which are quite similar to those depicted on faience objects (Figure 10). In the mid-18th century, large tile panels were manufactured in Portugal depicting a varied naval iconography. These represented boats and associated activities such as fishing, moored at port cities and building shipyards, naval battles and wrecks. Some of these scenes are sometimes associated with fantastic or mythological beings. These tile representations are closer in style and craft to oil paintings and are distinct from the naïf faience paintings (Câmara 2005: 175–77).

Conclusion

The 29 vessel representations presented in this paper were manufactured in the 17th and 18th centuries and are depicted on large plates (16), cylindrical drug jars (six), bottles (five), one pot and one pitcher. In these last two forms, as well as on one of the bottles, the preference goes to representations of large ships, *naus* or galleons (cf. Table I). Small boats are the most commonly represented with one occupant moving the boat with paddles (six examples) or small boats with one triangular sail (seven examples) and the medium-sized boats with two sails (seven examples). Larger ships such as *patachos* or *caravelas* are only found on only one object. This last type of ship was rarely in use in the 17th century, though probably quite emblematic due to its role in the Discoveries. Three possible *naus* or galleons were also recorded.

This type of pottery can in fact be considered important evidence for the study of ships and sailing in Portugal's early modern age. However, one should not forget that the decorations on this pottery are always telling a story and those ships should not be disassociated from the environment where they are located. Portuguese faience is in itself the representation of something more than pots. It is the symbol of a country where coats of arms of noble Portuguese families indicate that this was a vehicle of taking the country to wealthy consumers. In this sense, these ship representations were probably kept at the homes of nobles or rich merchants themselves involved in international trading systems where ships were the transportation vehicle.

Ship representation, as a symbol of the empire and of a seafaring nation, can be considered part of political publicity. The Lisbon coat of arms has completely fulfilled that task since the 13th century.

It is interesting to note that despite frequent Eastern decorative influences, so far no Chinese vessels, such as junks, have been recognised in Portuguese faience, not even in the boat where the occupant is holding a cormorant, an activity most likely imported from that country (Figure 1D) or even when the boat is in the same scene as a Chinese man (Figures 2B, 3C, 4A, 4C).

Boat images were so popular in ceramic decorations that these continue to be used until the 20th century, namely in popular productions. A. R. Radcliffe-Brown (1952: 129) mentions that in some ethnographic societies when an artefact has a huge economic importance it starts to distinguish itself from others and gains an ontological importance integrating symbolic systems related to social and religious activities. In this sense, the ships, able to move through agitated waters from rivers and oceans generating wealth and riches, seem to integrate such categories. However, one should not forget that the sea and the water, whose depth and extent are unknown, create an opposition between the organised and social human world and chthonic nature or chaos.

All sea populations are aware of this and know that the use of the sea as a circulation route and the extraction of its riches do not come without sacrifice. This is why those populations are so superstitious and ships are the vehicles of the uneven match, fundamental in the quest for survival. Work at sea is always a cooperative activity, which makes the creation of bounds and symbols even more necessary, where the boat images are preponderant. In Mediterranean navigation in Antiquity, the symbolism relating to the images of vessels connects to the concepts of the passage between two worlds, namely heaven and earth or with the voyage of a civilisation agent considering the wealth and knowledge that travelling could provide. In some Mediterranean mythologies the Sun was transported in a small boat on its daily voyage from day to night. Ulysses sailed the 'Ocean currents, beyond the gates of Sun and the land of dreams', searching the souls of his war companions in the Western seas after the Trojan Wars (*Odyssey* XXIV, 10–20) (Lourenço 2003: 379).

Also, the Egyptian God Ra had a solar boat, both symbols of continuity and cultural reproduction. In some cultures related to the sea the dead are sent back to the underworld or to the great maternal uterus that is the Ocean on board a ship (Chevalier and Gheerbrant 1997: 80–81, 115–16, 468–69; Neumann 1963: 257–58). In many churches in Europe there are reliefs on walls and capitals or even wall paintings that depict boats, some representing Noah's ark, a safe place protected by God (Arduini and Grassi 2002, 53–63).

In the 15th–17th centuries, silver ships are incense containers used in catholic churches, a depiction of the boat of the Just and the one of the Sinners where the main mast is the cross. Also Jesus was the divine pilot of the church's boat and he and St. Peter were in fact fishermen.

In the end, ships—those large wooden buildings, which sail the surface of the oceans—touch the interface between two worlds (the deep sea and the sky) and only they permit seamen to survive, albeit facing great dangers. Therefore, ships are apotropaic elements, which create wealth but also protect people and commodities.

Figure 1. Small boats with one figure on board. A. after Pais, Fernandes and Correia, 2015, 64; B. after Pais and Monteiro, 2003, 47; C. after Calado, 1997,30; D. after Baart, 2007, 124 (Scale 1:5).

Figure 2. Small boats with one figure on board. A. after Stapf, 1997, 21; B. after Matos and Monteiro, 1994, 117 (Scale 1:5).

Figure 3. Small boats with one sail. A. after Pais, Fernandes and Correia, 2015, p. 89; B. after Etchevarne, 2007, 121; C. after Moncada, 2008, 50 (Scale 1:5).

Figure 4. Small boats with one sail and one character. A. after Pais, 2013a, pp. 276-279; B. after Matos and Monteiro, 1994, 111; C. after Ostkamp, 2010, 61 (Scale 1:5).

Figure 5. Small boats with two sails. A. after Moncada, 2008, 77; B. after Moncada 2008, 77; C. after Matos and Monteiro, 1994,143 (Scale 1:5).

Figure 6. Boats with two sails, one triangular and one rectangular. A. after Sebastian, 2015, 174; B. after Moncada, 2003, 152 (Scale 1:5).

Figure 7. Boats with two sails. A. after Pais, Fernandes and Correia, 2015, 61; B. after Pais, 2013, pp. 249-253 (Scale 1:5).

Figure 8. Small and large ships. Caravelas and naus. A. after Moncada, 2008, p. 140, fig. 164; B. after Matos and Monteiro, 1994, p. 63, fig. 9 (Scale 1:5).

Figure 9. Ships in heraldry. A. after Santos, 1960, p. 90; B. after Bauche, 1996, 29; C. after Bauche, 1996, 69; D. after Trindade, 2016, 477; E. Pais, Fernandes and Correia, 2015, 83 (Scale 1:5).

Fig.10. Single figure tiles 17th–18th centuries, after Arruda, 1998 (Scale 1:5).

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Does an Extended Logboat Drevák from the Notranjska Region (Slovenia) Originate from the Celtic-Roman Shipbuilding Tradition?

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Abstract

In 2015 the Slovenian Register of Intangible Cultural Heritage was enriched with the description of how to make a characteristic extended logboat, called a *drevák*. Its presence can be traced to the 17th century when the first written sources witness its use in the basin of the Ljubljanica River—a region of karstic fields (called '*polje*') in Notranjska. The boat is made from spruce and is still used for fishing, rescuing, recreation and heritage promotion.

The *drevák* is made from C-profiled chine-girders and embedded with one to three bottom planks, which are no more than 70cm wide. The flat central bottom rises towards the bow and stern where it rounds into an ellipse. Based on iconographic sources and boats still in existence, we can gather that the *drevák* was between five and 12m long, but, unlike similar boats, it has no knees or floor timbers.

Until recently, it was believed that this type of logboat originated in the basin of the Po River in Italy. However, new research into the Roman Age shipbuilding tradition through excavating a shipwreck in the Ljubljanica River in Slovenia and another in the Kupa River in Croatia, provided a reason to reconsider its origin.

In Europe, there is wide-ranging evidence of boats constructed similarly to the *drevák*; the closest can be found in Krefeld-Gellep II in Germany, which is a logboat from the early Middle Ages. During our research, we also found a surprisingly similar extended logboat in Lake Suwa near Nagano in Japan.

Keywords

'*notranjski drevák*', extended logboat, Ljubljanica River basin, traditional watercraft, roots in Roman shipbuilding tradition, worldwide similarity.

Introduction

Over the past two centuries, and especially in the last two decades, research into cultural heritage along with its preservation and promotion has made significant progress across Europe. As tourism grows, this kind of cultural preservation will remain a valuable tool for the presentation of different cultures and nations.

Logboats, together with reed boats, skin boats, bark boats, rafts and simple three to five plank boats, constitute a group of early watercraft. Along with fire, housing and tools, boats are the oldest inventions of humankind (Erič 2014: 603). Early watercraft are crucial to human cultural heritage but, unfortunately, are often ignored despite their being one of the most important human inventions. Internet-based research supports this apparent prejudice.[1]

The crucial importance of early watercraft is not only in their material and physical properties—that enabled survival on water—but also in how they shaped human history. Early watercraft allowed humans to cross rivers, travel along their branches into open seas and oceans, and on a global scale. They also enabled long-distance trade.

Years ago, Detlev Ellmers (Elmers 1996 (1976): 12) said:

[1] See search strings 'the oldest human inventions', 'timeline of historic inventions', 'the most important human invention.'

> In fact, only three times in human history has man succeeded in leaving his natural habitat—dry land—and penetrating into other dimensions. On each occasion, a special 'apparatus' was required: first the boat, then the aircraft and finally the rocket and space capsule.

Later inventions, such as the compass, astronomy, the wheel, and many others, may have occurred because of the invention of early watercraft, which were simple at the beginning. Inflated animal skins, rotten fallen trunks, islands of dried grass or papyrus, tied bamboo stalks, or simply enough large pieces of bark could all be considered. So, why do we overlook the invention of early watercraft?

One possible explanation could be that boats are largely taken for granted, primarily because they have mostly remained unchanged from their beginning to the present day. They are almost universal. Alternatively, perhaps it is some similarity in the mental process used for making stone tools or in making fire. Just like at a particular moment when our ancestors found that a bonfire ignited dry grass, they could also see that if they grabbed a bloated animal skin or a sufficiently large timber, they could cross a river and overcome great distances.

How far back does the use of early watercraft in the Ljubljanica River basin extend? Despite the fact that so far the oldest radiocarbon-dated logboat of the marshes is from the Neolithic period (Velušček, Veranič and Čufar 2009), the fact that the Ljubljana Marshes have been inhabited for at least 40,000 years allows us to conclude that these occasionally flooded karstic fields were mastered by boat much sooner.

This area was particularly lively more than two millennia ago (Gaspari 2014; Šašel Kos 2012) when the Ljubljana Marshes and Ljubljanica spring at Vrhnika became the starting point for the Roman Empire to conquer eastern territories. In the first half of the first millennium, and even earlier, water transport between Nauportus and Emona over the flooded Ljubljana Moors was frequent through most of the year and was redirected by the Ljubljanica River in dry periods (Gaspari 1998b: 217). Until the first half of the 20th century, the Ljubljana Marshes and Ljubljanica River remained an important water transportation route. That was witnessed in the Valvasor record (1689, II: 145):

> The Ljubljanica river is always full of ships. Driving upstream is just as easy as downstream, but this is not just because of the paddles, but because this river is creeping so slowly that it cannot be even noticed, whether it is standing or running. However, it can reach 3, 4, 5 and even 6 fathoms deep ... floods occur between Ljubljana and Vrhnika large lake, which stretches two or more miles long and wide so that there appear to be but few trees along it. At such times, the boatman navigates outside the river through meadows and bogs up and down, by the shortest route.

It is not surprising that the Ljubljanica River basin provides an opportunity to explore the traditions of navigation and describe this probably indigenous watercraft, which was in active use until the 1960s. That is the *notranjski drevák*—the extended logboat—that, at the end of 2015, was entered in the Register of the Intangible Cultural Heritage of Slovenia (KZD 2015).

Early watercraft as one of the most important and oldest human inventions

The cultural heritage of early watercraft, their use and navigation on water, is an extraordinarily important topic even today, given that more than 70% of humanity live near water, no more than 5km from lakes, rivers, seas and oceans (Kummu *et al.* 2011). These bodies of water are still heavily involved in human economic activities. Even today, despite advances in technology, more than 90% of world trade is by water (IMO 2016).

According to some anthropological theories (Bednarik 2014; Geoff 2012; Luskin 2015), *Homo erectus* was already navigating long distances 800,000 years ago. The evidence for this is that very similar stone tools have been discovered on several Indonesian islands. Australia was colonised more than 60,000 years ago when people crossed the Torres Strait (Bednarik 2014), most likely using early watercraft. The first direct archaeological evidence that people used early watercraft is around 12,000 years old: petroglyphs depict a reed boat for about 20 paddlers on walls in Gobustan in Azerbaijan (White 2003). An 8200-year old logboat from Pesse (a village in the Netherlands) is the earliest surviving early watercraft (Van Zeist 1957).

This significant story of the use of early watercraft, closely linked to traditional human coexistence with water, has a strong symbolic meaning. In the history of navigation and shipbuilding, traditional indigenous watercraft have not received sufficient attention, despite the fact that they represent the origin of navigation (Erič 2014).

The opportunities early humans had for navigation were limited by geography and environmental circumstances. Therefore, the invention cannot be assigned to just one group of humans. This fact is reflected in the variety of early watercraft (Figure 1). Material for overcoming the water surface differed from region to region, as inhabitants used available

Figure 1. Early Watercraft: a. logboat - river *Omo-Bottego*, Ethiopia, photo by Peter in Hinda Schnurman (Schnurman 2012); b. the skin boat *Angyaqatak* is made in 2007 by Joe Speinand and Alexie from Kwethluka, Anchorage Museum, Alaska (Speinand 2007); c. a 3D model of a skin boat, a traditional Indian North American canoe (SWA 2012); d. a traditional aboriginal bark boat from the south coast of New South Wales, Australia. Contributors to the experimental workshop of traditional aboriginal bark boat building organised by the Australian National Maritime Museum of Sydney. Photo by David Payne (Payne 2012); e. a traditional double balsa raft from Western Australia. Drawing by Xiangyi Mo (Barlow 1994); f. bamboo raft from Kerala, India. Photo by Enjo Mathew (Mathew 2012); g. traditional raft made from inflated goatskin from Lanzhou river basin in Gansu province, China. Photo by Meng Zhang (Zhang 2012); h. typical traditional reed boat from the Nile river basin in North Sudan. Photo by Linda Sue Park (Park 2011); i. a traditional yak-skin boat, so called *ku-dru* from the region of Buddha rock near Lhasa, Nepal. Photo by Jerome Ryan (Ryan 2005).

materials found in their environments. Thus, people dwelling near lakes and rivers with sharp reeds and water grasses developed reed boats. People living in areas where there were trees with distinctive peelable bark developed the bark boat; hunting and domestication of animals provided hides which led to the development of skin boats and inflated skin rafts. On the other hand, in areas with a number of different bamboos and light wood, we find rafts and simple three or five-plank boats. In the forests of Europe and other similar regions, people invented the logboat.

The Ljubljana Moor and Ljubljanica River basin (Gaberščik 2003; Skoberne 2004) were inhabited very early. This is confirmed by the discovery of beautifully carved wooden points, parts of hunting weapons, made from yew (*Taxus baccata*). They are around 40,000 years old and were discovered during the intensive archaeological examination of the Ljubljanica riverbed in Sinja Gorica in 2008 (Gaspari, Erič and Odar 2011; 2012). No material evidence from that time suggested that the community used early watercraft. The oldest logboat found in Slovenia, 7500 years old, was discovered deep in the rubble embankments in the oxbow lake of the Mura River near Lendava (Erič, Tušek and Nemec 1994; Erič and Kavur 2012). The oldest logboat in the Ljubljana Moor is from the pile-dwelling Stare Gmajne along with the oldest wooden wheel in the world (around 5200 years old), documented by Anton Velušček and a team from the Institute of Archaeology ZRC of Slovenian Academy of Science and Art (Velušček, Veranič and Čufar 2009). So far, 76 vessels have been discovered in the Ljubljana Marshes, mainly logboats from all periods from the Neolithic to the 19th century (Erič 2008 and 2009; Erič, Gaspari and Kavur 2012).

There is clear archaeological evidence for the use of boats in the basin of the Ljubljanica River for several millennia.

Characteristics of the construction of *notranjski drevák*

Drevák—today the name of a type of boat in the Ljubljanica River basin—is an extended logboat whose base is a tree trunk. It can be extended or enlarged in various ways.

Dreváks from the Ljubljanica River basin were made in two or more lengths.[2] Compact, standard lengths of 5 to 7 metres were intended for the transport of people and goods in the farming villages of the region. The maximum length of 12 to 15m was used to transport large cargoes and livestock. In both versions, the width of the boat is about 1m, with a variation of up to 10cm.

The *drevák* is made from a fir trunk (dialect *hoja*, Latin *Abies alba*), longitudinally cut in half and hollowed into the C or L cross-section chine-girder (see below). Between two chine-girders, a flat bottom plank is inserted. The central bottom plank is generally 70cm wide. If instead of one bottom plank, two or more bottom planks were used, these planks together never exceeded a width of 70cm. It seems that the decision to use more bottom planks than one is caused by the scarcity of available suitable material (Figures 2 and 3).

The stern and bow consist of four bottom planks in a gentle curve (dialect *krivce*) cut from curved fir. The chine-girder and the bottom plank are fixed together with iron nails, at a thickness in the middle and right and left (see Figure 3 at the bottom). On end, the outer and inner surfaces are carefully sanded. Longitudinal joints are sealed with hemp (*Cannabis sativa*) twine. Upon use, when the *drevák* is water-soaked, a smaller version weighs from 400 to 700kg. The boat is about a third lighter in winter-time when there is no water and the wood is dry. The weight of the bigger version of the boat is more or less double the weight of the smaller boat. The boat has a lifespan of between 10 and 12 years. The *drevák* is broad and a very stable farming boat with a flat bottom, which cannot be overturned. Navigation with oars requires specific skills and rowing through shallow and deep waters is different. Up to the 1960s, *dreváks* were used in the flooded Notranjska Karst fields for farming, fishing, hunting and transport throughout the Ljubljanica River basin, especially on the Ljubljana Marshes, Planina Field, Lake Cerknica (Peršič 2003), and Lož Valley. The skill of making *dreváks* with old tools is mastered today only by Anton Lovko of the village of Dolenje jezero near Cerknica. That traditional knowledge, with the help of NGO Heritage House and Ljoba Jenče, has been passed on to his sons Toni and Sandi Lovko, and to international woodworking students. In recent years Vekoslav Kebe from Lake Cerknica museum at Jezerski Hram in the village of Dolenja vas has started to build a few boats for museum presentation.

Discussion of historical background and source of construction type

The Ljubljanica River basin and karst fields (Ljubljana Marshes, Planina Field, Lake Cerknica and the Lož Valley) are often flooded, sometimes for the greater part of the year. The Ljubljana Marshes—before the water regulation by the agrarian reforms of Maria Theresa in the 18th and 19th century—and Lake Cerknica (which is by geological terminology an intermittent lake) can be dammed and flooded most of the year with prominent

[2] This description is based on an interview with watercraft master Anton Lovko from Dolenja vas near Cerknica, conducted by Ljoba Jenče.

Figure 2. Top: 3D model. The Technical Museum of Slovenia has a 5.6m long *drevák* built in second half of 19th century in the village of Laze on Planina Field. For the study of 3D documentation in underwater archaeology, the *drevák* was scanned with a structured light 3D scanner by the working group at the Laboratory for Computer Vision of the Faculty of Computer and Information Science. A series of 3D images produced by multi-image photogrammetry (conducted by Rok Kovačič, Gregor Berginc, Žiga Stopinšek, Luka Rozman and Janez Rupnik). Bottom: The last traditional *notranjski drevák* which was owned by the Laze village community on Planina Field was the property of villagers at least from the end of the 19th century. It was in use whenever Planina Field was flooded. Unfortunately, after this last rowing on a flooded Planina Field in 1998, this 12m long *drevák* was removed to the Cerknica museum without the consent of Laze villagers (Miran Erič).

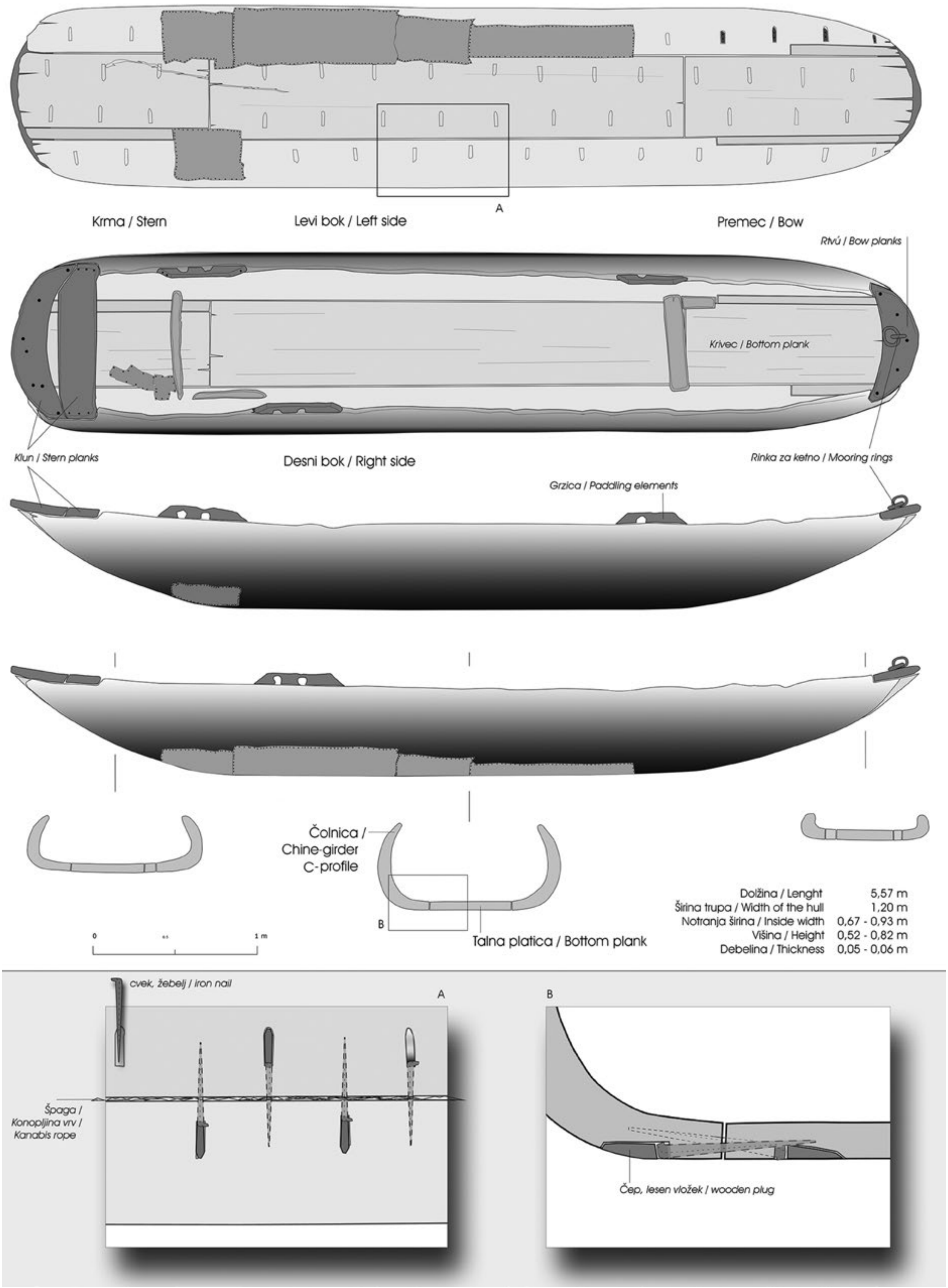

Figure 3. The archaeological plan of a *drevák* from the Technical Museum of Slovenia (base plan by Miran Erič).

springs on one side and sinks on the other. Planina Field and Lož Valley may be flooded a little less frequently but nevertheless are also often flooded. This feature of the karst region forces the village communities to use boats. The boats allow their farming, hunting, fishing and social activities to continue all year round despite the communities being surrounded by water.

It is not clear when the *drevák* came into use in the Ljubljanica River basin and how this particular type of extended logboat evolved into the indigenous tradition that we know today. From pictures and references to these logboats, we know they were used as traditional boats in the 17th century, as reported by Janez Vajkard Valvasor (1689; Figure 4, top). In recent decades, interest in studying this construction type has grown in the Po River basin. Until the second half of the 19th century, with the advent of photography, depictions of the *drevák* are not frequent. However, there is a surprising representation of Cerknica Lake by the engraver Jan ten Hoorn from Amsterdam. The *drevák* is shown together with a Latin-type square and lateen sail on the flooded lake (Figure 4, bottom-left). This is the only known depiction of sails on inland waterways in Slovenia (Brown 1696: 190).

Evidence of similar construction

After a study of similar constructions around Europe, the authors surprisingly could not find any archaeological, anthropological or ethnological evidence for the extended logboat's originating in the Po River basin. We therefore should not suppose that this kind of boat construction originated in the Po River basin. We can find a similar approach to boatbuilding in other parts of Europe and even in Japan.

Some logboats similar to the *notranjski drevák*, dated to the Middle Ages, are found in northern Europe. With just three pieces of archaeological evidence, we can compare some elements of construction, but we cannot compare their construction in detail as a whole.

Concerning the Oberlander (Rhine) river boat (Figure 5, top-left), also named as Krefeld-Gellep II (Kröger 2014: 99, Tab. 2) found near Krefeld-Gellep, we read that:

> the tradition is very old and comes from the dugout boat tradition. An Oberlander has a flat-bottomed keel (four planks), with lashed boards consisting of two halfs of a dugout tree. These boats were used for fishing and transport on calmer bodies of water.[3]

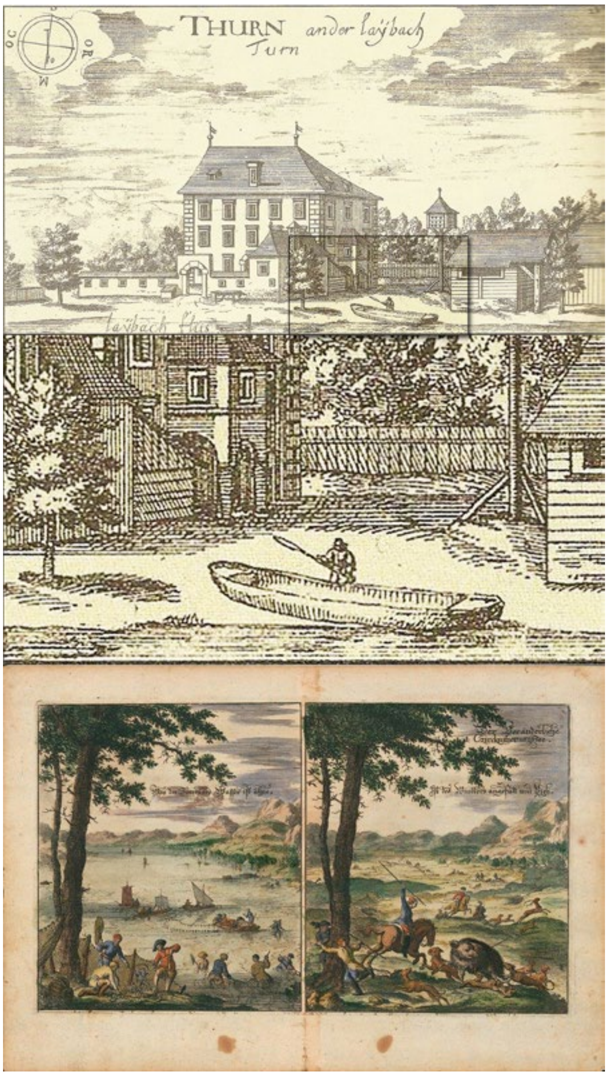

Figure 4. The engraving of Kodeljevo castle in Ljubljana (top and middle), shows the typological appearance of the boat. But the copper engraving makes it extremely difficult to confirm that all the relevant elements of the construction of a *drevák* are present (Thurn an der Laybach; Valvasor 1689: 264). Two different images of Lake Cerknica (bottom). The *left* image is highlighting the human activities (fishing, etc.) on the field during the flooded Lake period. On the *right* image, they have presented bear and deer hunting as well as mowing meadows. 'Derberanderliche Czircknitzer See' (Brown 1696: 190).

The approach to construction is the same as that for the *notranjski drevák*, but there is a big difference in the building techniques of the bow and stern. In the case of the Oberlander boat, the longitudinal bilge between bottom and bow finished in an acute, at least 45° angle, and the longitudinal bilge between bottom and stern is at an absolute right angle of 90°. We can observe the same idea in the construction of Meinerswijk 3 (Figure 5, top-right; Reinders 1983; Vermeersch 2012: fig. 9)[4] where we can see the same construction as in the

[3] Citation available on the MACHU Project find as 'ID Oberländer Schiff', viewed 30 January 2017 <http://www.machuproject.eu/WIS-viewer.htm>. Description as a flat-bottomed ship should be revised while documentation clearly shows just a flat bottom and no keel is included.

[4] Credit for the drawing of Meinerswijk 3 in Figure 7 belongs to the

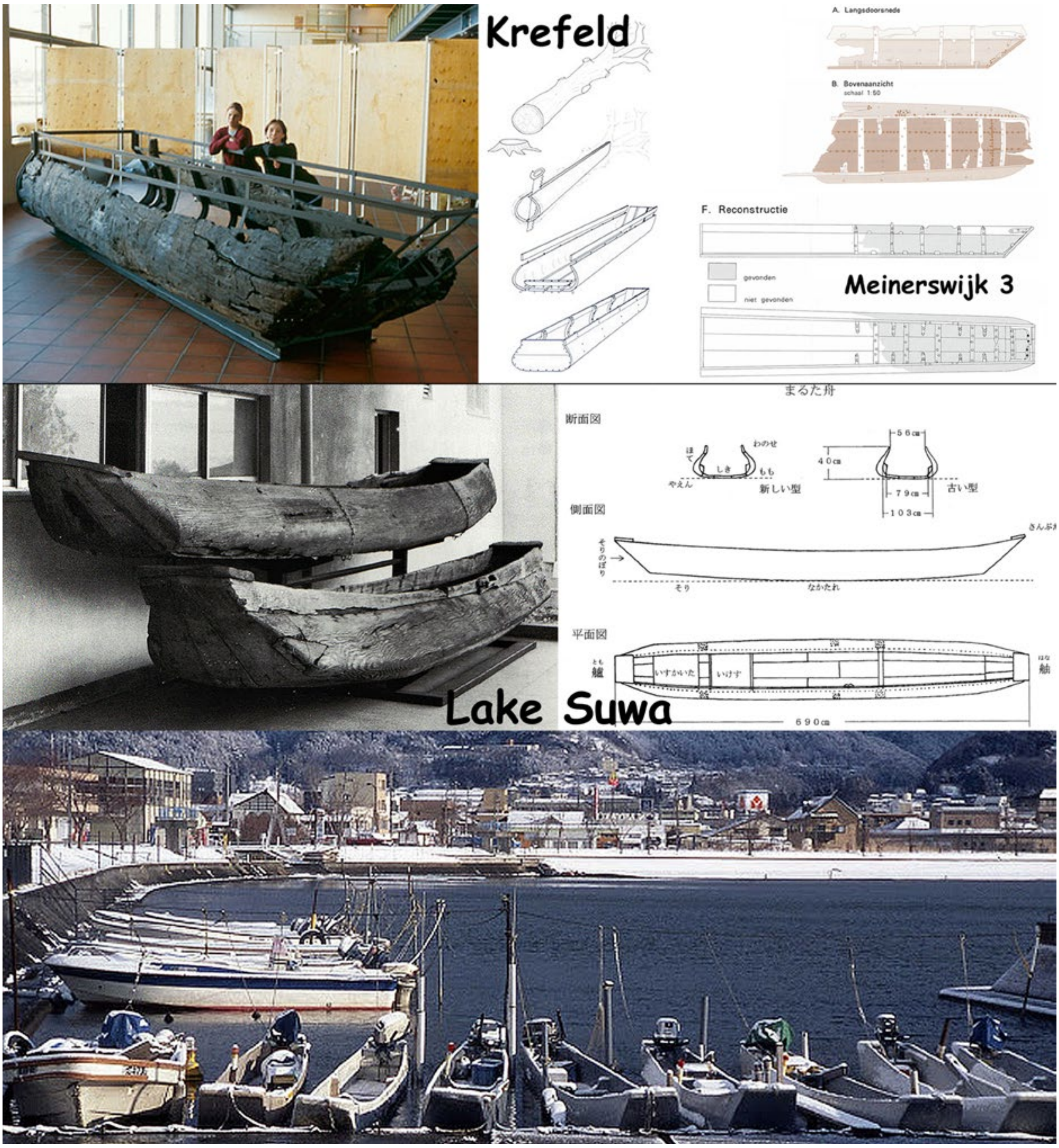

Figure 5. Top: Oberlander boat or Krefeld-Gellep II (left and middle) and Meinerswijk 3 (right) are clearly from same regional boat building tradition, but the similarity to the construction of *notranjski drevák* is not as apparent. Middle left, and right: *Suwaku maruta-bune* (諏訪湖まるた舟) or Lake Suwa logboat are a Material Folk Cultural Property of Nagano Prefecture (Listed 21 March 1968), held in trust by the town municipality of Shimosuwa. They can be visited at the Lake Suwa Museum and Akahiko Memorial Museum Ushiyama Tengai (牛山天外). 1902 *Suwa Onbashira-shi* 諏訪御柱史 (History of Suwa's Onbashira). Kamisuwa: Horita Matsuzō (Seibundō). Photo by SBSI, (Shimosuwa-machi Bunkazai Senmon Iinkai). Shimosuwa-machi no bunkazai 下諏訪町の文化財 (Shimosuwa's Cultural Heritage) Rev. Edition. Shimosuwa: *Shimosuwa-machi Kyōiku Iinkai*. 2003: 132). Bottom: Contemporary aluminium incarnations of the Lake Suwa boats, not quite abandoned here in the early winter of 2006-7, before the ice and thaw. Photo by Ann Bayly, viewed 30 January 2017 <http://blog.sdrobertson.org/2013/02/the-abandoned_22.html>.

Oberlander boat. However, this should not be surprising since both boats were found in the Rhein River basin within just 130km of each other, and both are dated to the 12th century. We can see that such constructions are a regional type of medieval boatbuilding tradition in the Niederrhein and Deltarhein regions of northern Europe.

However, the traditional shape and construction of an extended logboat from Lake Suwa near Nagano in Shinano province in Japan (Figure 5, middle-bottom) is indeed amazing. The underlying approach to boat-building is much closer to the *notranjski drevák* than any other boat found in Europe. As we can see, we also have the L and/or C formed chine-girder as well as the boat side and gently longitudinal bilge angle in the bow and stern.

This close similarity between two boatbuilding traditions in entirely different cultures on opposite sides of the Earth is astonishing. The similarity in construction challenges us: are these two boat-building traditions with long histories in each region developed independently, or did they influence each other and if so, how?

Finally, we found one small detail of a chine-girder/bottom planks butt scarf nailing technique on a shipwreck from the 19th century (Reitmaier 2008: fig. 81), which is very similar to the one in *notranjski drevák* as well as that one from Lake Suwa and Lake Ohrid (Figure 6, top). There is no other similarity with other boat constructions, while the transporting plank boat from Altenwörth in Donau River, not far west of Vienna, has an entirely different shape and function (Figure 6, middle).

Significant new evidence in the region

In recent years, underwater archaeological research in the Ljubljanica River and Kupa River near Karlovac in Croatia has resulted in the discovery of a Roman shipwreck, which in construction is not precisely the same as *notranjski drevák.* However, there are some important details that are forcing us to rethink the origin of the *drevák*. We need to find out whether this construction method, which today is considered traditional, actually developed here in the eastern hinterland of the northern Adriatic Sea and the upper Ljubljanica River basin and Kupa River basin, rather than in the Po River basin as previously thought.

The tradition of logboat hollowing is very rich, at least in the area of the Ljubljana Marshes, and has been present in this region for more than 5000 years. Upon the arrival of the Romans in the 2nd century BC, the region developed one of the four local practices known to shipbuilders of the influential North Adriatic Celtic-Roman tradition of shipbuilding: cargo ships with a flat bottom (Erič *et al.* 2014: 213). One detail which has attracted our attention on the cargo ship from Sinja Gorica is the so-called '*chine-girder*', which connects one part of the bottom with the ship's side. In the Celtic-Roman shipbuilding tradition, the chine-girder was an essential element in the construction of the ship, which was mostly V, L or C-shaped at its cross-section.

Chine-girders could be designed as a smaller part to join a boat with bottom and side plank thicknesses not exceeding exceed 3–4cm (e.g. barge from Lipe; Gaspari 1998a and 1998b: fig. 10). However, they could also be shaped to a very robust cross-sectional thickness of 4–5cm, and even up to 7cm (Figure 6, bottom-right).[5] Flat-bottomed ships, built in the Celtic-Roman shipbuilding tradition for transportation on lakes and rivers across Europe were oval or polygonal in shape. Ranging usually from 18 up to 40m, the structural joining elements were diverse—sewn, iron and bronze clamps, wooden nails and mortise and tenon techniques (Gaspari 1998a).

The flat-bottomed barge from Lipe was recorded by Alfons Müllner (1890a, 1890b and 1892) in 1890, and more than 100 years later in a survey by Andrej Gaspari (1998a and 1998b). As seen in Figure 6 (bottom-right), the flat-bottomed ship from Lipe, due to the construction characteristics (the chine-girder is slender and adapted reasonably to a thinner bottom and side planks of 3cm) could not be the reason for the comparison with *drevák*. Then there was the discovery of the flat-bottomed ship from Sinja Gorica in 2008. Research in 2012 into its construction showed it to have very different characteristics from the barge from Lipe. It was a great surprise that a very robust construction and foremost cross-section L-shaped chine-girder were documented, comparable to the other very rare similar solution. The tradition of the *drevák*, present on the Ljubljana Moor until the middle of 20th century, was well established. It was now possible for the first time to assume that the boatbuilding tradition of the *drevák* on the basin of the Ljubljanica River, as we know it today, dates back before the 17th century.

The second case, which requires further examination, is a discovery, not yet fully explored, of a new flat-bottomed Roman cargo ship from the second half of the 1st century AD loaded with a cargo of bricks in the Kupa River in the village of Kamensko near Karlovac

Museum voor Scheepsarcheologie, Rijksdienst voor de IJsselmeer-polders; Kartografie W.A.

[5] e.g. ships from Sisak (Erič *et al.* 2014: figs 29, 31; Gaspari, Erič and Šmaljcelj 2006), De Meeren 4 (Bockius 2011: fig. 4) Woerden 1 and Yverdon-sur-Bains 1 (Bockius 2000).

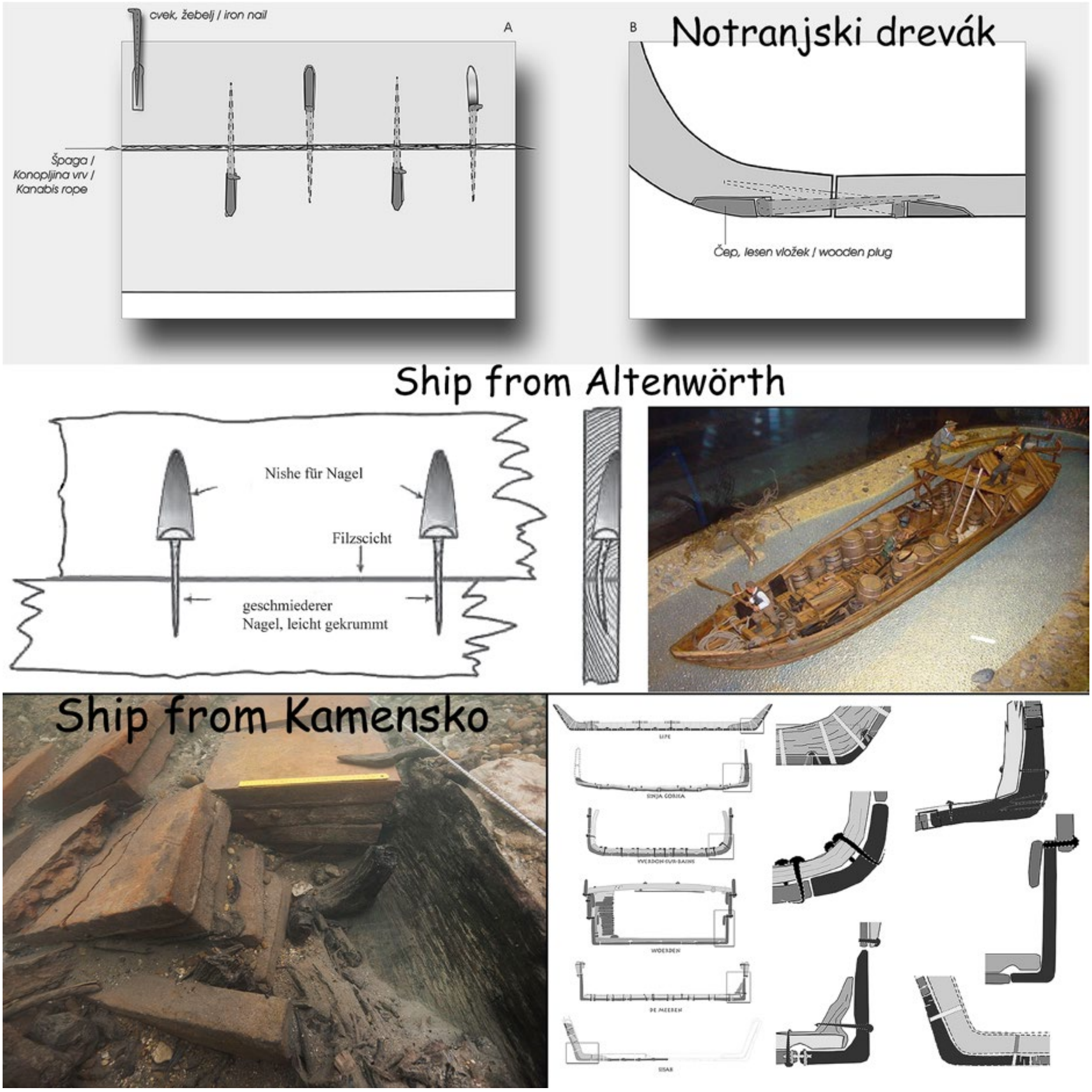

Figure 6. Nailing techniques are the same in the case of a ship from Altenwörth as *notranjski drevák*. The only difference is that in the case of the ship from Altenwörth (Reitmaier 2008: fig. 81) the nailing process was done from the inner side of the boat, and in *notranjski drevák* from the outside (top and middle). Bottom right: Comparison of flat-bottomed Roman ships from the Lipe, Sinja Gorica, Yverdon-sur-Bains, Woerden, De Meern and Sisak (Erič *et al.* 2014: fig. 31). Bottom left: On the image of a Roman ship from the 1st century AD from the Kupa River in Kamensko near Karlovac (Croatia) the open L-shaped cross-section of chine-girder is clearly visible. Photo by Loïc Dammelet (CNRS, CCJ, 2016).

in Croatia.[6] After the second season of research, it can be confidently stated that the ship from Kamensko has constructional details that are comparable to the flat-bottomed ship from Sinja Gorica and the *notranjski drevák*. We can conclude that the *drevák* comes from the Celtic-Roman shipbuilding tradition native to the Ljubljanica and Kupa River basins. The ship is about 2m wide; it has a flat bottom and by some estimates could be as long as 16m. However, what is very surprising is that the chine-girder is robust and open L-shaped in cross-section (Figure 6, bottom-left).

[6] The excavation on the Roman shipwreck with a cargo of bricks on the Kupa river at Kamensko is directed by Kruno Zupčić of the HRZ and Giulia Boetto, Senior Researcher, Aix Marseille University, French National Centre for Scientific Research (CNRS), Centre Camille Jullian (Aix-en-Provence, France) and is mainly supported by the Ministry of Culture of the Republic of Croatia and the French Ministry for Foreign Affairs.

The ships from Sinja Gorica and Kamensko are of a different size than the *drevák* but are very similar in structural features and details, particularly the chine-girder, one of the most important components of the ship. All the vessels have a flat bottom and the chine-girder was hollowed out with an L cross-section (Kamensko and Sinja Gorica). It is robust and in both cases represents at least two-thirds of the height of the ship—the full height of a *drevák*—and in between them, they laid flat-bottomed planks. The chine-girder is a vital part of the vessels and gives them essential navigating characteristics.

Discussion

It is likely that the *notranjski drevák* constructions were endemic, indigenously developed in the eastern hinterland of the northern Adriatic Sea. This area is the region where the karstic Dinaric mountain range runs from the Soča River through the karst region of the Velebit mountains only a few kilometres east of the coast of the eastern Adriatic Sea. It represents the hinterland of the western side of the Danube River basin, including the Ljubljanica River basin and Kupa River basin, which are separated from each other by a distance of less than 100km.

The visual sources (engraving, photography) from the last few centuries and the testimony of knowledgeable witnesses allow us to conclude that the *notranjski drevák* was in regular use on the Ljubljana Marshes, Planina Field, Lake Cerknica and Lož Valley until the first half of the 1960s.

Today's name *drevák* is relatively new and coexists with other names for the boat. There is a sense that the name *drevák*, the production of which is described in this paper, came into use only in the last few decades to describe the constructional and technical characteristics of the boat for farming, fishing and hunting utilised in the Ljubljanica River basin. All indications show that the term caught on when Slovenian parish priest and novelist Janez Jalen wrote the book *Bobri* ('*Beavers*' in English) in 1943. Janez Jalen wrote stories about the inhabitants of prehistoric pile-dwellings on the Ljubljana Marshes, where his term for the generic logboat used by the residents for at least the last 5500 years on the Ljubljana Marshes, was *drevák*, which etymologically we can translate as 'tree boat'. We consistently find in Slovenian literature, from the 16th until the first half of the 20th century, the term 'čoln izdolbenec' (English: 'dugout boat'), used for a vessel with the generic name 'logboat', which is a boat dug out from one tree trunk. We can assume that Janez Jalen, because of the needs of the novel, invented a more poetic name for a 'čoln izdolbenec', which sounds rather rigid in Slovenian, so he 'proposed' the name *drevák.*

Etymologically, the term *drevák* for a boat from one trunk is questionable. The word *drevák* for a boat hollowed out from a tree trunk as in Janez Jalen's book, has in recent decades also been applied to the logboat as a false generic name. This name has also been used for a particular type of extended logboat, which locals simply called 'boat' before many other, newer, types of boat began to be used on Lake Cerknica. To be precise, the generic name in the Slovenian language for a boat made from one tree trunk is *deblák*, which is etymologically close to terms in other languages, such as 'logboat', *einbaumler* (German), *stammebåd* (Danish), etc. Moreover, for that particular autochthonous extended logboat, we started to use the personal name *notranjski drevák*, as a generic type of extended logboat. Then there is the widely known term 'dugout canoe'. This term is a tautology because both terms 'dugout' and 'canoe'[7] describe the same action: carving wood from the middle of a tree trunk.

The newly established name is however suitable, because the *notranjski drevák*[8] is clearly distinct in construction from other older wooden boats, for example, the plank boat, and the new types of boats made from modern materials (contemporary canoes, kayaks, dinghies, fishing boats, etc.).

Notranjski drevák is therefore not a boat from one trunk such as a logboat but most often consists of eleven parts. The construction technique and details—from the selection of trees to the launch—is today passed down orally from generation to generation, usually by boatbuilders and sometimes farmers. The *drevák* as we know it today, along with its components and boatbuilding techniques, comes from an oral tradition known at least since the mid-19th century.[9]

It should be emphasised that the *notranjski drevák*, along with other types of vessels, has an important economic and social role. On the Ljubljana Moor and the Ljubljanica River between Ljubljana and Vrhnika, boats followed an incredibly important trade and transportation route between Vienna and Trieste

[7] Canoe. (n.d.). Online Etymology Dictionary. Retrieved January 27, 2017, from Dictionary.com viewed 12 February 2017 <http://www.dictionary.com/browse/canoe>: '1550s, originally in a West Indian context, from Spanish *canoa*, a term used by Columbus, from Arawakan (Haiti) *canaoua*. Extended to rough-made or dugout boats in generally. Early variants in English included *cano*, *canow*, *canoa*, etc., before spelling settled down c.1600.'

[8] The term for this particular type of extended logboat construction in the Ljubljanica River basin was adopted in the years 2014 and 2015, during the preparation of the dossier for inclusion of the *notranjski drevák* on the List of Intangible Cultural Heritage of Slovenia.

[9] Boatbuilder Anton Lovko said that his grandmother, born in 1860, told him that she was already in her early youth aware of such boats. (Interview from 5 May 2015).

(including Idrija), in the absence of road networks in past centuries.

Before the construction of a modern railway and road network in the 19th century, the Ljubljanica River was for at least two millennia the most significant traffic and transport artery on the Ljubljana Moor, as attested by numerous written and visual sources. This includes Roman roads, the later accelerated road construction starting in the 18th century, and finally in 1856 a railway line built by the Ljubljana Moor as a part of the Austrian Southern Railway. However, boating on the Ljubljana Marshes, where the *notranjski drevák* was in extensive use (along with logboats and other ships), slowly died out. Still, the local economic, fishery and social needs maintained the *drevák* until the 1960s. In the last millennium boating traffic was frequent between Vrhnika and Ljubljana, mainly for the transport of building materials. The famous Vrhnika brickworks transported bricks, and from Podpeč stone, lime, and wood were transported into Ljubljana and further south by the Sava River.

Conclusion

In the case of *notranjski drevák*, we have asked more new questions than we have answered. We have initiated new research questions into the provenance of this particular kind of boat-building construction. Carving of C or L-shaped chine-girders, the gentle curve with longitudinal bilge in the bow and stern, chine-girders being joined to bottom planks by horizontal nailing into the planks, etc. are all parts of a long-lived and growing shipbuilding tradition. New evidence from the Ljubljanica River basin and Kupa River basin has given us an opportunity to conclude that this particular boat-building tradition originated more than 2000 years ago, probably from the Celtic-Roman shipbuilding tradition. However, we are left with one open and unanswered question: why are there similarities in a type of extended logboat in entirely different regions of the world: Slovenia, China, Japan and Macedonia?

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The Ribadeo Shipwreck (*c.* 1600): Can We Identify the Ship Through a Multidisciplinary Approach?

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Abstract

During dredging works in the Ribadeo estuary of north-west Spain, in 2011, a large and well-preserved shipwreck was discovered. Construction features suggested a date for the ship in the late 16th century, making this wreck a remarkable find for Spanish heritage, as it is one of the best-preserved shipwrecks from that time ever found in Spanish waters.

Dendrochronological research on 29 samples retrieved in 2012 failed to produce dates for the timbers; consequently, the exact date of the ship and its possible construction location remained unknown. In 2015 additional archaeological survey works were planned for the site in order to document further exposed structures of the shipwreck, and to collect additional samples for dendrochronological research. Simultaneously, historical research was conducted in Spanish archives to search for documents referring to the wreckage of ships in the Ribadeo estuary in the 16th and early 17th centuries.

The results of this multidisciplinary research have led to the hypothesis that the shipwreck could be the *Santiago de Galicia* galleon built at Castellamare di Stabia, near Naples, Italy, in the late 1580s or early 1590s, and sunk in Ribadeo in AD 1597. Dendrochronological dates obtained for two planks date the construction of the ship after 1580. Construction features of the shipwreck have been compared to those reported in 16th-century documents for the *Santiago de Galicia* galleon; and, the potential limitations of our methods for identifying the shipwreck are discussed.

Keywords

Shipwreck, shipbuilding, forest resources, timber supply, dendrochronology

Introduction

In 2011 dredging works in the Ribadeo estuary of north-west Spain led to the discovery of archaeological remains of an ancient wooden vessel (San Claudio Santa Cruz *et al.* 2013). The Ribadeo shipwreck was found at a 4.6m depth in a strong tidal area. After observing numerous wooden remains exposed by the dredging works, archaeologists discovered the structure of the hull preserved in its original shape. The shipwreck corresponded to a vessel with a length of 32m and width of 9.38m, giving a length to breadth ratio of 3.41 (San Claudio Santa Cruz *et al.* 2013: 210). During the 2012 survey archaeological evidence suggested that it was a warship, as its hull was covered in lead, the ship carried artillery and stone shot, and had caulked decks below the waterline, that would enable the ship to float if shot below the floating line (San Claudio Santa Cruz *et al.* 2013). The planking thickness of the outer hull and the scantlings of the beams and futtocks also indicated that the ship was a large military vessel. All these features lead to the hypothesis that the ship may have been a galleon (San Claudio Santa Cruz *et al.* 2013). Samples were taken from different construction elements for tree-ring analyses, but these failed to provide absolute dates for the timbers. Therefore, the exact date of the ship, as well as the possible construction location remain unknown. However, structural and artefactual

Figure 1. View of a deck and bulwarks still joined together between some stone shot and wooden cask remains.

information retrieved from the remains of the ship (stone shots, ceramics and breech loaders) suggested a possible date of late 16th or early-17th century.

In 2015 a new archaeological survey was carried out promoted by the ForSEAdiscovery project (www.forseadiscovery.eu) to further document the shipwreck, and obtain additional dendrochronological samples for tree-ring analyses. Concurrently, historical research was conducted at Spanish archives for information about 16th and 17th century shipwrecks in the Ribadeo estuary. The goal of this multidisciplinary approach combining history, maritime archaeology and dendrochronology was to attempt to identify the Ribadeo shipwreck (Figure 1).

The first lead towards the identification of the ship

In June 2015 the discovery at the Municipal Archive in Ribadeo (RMA) of a document dated 13 November 1597 provided the first clues about the possible identity of the shipwreck under study. According to the minutes of a meeting of the municipal council, 'the *Santiago* galleon and two *urcas* from the royal navy' had arrived in the harbour of Ribadeo, badly damaged and loaded with infantry and horses (RMA, *Libros de Actas,* 6 [1595–1611], fs. 49). The crew went to the village begging for food, so the municipal council resolved in this document to provide the infantry with bread. Two other documents in this archive, one from 20 February 1598 (RMA, *Libros de Actas*, 6 [1595–1611], fs. 56a-56r) and another one from 8 November 1599 (RMA, *Libros de Actas*, 6 [1595–1611], fs. 82r-84a) referred to the *Santiago* galleon as the '*Santiago de Galicia*' galleon, in relation to the good deed of the village of Ribadeo in supplying the infantry with victuals.

During the research, significant progress was made in identifying three potential vessels that had sunk in the estuary within a narrow range of seven years (1597–1604). According to the historical data, the earliest vessel noted was the *Santiago de Galicia*, sunk in November 1597—a galleon built in Naples as part of the 12-galleon fleet of Pedro de Ivella and Estefano Dolisti (RMA, *Libros de Actas*, 6 [1595–1611], fs. 49). The second vessel was an *urca* sunk in December 1597; it arrived with the galleon *San Francisco de Paula* lost from the fleet of Aranburu (AGS, GYM, leg. 492, doc. 178). Finally, the third vessel was the caravel *Santiago* lost in October 1604 (RMA, *Libros de Actas*, 7 [1604], fs. 133a–133r).

Archaeological construction features of the Ribadeo shipwreck

In 2015 new archaeological survey and documentation works revealed that the wreck was very well preserved from the main deck downward. The diagnostic timbers exposed were measured: first or second futtocks are 24cm sided and 24cm moulded; the planking is 12–15cm thick; and the main wale 15cm sided. Inside the hull, all along the starboard side, is a girder attached to the frames with the same thickness than the planks, so that the hull planks, the frames, and the girder are around 54cm thick. There is no doubt that such thick planks provide a massive and solid structure for the hull and contribute to the robustness of the vessel. The planks seem to have been sawn tangentially, and they are pieces of great quality and good manufacture.

The most remarkable aspect of this site is the extensive preservation of construction timbers, mostly in their original positions. The hull is deeply buried in sediment, and the soft mud that filled the wreck immediately after the sinking contributed not only to the preservation of the structural timbers and archaeological artefacts, but also the original position of such elements in the ship's structure. Such conditions allow the hull to be near vertical, and show the stem as if the shipwreck was ready to sail away. On this stem, the rabbet carved on to receive the hood ends of the hull planks is still visible.

One breast hook is still attached horizontally inside the bow. Directly over this breast hook lays the forward part of a deck, still covered with pitch and with its planks caulked exactly as Alvaro de Bazán the Elder indicated that ships for the crown should be constructed with a watertight deck below the flotation line (Fernández Duro 2007: 15). This deck feature, characteristic in Spanish ships of the 16th century, is documented in the construction of galleys and galleons (O'Donnell and Duque de Estrada 2003), although this is the first time that it has been empirically documented in a shipwreck. The forward part of the deck is carved to fit around the apron and the contact between them is also caulked.

Another remarkable characteristic is the presence of several transversal bulwarks. They are made of oak planks, almost all of which exhibit an 'L' shape along their longitudinal edges, most probably to ensure a close fit between adjacent planks in the bulwark. The planks are fixed with vertical shores, some of which are still attached, probably to the frames, under the sand in the bilge. In one case, one of the shores seems to be associated with a beam attached to the starboard side. Some beams are partially preserved and have been documented on the starboard side of the wreck. Not all of them were used to support a deck. Some beams seem to have been used more as structural reinforcements, as they are very close to but lower than those used as deck beams. All these structural elements, except for the bulwarks, were fastened using iron nails, although most of them have since corroded away; no treenails were found.

The hull below the waterline is lead-sheathed presumably to avoid biological fouling of the hull and to protect the timber from shipworm. The sheets are directly attached to the hull with square iron nails, most of which have corroded.

Between the central ballast pile and the stern, an assemblage of balusters was found, which maintain a peculiar spiral arrangement that seem to correspond to a spiral staircase, although this has not been confirmed. Manufactured from turned wood, these are very unusual elements in wrecks of the time because this type of fittings, being pieces of limited size and weight, usually do not survive a wrecking. On the other hand, they are elements widely represented in pictorial works and surviving contemporary models.

Dendrochronological analyses on shipwreck timbers

In an attempt to place the construction of the ship in an absolute temporal context, samples from different timber elements were collected in 2012 when the shipwreck was first discovered (San Claudio Santa Cruz *et al*. 2013). In that campaign, 29 samples were retrieved both from structural elements and from timbers from inner compartments, banisters and cargo. The majority of these samples (19) corresponded to framing elements and bulkheads made of deciduous oak (*Quercus* subg. *Quercus*), but the non-structural timbers were of very different species, including spruce/larch (*Picea abies/Larix decidua*; two fragments of a bulkhead and a post), silver fir (*Abies alba*; two planks from inner compartments), chestnut (*Castanea sativa*; two elements of banisters), Scots/black pine (*Pinus sylvestris/nigra*; one plank), poplar (*Populus* sp.; bulkhead), and beech (*Fagus sylvatica*; one barrel stave) (San Claudio Santa Cruz *et al*. 2013).

Fourteen samples presented more than 70 tree-rings, and although this number is below that which is considered optimal for dendrochronological research (80–100 tree-rings), the samples were analysed. The results only revealed relative cross-matching between two oak samples and two spruce/larch fragments that derived from the same parent trees. The absence of more relative cross-matching between the oak timbers suggested different procurement areas, and recommendations were made to target more timber elements in future campaigns.

This opportunity arose in the archaeological survey carried out in July 2015 by the nautical archaeology team. Following the recommendations proposed by San Claudio Santa Cruz *et al*. (2013), new wood samples were collected for dendrochronological analysis, this time selecting exclusively structural timbers.

Table 1. Results of the tree-ring analyses. Species: 1, *Quercus* subg. *quercus*; 2, *Castanea sativa*; 3, *Fagus sylvatica*; 4, *Populus* sp.; 5, *Picea abies/Larix decidua*; 6, *Pinus sylvestris/nigra*; 7, *Abies alba*; 8, *Pinus* sp. (possibly *P. pinaster*). Pith: present (+1) / absent (-); bark edge: present (+, LW: latewood, EW, earlywood) / absent (-) / estimated; MRW: mean ring width (mm); σ: standard deviation (mm). Shaded rows indicate pairs of timbers originating from the same tree.

Sample number	Type of timber element	Species	Dendro-code	Nº rings	Pith	Sapwood	Bark Edge	MRW	σ
Samples collected in 2012									
M02	Inner plank	1	SGRW0020	97	-	0	-	2.17	1.02
M11	Fashion frame	1	SGRW0101	71	-	0	-	3.44	1.75
M05	Inner plank	1	SGRW0040	76(+1)	-	21(+1)	4+/-3	1.41	0.74
M06	Inner plank	1	SGRW0050	106	-	0	-	1.54	0.84
M15	Inner plank	1	SGRW0140	90	-	17	5+/-2	1.54	0.37
M09	Unknown	1	SGRW0080	109	-	0	-	1.21	0.36
M16	Unknown	1	SGRW0150	106	-	0	-	1.23	0.32
M10	Unknown	1	SGRW0090	145(+5)	-	26(+5)	7+/-2	0.90	0.35
M13	Forecastle beam	1	SGRW0120	58	-	23	+(LW)	0.88	0.28
M03	Bulwark	1	SGRW0030	47	-	0	-	1.30	0.33
M07	Bulwark	1	SGRW0060	44	-	0	-	1.52	0.81
M12	Bulwark	1	SGRW0110	43	-	0	-	1.46	0.47
M14	Bulwark	5	SGRW0130	110	-	?	-	0.93	0.29
M27	Loose Plank	5	SGRW0190	94	-	n/a	-	0.89	0.28
M?	Loose Plank	1	SGRW0010	90	-	0	-	0.65	0.16
M08	Loose Plank	7	SGRW0070	76	-	0	WK?	1.88	0.83
M17	Loose compartment	7	SGRW0161	95	-	n/a	?	1.29	0.36
M21	Unknown	6	SGRW0170	93	-	16	-	1.25	0.47
M23	Barrel stave	1	SGRW0181/2	52/45	-	0	-	0.83	0.16
M24	Stanchion?	2	n/a	25(+1)	-	n/a	+(EW)	-	-
M26	Barrel stave	3	n/a	44	-	n/a	-	-	-
M26	Treenail	1	n/a	16	-	0	-	-	-
M04	Starboard plank	1	n/a	10	-	0	-	-	-
M01	Unknown	1	n/a	38	-	6	-	-	-
M18	Bulwark	4	n/a	?	-	?	?	-	-
M19	Unknown	2	n/a	14	-	n/a	-	-	-
M22	Unknown	5	n/a	36	-	n/a	+(LW)	-	-
M28	Unknown	1	n/a	37	-	0	-	-	-
M29	Unknown	1	n/a	37	-	0	-	-	-
Samples collected in 2015									
RIB01-001W	Unknown	1	RIB00011	195	-	14	2+/-1	1.34	1.00
RIB01-002W	Plank	1	RIB00020	61	-	6	-	1.74	0.55
RIB01-003W	Unknown	1	RIB00031	33	+	12	+(LW)	4.45	1.30
RIB01-004W	Beam	1	RIB00040	81	+	10	-	2.50	1.31
RIB01-005W-01S	Wedge cut plank	1	RIB00050	87	-	13		1.98	0.70
RIB01-005W-02S	Frame						-		
RIB01-006W	Beam	1	RIB00060	228	+	44	2+/-1	0.81	0.46
RIB01-007W	Plank	1	RIB00071	50	-	0	-	1.38	0.34
RIB01-008W	Plank	1	RIB00080	84	-	8	-	0.93	0.24
RIB01-009W	Plank	1	RIB00091	51	-	0	-	2.52	0.83
RIB01-011W	Plank	1	RIB00100	121	-	0	-	0.75	0.27

Sample number	Type of timber element	Species	Dendro-code	Nº rings	Pith	Sapwood	Bark Edge	MRW	σ
RIB01-012W	Frame	1	RIB00110	63	+	17	2+/-1	1.65	0.72
RIB01-013W	Barrel top	1	RIB00121	95	-	9	-	1.08	0.20
RIB01-016W	Beam	1	RIB00130	94	+	25	-	2.14	1.12
RIB01-017W	Chocking timber?	1	RIB00140	52	-	0	-	1.35	0.75
RIB01-018W	Frame	1	RIB00150	202	-	39	2+/-2	1.01	0.52
RIB01-020W	Wale or outboard plank	1	RIB00160	79	+	0	-	1.71	1.06
RIB01-010W	Plank	1	-	13	+	0	Very fast grown, not suitable dendro		
RIB01-014W	Plank	6	-	20	-	20?	Fragment radial plank, slow grown; potential dendro		
RIB01-015W	Stanchion	8*	-	16	-	0	Very fast grown; not suitable dendro		

*Identification proposed by Mª Oliva Rodríguez Ariza, dpt. Cultural Heritage, University of Jaen.

Samples and dendrochronological methods

In 2015 a total of 19 timber elements were sampled for tree-ring analysis. Samples were conserved in wet conditions inside plastic bags to prevent them from drying, then sent to the laboratory of botany at the University of Santiago de Compostela in Lugo, Spain.

A preliminary inspection was carried out to determine the suitability of these samples for dendrochronological dating. Ideally, samples should contain more than 80 to 100 rings to deliver statistically robust results, although samples with a lower number of tree rings can sometimes be considered suitable as well. However, given our objectives, which include the characterization of trees used during the early modern period for shipbuilding, some samples with as little as 30 rings were nevertheless selected as an exception for tree-ring analysis in order to acquire empirical data regarding growth rates of the trees used for specific elements of ships. To perform a ring count, the transverse surface of the samples was cleaned with razor blades from the inner to the outermost ring. The presence/absence of pith and sapwood were also recorded. Furthermore, this inspection served to identify some species that show distinct anatomical features in the transverse section, which make them distinguishable by the naked eye. Such is the case for example of the group of deciduous oaks (*Quercus* subg. *quercus*), which show large earlywood vessels placed in a ring-porous disposition and large multiseriate rays, or chestnut (*Castanea sativa*), which are very similar to the group of deciduous oaks, but lack these multiseriate rays (Schweingruber 1990). The identification of other species was done by cutting thin slices of wood with razorblades from the transverse, tangential and radial sections of the samples, and observing the anatomical features with an Olympus BX40 microscope. The identification key of Schweingruber (1990) was used to identify the species. Tree-rings were measured in selected samples with a TimeTable measuring device (University of Vienna) coupled with PAST5 software (SCIEM).

Wood identification and dendrochronological results

Seventeen samples were identified as deciduous oak (*Quercus* subg. *quercus*) and two as pine (*Pinus* sp.) (Table 1).

The oak sample RIB01-010W and the pine samples RIB01-014W and RIB001-015W were discarded for further research as they contained 13, 20 and 16 rings respectively.

On this occasion, ten samples presented more than 70 rings, and five presented the bark edge (last ring under the bark corresponding to the cutting year), or partial sapwood.

Combining these samples with the ones collected in 2012, the final dataset consisted of 48 samples, most of them representing structural elements made of oak. More than half of the samples (53%) contained 70 tree-rings or more, but only 19% surpassed the optimal number of 100 rings (Figure 2).

Cross-dating between the samples failed to produce internal crossmatches, which reinforce the hypothesis that the timber may have originated from different procurement areas (San Claudio Santa Cruz *et al.* 2013). This hypothesis is also supported by the disparity in growth patterns of the oak samples, with some showing

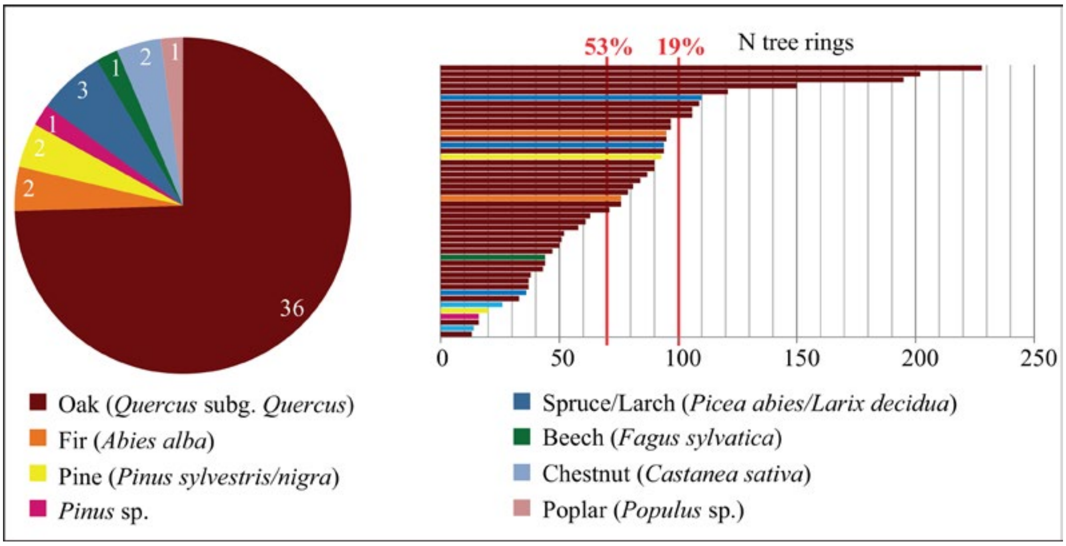

Figure 2. Results of species identification (pie chart) and number of tree rings (bar graph) present in the Ribadeo samples collected in 2012 and 2015.

mean ring widths of 0.65mm, and others as much as 4.45mm (Table 1). Using dendroprovenance to try to identify the place where this ship was built is therefore highly problematic.

The comparison of the oak, pine, spruce/larch and silver fir tree-ring series with European reference chronologies, including the newly developed oak chronologies for the Cantabrian Mountains, produced successful results for the silver fir samples, which cross-dated with chronologies of this species from Central Europe developed by Büntgen *et al.* (2011). The fir timber M17 (SGRW0161) dates to 1570 (outermost preserved tree-ring), whereas the outermost ring on timber M08 (SGRW0071) dates to 1580. None of the samples contains the last ring under the bark, therefore, these dates can only be considered as *terminus post quem* (date after which the tree was cut). The chronologies dating these samples represent wide areas in Central Europe, therefore, it is not possible to pinpoint the provenance of this silver fir wood. The oak, pine and spruce/larch samples remain, for now, undated.

Building up a hypothesis

At this point three scenarios were clear:

- Three ships sunk in the estuary between 1597 and 1604: the galleon *Santiago de Galicia*, an *urca* and the caravel *Santiago*;
- The shipwreck corresponds to a galleon based on the construction features and associated artefacts found in 2011;
- This ship was built after 1580 with wood from different sources, as inferred from the dendrochronological research.

The overall evidence of the wreck in the estuary was pointing towards the remains of a heavily armed vessel of the late 16th century, therefore, the *urca* was initially discarded. *Urcas* are known to be northern merchant vessels, but the outstanding scantlings of the framing and dimensions of the planking of the Ribadeo shipwreck suggested that this was a military ship, heavily built and armed, and caulked with watertight decks (San Claudio Santa Cruz *et al.* 2013). These construction features should in principle eliminate the caravel as well, because in Spain they were typically small and light vessels (Martínez Hidalgo 1957). However, it is worth noting that the names of types of ships varied from one place to another. In 1565 Fernando Oliveira said 'The names of species, or manners, of ships and boats, of one type or another, are almost incomprehensible, as much because there are so many of them, as because there have been many changes over time and from place to place; the same species of ship or boat will have one name in Spain, another in France and another in Italy. In Spain they call *naos* what in Italy are called carracks, and in Germany hulks' (quoted in Rahn Phillips 1986: 39). Therefore, the caravel Santiago documented to have sunk in the estuary on 1604 could have had different construction features than those typically exhibited by Spanish caravels.

Given this scenario, additional aspects were considered to develop a hypothesis. In terms of the time frame and considering some of the artefacts associated with the shipwreck, the wreck of Ribadeo seems to be connected with the failed fleet of 1596, which lost several ships off the coast of Galicia, particularly in the area of Finisterre. One of these ships is the Punta de Restelos shipwreck (Casabán Banaclocha *et al.* 2013) from which some breech loaders were recovered similar to those found on the Ribadeo shipwreck. Furthermore, some of the breech loaders from the Ribadeo shipwreck perfectly fitted in cannons found in Punta de Restelos wreck, suggesting a similar context of origin and supply of the artillery for both ships (Casabán Banaclocha *et al.* 2013). Therefore, having considered all these factors and research findings, it has been hypothesised that the Ribadeo shipwreck is the *Santiago de Galicia* galleon.

Historical research on the *Santiago de Galicia* ship

In order to reveal whether the identity of the Ribadeo galleon could be the *Santiago de Galicia*, further historical research was conducted at the Archive of the Museo Naval de Madrid (AMN) and the General Archive of Simancas (Archivo General de Simancas, AGS), in search of documents relating to the history and the construction of that specific ship.

How and where was the ship constructed?

Spanish primary sources and contemporary bibliography allowed us to cross-match historical information from data collected at Spanish archives and information published by other researchers, mainly Thompson (1976). The sources of Consejo de Guerra y Marina (GYM) and Contaduría Mayor de Cuentas (CMC) stored at the General Archive of Simancas (AGS), and those of the Archive of the Naval Museum in Madrid have been the primary historical sources researched in Spain.

The outcome of this investigation revealed that in 1589, the Ragusan (Dubrovnik, Croatia) captains Pedro de Ivella and Estefano Dolisti, proposed to the Spanish monarch the construction and outfitting of a squadron of 12 galleons of 700 tons each, seven of which were already under construction in 'Ragusa, Gravosa, Isola de Mezzo, Castellamare et Vietri' (AGS, GYM, leg. 303, doc. 29). These captains had served in the fleets of the Spanish Monarchy since the 1560s. In return, Spanish King Philip II would pay in the realm of Naples the money that the Spanish Monarchy owed them (AGS, GYM, leg. 303, docs 10, 11, 13, 15). It is most likely that the King funded these fleets with revenues from the realm of Naples, although it is not possible to state whether the funding originated from incomes of the Kingdom of Naples, or from elsewhere. Probably a combination of both occurred. As the captains would own the ships, the King agreed in 1593 to pay them a fee and income for serving with those galleons within the royal fleets of the Spanish Monarchy (AGS, GYM, leg. 303, doc. 20).

Ragusans were skilled seamen in both the Atlantic Ocean and the Mediterranean Sea (Carter 1971), and in the spring of 1589 the Spanish Council of War discussed the possibility of accepting the offer of the captains to construct the 12 galleons (AGS, GYM, leg. 303, docs. 10, 11, 13–18). The Monarchy was willing to build warships in order to strengthen its naval power (Thompson 1976; Wing 2015) and the ministers were open to the suggestions brought by the captains. The Council of War agreed to construct and outfit a 12-galleon squadron, which would be composed of seven new vessels, completed with five galleons selected from the Ragusan fleet (AGS, GYM, leg. 303, docs 11, 16, 27, 28). The Council planned to construct two light galleons in Naples 'according to the measurements and features of the English', and the remaining ships in Castellammare di Stabia, a shipyard located around 30km south of Naples (AGS, GYM, leg. 303, doc. 12).

In May 1589, the Council of War had stated that the fleet was 'going to be one of the best squadrons of Your Majesty's fleets' (AGS, GYM, leg. 303, doc. 15), and a month later Philip II accepted the proposal. Around this time, Pedro de Ivella and Estefano Dolisti stated that seven galleons were under construction in 'Ragusa, Gravosa, Isola de Mezzo, Castellamare et Vietri' (AGS, GYM, leg. 303, doc. 29). In October the Council of War delivered the proposal of the Ragusan captains for constructing and outfitting these 12 vessels in more detail, stating again that seven of the 12 vessels should be new constructions (AGS, GYM, leg. 303, doc. 11, October 23, 1589. Further details in doc. 17). Disclosure and signature of the contract took place on the 20 February 1590 (AGS, GYM, leg. 303, doc. 20.), but the document stated that of the 12 galleons, only six instead of seven would be of new construction. The contract specified the duties and rights for both sides. The captains committed to the production of a squadron composed of twelve warships to serve the King for an initial period of five years. The construction contract ran from 1 January 1590 to December 1594, and the captains outfitted the fleet (including the artillery, rigging and recruitment of a crew of 20 people per 100 tons) within four months of having received the notification by the King's officers being similar to other contracts (Goodman 1997: 30–32, 126–129; Thompson 1976: 200–205). Finally, the captains and their associates agreed on building six new galleons, instead of the seven they had offered initially (AGS, GYM, leg. 303, doc. 20, clause 11) and lease them to the King (Clauses 1, 2, 11). In return, Ivella and Oliste would be appointed general captain and admiral respectively of the squadron, under the command of the general captain of the fleet, and would receive a monthly income in Naples (Clauses 6, 12).

In October–November 1590 captain Ivella departed Madrid for Naples, from where he wrote letters providing information regarding the construction process. In January 1591 three galleons capable of sailing the Atlantic were launched, and construction of the remaining four was near completion. Trees were felled for their timber during the waning moon of January 1591 and seasoned in February for the construction of the two additional galleons, following the English measurements, with the expectation that this design would produce vessels with an extraordinary sailing speed (AGS, GYM, leg 317, doc. 194 and leg. 318, doc. 176). The construction of these ships continued in May, and finished by July of that same year (AGS, GYM, leg. 321, doc. 324). Thus, it is most likely that Pedro de Ivella and his partners constructed seven new galleons in 1591. By 1594, nine of the 12 galleons had been constructed or outfitted (AGS, GYM, leg. 303, docs, 470-471).

According to the historical sources stored in AMN, the wood used for the construction of the ships, including the *Santiago de Galicia*, was sourced in different places: Monte Gargano in South Italy, nearby Napoli, and Albania supplied construction timber, but the masts originated from Calabria in the South of Italy, and the Peninsula of Istria (AMN, Colección Sans Baturell, Ms 396, art 5, nº 53, p. 225–226).

The performance of the squadron (1591–1597): from the shipyards to the seabed

The new squadron was most likely made up of 12 warships. However, in 1591 the ships were mainly used as merchantmen to carry wheat, wool and other commodities (AGS, GYM, leg. 324, doc. 213, 3 August 1591, Naples). In the ensuing year, it seemed that the ships remained inactive in southern Italy, a circumstance that Ivella could not afford because he needed funding, both to maintain associates close to him and also to ensure the economic viability of the squadron. Thus, in April 1593 he offered his ships to the Spanish Crown when he realized that the Merchant Guild of Seville (*Casa de Contratación*) had set up negotiations with the Genovese to build galleons to protect the Indian trade (AGS, GYM, leg. 387, docs 610–612, Naples 9 April 1591). Ivella channelled his pretensions through the Duke of Medina Sidonia who backed the captain by writing a long report supporting the convenience of electing the squadron of Ivella to protect the trade (AGS, GYM, leg. 387 doc. 609, 30 May 1593). In the meantime, Ivella continued offering the service of the squadron to the King. During the winter of 1594 Philip II issued orders to his viceroy of Naples to extend the original contract signed in 1590 with Ivella (AGS, GYM, leg. 388, doc. 301).

Consequently, the King had at his disposition a nine-galleon squadron, including the galleon *Santiago de Galicia*, which was acknowledged as the '*Almiranta*' of that squadron. Jacome Juan de Polo was the captain and owner of the vessel. The economic records of the ships, stored in Simancas, clearly state that Jacome Juan de Polo was enlisted by contract with the *Galleon Santiago* from 1594 to 1597 (AGS, Contaduría Mayor de Cuentas [hereafter CMC], 3º época, leg. 2556). From the outset of 1595 to July 1596 the captain received considerable funds from different hands in Naples, Seville and Lisbon to pay the crew, supplies and transportation of materials. During June and July 1596 carpentry works were carried out in Lisbon. In the accounts of these works many materials were specified such as 36 planks from Prussia, 96 planks of ordinary pine from Flanders, 12 squared pine sticks, two oak planks of 28 *codos* (a *codo* was 57.46cm), and 24 small pine bars. Don Rodrigo de Cieza, who held the office of *tenedor de bastimentos* in Lisbon, also provided a significant volume of pine and oak timber from July to October 1596. Amid others, the Spanish Monarchy paid 150 *reales* for 'an old pine from Corcubión of 33 *codos* in height and half wide' another 276 *reales* for 'a new pine, 30 *codos* long and two thirds of a *codo* wide, six from the feet, and six with half an elbow from the top' 150 *reales* for 'another new pine, 27 *codos* long and a third wide, measured at six *codos* from the top and six *codos* from the *coz*' (AGS, CMC, 3º época, leg. 2556). According to the economic records it is most likely that in October 1596 Juan Jacome Polo sailed from Lisbon to Galicia with the ships because that month in 1596 he received 220 ducats '*del pagador por cuenta de libranza del Adelantador Mayor de Castilla, pagador general de la armada*.' The Crown paid another 2.176 *maravedíes* for the carpentry works (*maestranza*) undertaken in El Ferrol (Galicia, Spain) from 6 to 27 April, 1597. Similar payments were made for further *maestranza* works undertaken in Ferrol from 28 April to 17 May, 30 June to 20 July and 10 to 30 August 1597 (AGS, CMC, 3º época, leg. 2.556).

Jacome Juan de Polo outfitted the ships in Lisbon, and they were consequently re-measured as they had been originally in Naples (AGS, GYM, leg. 303, doc. 20, clause 2).

In 1597 the galleon *Santiago de Galicia* was sailed through a huge storm, which dispersed a large part of the fleet that Philip II had sent out against England (AGS, GYM, leg. 490, doc. 431, 1597). The *Santiago de Galicia* was acknowledged as a very sturdy vessel and appointed to carry 91,000 ducats (Fernández Asís, 1943: 338). Afterwards Bernabé de Pedroso documented that the *Santiago* had reached the Eo estuary, together with two *urcas*, '...so damaged that it is likely a miracle, people on board came badly and ill as a result of the hard work they have had...' (AGS, GYM, leg. 491, doc. 190). Later it was learned that the galleon *Santiago de Galicia* had encountered four enemies and fought against the Flemish and English under their musketeer's fire (AGS, GYM, leg. 491, doc. 139). Damaged by the naval battle and fighting the storm, the *Santiago de Galicia* hit the sandbanks at Ribadeo and was beached although it was not considered lost by the authorities. The Crown sought to recover the coins and some of the supplies that were on board. It is most likely that this was done as some of the ministers of Philip II praised the cooperation of Ribadeo's inhabitants (AGS, GYM, leg. 491, docs 146, 226, 335). In November 1597 there were delivered payments in Ribadeo like the 1500 *reales* '*que Tomás Blanco capitán de este galeón recibió en la villa de Ribadeo de los dineros del cargo del pagador general Juan Pascual por mano de Lope García de Tinoco*' (AGS, CMC, 3º época, leg. 2556). In a letter sent to Philip II, Jacome Juan de Polo blamed the officers governing the vessel for their bad seamanship, which had led to the loss of the ship (Casabán Banaclocha 2015): 'Due to poor governance, the officers lost her in the village of Ribadeo.'

Construction features and proportions of the *Santiago de Galicia* galleon

An historical document describing the dimensions of the ship was found in the *Archivo del Museo Naval de Madrid* (AMN, Colección Sans Baturell, Ms 396, art 5, nº 53, p. 225–226) (Table 2, Figures 3 and 4). Dimensions given in this document are provided in *codos.* The measurement conversion used here is based on the 16th-century *codo de ribera* from northern Spain. This unit of measurement was the equivalent of 57.46cm (Casado Soto 1988: 58–67; Grenier *et al.* 2007: III, 17).

Table 2. Measurements of the galleon *Santiago de Galicia* as reported in the historical document.

Measurement	Codos	Metres
Keel	44.50	25.36
Weather deck	61.00	34.77
Carling	60.00	34.20
Beam	20.50	11.68
Depth	13.50	7.69
Flat of the floor timber	7.25	4.13
Aft Runs	7.50	4.27
Fore Runs	2.00	1.14

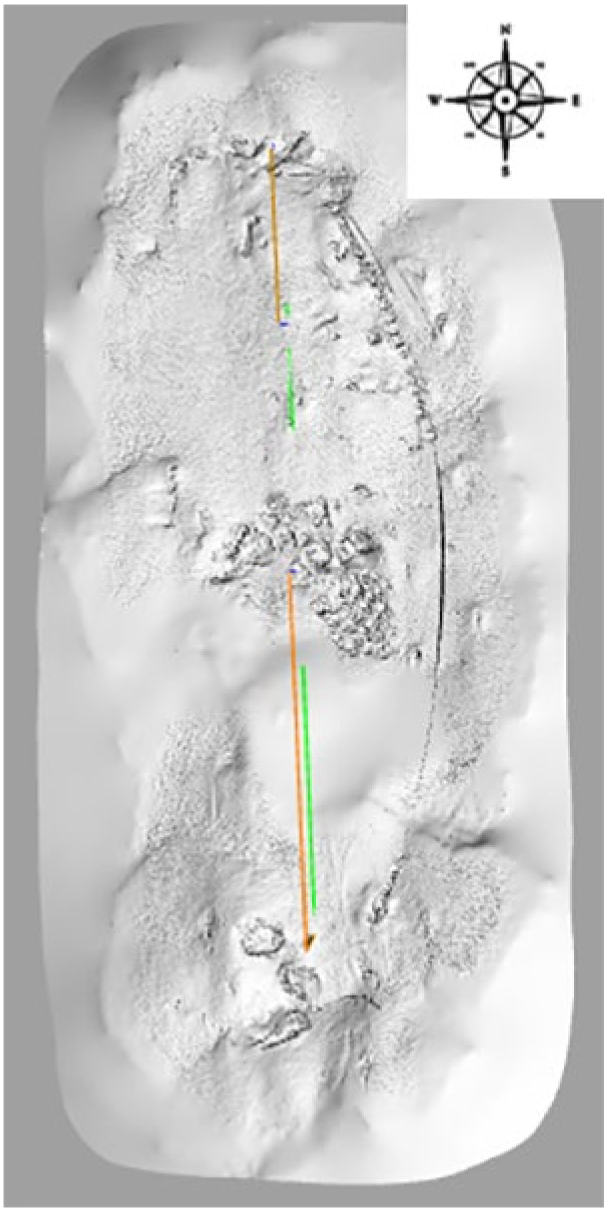

Figure 3. Photogrammetric model from above, matching the archaeological hull line of the Ribadeo wreck to the hull line of the hypothetical reconstruction of the Santiago de Galicia, based on historical documents.

According to the document, the 12-galleon fleet combined measurements from different origins following English, Bizcayan and Ragusan shipbuilding traditions. This means also that these shipbuilding traditions influenced the shape of the hull. In particular, the proportions of the *Santiago de Galicia* had a beam to keel ratio of 2.17, a length to beam ratio of 2.93, a depth to length ratio of 4.44, and a depth to beam ratio of 0.66.

In trying to find an archaeological example of a caravel to figure out what the dimensions of the caravel *Santiago* sunk in Ribadeo could have been, the first scholar to propose the concept of Iberian-Atlantic ships, Thomas Oertling, agreed that 'it was something of a disappointment to discover that the difference between a caravel or a *nao*, a *nao* and a galleon, and so on, could be not discerned based on the construction features' (Oertling 2004: 133).

Matching the historical and archaeological data

In order to test whether the wreck found in 2011 could be that of the *Santiago de Galicia* we combined in an innovative way a photogrammetric model that was created during the archaeological campaign in 2015 and a 3D model based on ancient shipbuilding

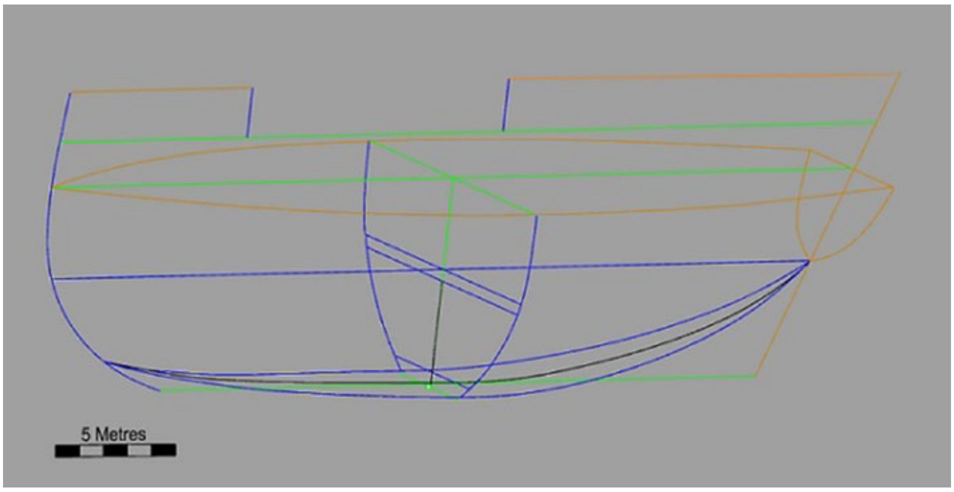

Figure 4. Reconstruction of the Santiago de Galicia ship, based on historical documents. Colours represent origin of sources. Green for direct evidence from documents, blue for estimated dimensions based on the overall basic dimensions in green, brown is indirect evidence of the time, collected from examples of ships specified in the Spanish Ordenanzas.

documents drawn from the measurements mentioned in historical documents for the *Santiago de Galicia*. The aim of this method was to test whether the shipwreck layer matched the historical measurements. The archaeological remains and the hull lines on the seabed were used to match the reconstruction of the shipwreck in the photogrammetric model providing a hypothetical shape and size. In 2015, the main wale of the ship was observed as located at the height of the main deck or first deck on the widest point of the ship. The height of the main deck offered a reference for where to place the 3D model and up to what height the ship was covered by the sand and silt in the estuary. From this data, the 3D-model reconstruction was developed based on historical documents (Figure 3).

On the starboard side, the original measurements were very similar to the reconstructed hull lines and composed of the frames in the wreck, represented in Figure 3. In Figure 3, the starboard side frames and hull line can be seen, with the bow of the ship pointing northwards. The hull line matched the reconstructed 3D ship at the height of the widest deck (Figure 4) or the first wale, and the frame lines along the starboard side of the wreck.

In the reconstruction in Figure 4, different parts of the ship can be seen coloured depending on the source used for interpretation. From top to bottom we have: the bow and stern castle decks in brown, based on the Spanish Ordenanzas from the early 17th century, which represent an estimate of the potential height of the ship in these upper structures; in green, the weather deck; the lower gun deck, in the middle showing the widest point of the ship or beam, as inferred from the measurements reported in historical documents for the *Santiago de Galicia*; and underneath, in blue, the orlop deck and the bilge at the very bottom (in blue on the sides, black in the middle), which was estimated taking as reference the measurements in green, such as the turn of the bilge line, the height of the first beams and possible height of the ceiling of the bilge. The transom panel can be seen at the right (in brown) and was inspired by how the transom panel is calculated in the Spanish Ordenanzas. The stem post at the left (in blue) was also an estimate from the measurements in the historical document (in green). The turn of the bilge line is marked at the very bottom of the hull in a curved blue line. The keel is situated underneath the bilge area, in green. The stern post is on the left side, in brown. The reconstruction and relationship of these elements were carried out based on archaeological publications and historical data on 16th-century shipbuilding and some of the early 17th-century Ordenanzas and treatises (Escalante de Mendoza 1985; Grenier *et al.* 2007: III, Hormaechea 2012: 246–294).

Once the photogrammetric model and the 3D reconstruction were completed at the same scale, they were superimposed and we observed that both the dimensions of the wreck itself and the estimates from the historical reconstruction were very similar. Although these theoretical reconstructions cannot serve to state with certainty that the shipwreck is the *Santiago the Galicia*, at least they do not rule out the ship as a potential candidate.

Have we identified the ship with a multidisciplinary approach?

Our multidisciplinary research has led to the hypothesis that the Ribadeo shipwreck corresponds to the *Santiago de Galicia* galleon of Ivella's fleet, built in Castellamare di Stabia, nearby Naples, Italy, around the early 1590s. According to the historical sources, the *Santiago de Galicia* galleon sank in Ribadeo in AD 1597. The artefacts found around the shipwreck together with the archaeological data—measurements and construction features—indicate that the ship was very likely a galleon. A crosscheck of the archaeological data and the measurements provided by historical sources for the *Santiago de Galicia* ship does not refute the hypothesis that this is the galleon that sunk in Ribadeo. As noted, the economic records of Juan Jacome Polo demonstrated that in November 1597 the ship was in Ribadeo (AGS, CMC, 3º época, leg. 2556). However, there are several aspects to consider that hamper the identification of the shipwreck with certainty.

We have not found in historical documents information about the measurements and dimensions of the *urca* and the caravel *Santiago* that sunk in the estuary respectively in 1597 and 1604. Conceptual approaches trying to find consistent 'ship types' have proven to be problematic and there has been a great terminological confusion. In this case, the *Santiago de Galicia* is defined in historical documents as a galleon. However, to determine whether the Ribadeo shipwreck was a galleon, a caravel or an *urca*, would be rather difficult due to the lack of fully preserved examples to be compared and we can only speculate in light of the associated artefacts. The words *caravel, urca and galleon* were used in different languages, but they did not represent a coherent and consistent shape of vessel through time and space. The lack of documentary information hampers carrying out the construction of a theoretical model for both ships to be crossmatched with the archaeological reconstruction we have made for the shipwreck. Therefore, those ships cannot be ruled out based on actual historical documents, and only if the shipwreck is fully excavated would we be able to improve our model and assess whether its dimensions correspond to the ones reported for the *Santiago de Galicia* galleon.

Dendrochronological research on 48 samples has resulted in the dating of two silver fir planks from the inner structure to after 1580. The natural distribution of this species comprises mostly central Europe, the Pyrenees, Balkans and Carpathian mountains, therefore this wood could have been available in Adriatic, Central and Western Mediterranean shipyards as well as in North European ones. Consequently, the provenance of this wood cannot serve as an indicator of the shipyard in which the ship was built. The absence of matches between oak samples collected in both campaigns suggests that the wood from the Ribadeo shipwreck originates from different areas. This would be in agreement with the information found in historical sources about the different provenance of the wood used to build the *Santiago de Galicia*. However, the lack of well replicated oak reference chronologies for the historically identified areas (southern Italy and Albania) impedes establishing the date and provenance of the oak timbers by dendrochronological methods. More samples should be collected from the shipwreck in order to achieve mean curves from different timber elements, as they have higher chances to be crossmatched with reference chronologies over individual samples. Furthermore, future dendrochronological work should focus on collaboration with Italian researchers and on the development of tree-ring reference chronologies for Albania and the rest of the Balkans—one of the remaining gaps in European dendrochronology.

These findings are the preliminary conclusions of an ongoing investigation and offer many potential lines of research inquiry for the future. The archaeological campaigns carried out so far have only involved prospective works. An archaeological excavation would be the desirable step forward to finally confirm the identity of the ship. After the 2015 study, the wreck was covered by a mesh that proved to be effective against the estuary´s currents. However, such temporary preservation interventions cannot be considered lasting. The preservation of the shipwreck is incompatible with the present activity of the harbour, and is constantly challenged by the mechanical influence of strong tidal currents, merchant traffic and biotic organisms that affect its integrity. Short-term action is needed to protect the wreck in this endangered area. In this way, not only the shipwreck but its full history can be preserved as valuable heritage and as source of data for future research.

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Reconstructing Trees from Ship Timber Assemblages Using 3d Modelling Technologies: Evidence from the Belinho 1 Shipwreck in Northern Portugal

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Abstract

During the winter of 2013/14 a number of violent storms and related surges exposed a remarkable shipwreck site—tentatively dated to the early or mid-16th century—containing a timber assemblage, hundreds of pewter plates and other artefacts on Belinho beach, near Esposende in the north of Portugal. An international team was assembled including archaeologists from the Esposende city council and researchers from the ForSEAdiscovery Project. The objective of this project was to join a number of different experts and explore innovative methodologies to record and analyse ship timbers with forest management and timber supply networks in the Age of Discoveries.

A key recording strategy included the use of a Faro-Arm digitiser to record wood grain and timber conversion, together with photogrammetry, which was used to represent the timber surfaces. The compounded digital models were processed with Rhinoceros 3D modelling software. The collected data allowed researchers to model and develop reconstructed parent tree shapes from each ship timber, and try to better understand tree growth patterns, possible forest management activities, and timber selection for one of Iberia's major post-medieval industries: shipbuilding.

The Belinho 1 Project is an ongoing experiment where an array of techniques is being tested with the involvement of the local community, in order to help us understand the Iberian shipbuilding world, share our discoveries as widely as possible, and let the technologies utilised interact and invite new questions and ideas, and hopefully produce a methodology to identify tree selection methods, conversion techniques, as well as shipbuilding practices and philosophies.

Keywords

Maritime archaeology, dendrochronology, tree reconstruction, computing, shipbuilding

Introduction

During the winter of 2013/2014, unusually large storms impacted the north coast of Portugal, provoking pronounced erosion along some stretches of sandy beaches. These storms exposed a remarkable archaeological find and sent a large collection of ship timbers and artefacts ashore (Figure 1).

These artefacts were first discovered by sculptor João Sá while looking for raw material during a walk on the beach. The artist accidentally spotted human-made shapes in the timbers nested among rocks. With the help of his family Mr Sá started to collect a variety of artefacts at low tide. Given the relevance of the artefacts found he contacted local and national authorities.

Archaeologists from the city council of Esposende promptly ensured the recovery and protection of the artefacts washed ashore. Soon after the discovery it became evident that the artefact collection encompassed two chronological horizons:

Figure 1. GIS map indicating where the timbers were found at the Belinho beach (provided by the Council of Esposende).

- Belinho 1: A post-medieval (disarticulated) site including the remains of a ship's hull, pewter plates, copper-alloy plates with relief figures, and a small number of personal artefacts, possibly dating to the middle of the 16th century.
- Belinho 2: Hundreds of Roman amphora fragments.

Previous work

In 2014 researchers from the Portuguese Centro de História d'Aquém e d'Além-Mar (CHAM), Universidade Nova de Lisboa, undertook a preliminary study of the post-medieval artefact collection under the direction of José Bettencourt, focusing on the key structural timbers that included the keel, stern knee, stern post, several floor timbers and hull planks (Bettencourt *et al.* 2014).

CHAM's team concluded that:

1. The surviving architectural signatures on the Belinho 1 ship timbers are consistent with early modern Iberian shipbuilding technology (Castro 2008; Oertling 2001).
2. One curved timber was used to connect the keel, stem, and sternposts (*couce* and possibly *coral*).
3. The keelson was almost surely notched over the floor timbers and the mast step was an enlarged portion of the keelson.

Following the announcement of the finding of the Belinho 1 shipwreck site, historian Amândio Barros conducted an archival investigation to identify potential historical events related to the Belinho 1 loss. His research focused on the Esposende area, near to the beach of Belinho, during the late-16th and early-17th centuries. The research yielded an interesting candidate: a small merchantman with 70 to 80 tons in capacity, named *Nossa Senhora da Rosa*, lost in the area during the winter of 1577. This ship was built at Massarelos, a parish of the nearby city of Porto, using trees from the surrounding forests, by the carpenters Fernão D'Aires and António Eanes. Further research uncovered documents that mention the salvage of part of the cargo on 14 March of the following year, from the Belinho beach. *Nossa Senhora da Rosa* was sailing from the Canary Islands to nearby Vila do Conde with a cargo of pitch and Madeira wine (Barros 2016).

The artefacts found on this site since do not support this hypothesis. The copper-alloy plates seem to indicate a northern origin for the ship, the pewter plates have crowned hammer marks typical of the German Swiss region, and the guns seem to suggest a tentative date for this shipwreck somewhere between the first and the third quarters of the 16th century (Almeida *et al.* 2017).

Belinho 1 research project

Given the significance of the Belinho 1 artefact collection, the city council of Esposende invited a team of maritime archaeologists and wood science experts from the Marie Curie project ForSEAdiscovery (2013–2017; Grant agreement no.: 607545) to continue CHAM's preliminary study, in the summer of 2015.

The evaluation of the Belinho 1 timber assemblage was carried out with four main objectives in mind (Martins *et. al* 2015):

1. To establish a date and provenience for the ship and its cargo;
2. To reconstruct the parent trees from the archaeological evidence, in order to try to understand timber growth patterns and ranges of shapes preferred by shipbuilders;
3. To develop dendrological studies on the Belinho 1 timbers (wood anatomy and dendrochronology); and
4. To develop a three-dimensional digital ship reconstruction based on timber shapes and other archaeological evidence.

The project was designed in accordance with Historic England's guidance on project design MoRPHE and the Direção Geral do Património Cultural (DGPC) archaeology code of practice.

The methodology was chosen to maximise efficiency given the short available time for fieldwork. Thus, multiple work-stations were established in the area where the municipality stored the timbers in specially designed tanks. Archaeologists and wood scientists implemented a set of parallel activities to record and interpret both timbers and artefacts.

The pewter plates were photographed, drawn, and scanned for maker's and possession marks under the microscope. The timbers were tagged, separated by function and recorded. The recording was carried out in three separate ways:

1. Morphological analysis: a fiche was filled for each timber and its conversion and special characteristics noted;
2. Wood grain: a FARO-Arm was used to record the most prominent grain patterns apparent of the timber surface, and digital photography to create 3D meshes of the timber surfaces with PhotoScan software; and,
3. Construction features: the shape, measurements, scarves, fastening patterns, and caulking solutions were manually recorded at a 1:10 scale, photographed, and described in individual fiches.

This methodology allowed different teams of researchers to rotate the timbers and work full time. The comprehensive documentation and recording process of individual timbers entailed unique labelling and the use of timber recording sheets (TRS) (Nayling and Jones 2014: 243); traditional recording techniques (Mckee 1978; Mardsen 1978; and Tremain 1978); 3D meshes (Jones, Nayling and Tanner 2013); computer vision photogrammetry (Yamafune, Torres and Castro 2016) and the collection of timber cross-section samples by hand-sawing. This workflow resulted in:

1. The recording of eleven key-structural hull timbers—seven Y-frames (BEL01-001W, BEL01-032W, BEL01-036,037W, BEL01-039W, BEL01-040W, BEL01-043W) keel (BEL01-071W), mast step (BEL01-051W), stern knee (BEL01-072W), stern post (BEL01-073W), and one floor timber (BEL01-003W)—with a FARO-Arm in a format adapted from the manual produced by Toby Jones (2014);
2. All the 75 timbers that composed the collection were photographed and recorded using direct measurements, computer vision photogrammetry, and hand sketches; and,
3. Twelve oak samples were collected from timbers displaying more than 50 rings.

Post-recording laboratory analysis undertaken by ForSEAdiscovery Project researchers led to the development of a dendrochronological report (Domínguez-Delmás *et al.* 2015a: 1; Domínguez-Delmás *et al.* 2015b), a detailed catalogue of the timber assemblage (Castro *et al.* 2015) and the editing and printout of the eleven individual timber´s 3D digital models, essential to developing advanced studies on tree and ship reconstruction of the Belinho 1 (Martins *et. al* 2015).

Data analysis

The digital models of each of the selected timbers were used to produce working files that better represented the morphology and the final shape of each of the eleven key-structural hull timbers. The original 3D files were first edited in Rhinoceros to remove irrelevant lines and ensure that all lines were associated with the correct layers, both in terms of the faces represented and the attributes assigned. The edited files provided clearer 3D reproductions of the eleven individual timbers and were used as the basis for another series of new files. In order to produce 2D traditional drawings,

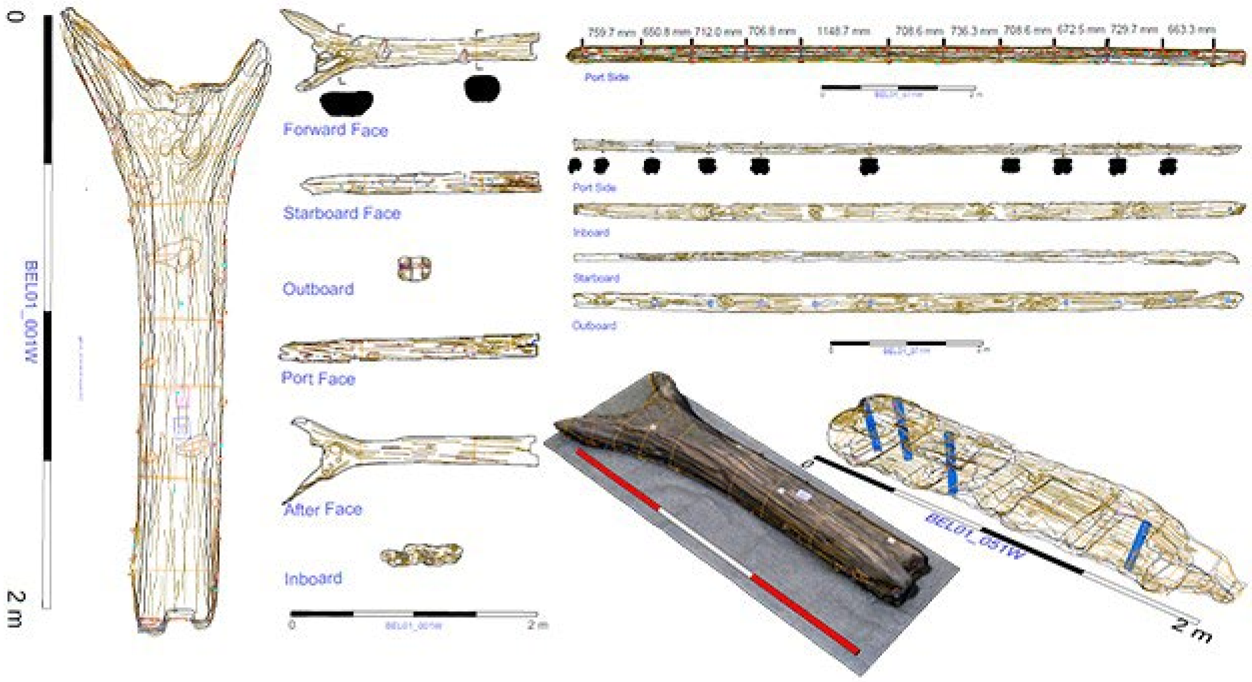

Figure 2. Timbers BEL01-001W Y-frame; mast step BEL01-051W; and keel BEL01-071W (3D digital drawings by A. Miguel Martins; photogrammetry merged against 3D drawing by N. Nayling).

each face was projected onto an orthogonal plane. This task produced a set of 2D orthographic projections of each timber face, complemented with cross-sections (Figure 2).

The drawings developed were produced by merging the 3D models with the photogrammetry data, and adding the information collected through inspection on the timber recordings sheets, and fieldwork notes. This task was aimed at highlighting construction features in each timber, namely the fastening patterns, scarves, caulking arrangements, sections and shapes.

Although none of the then 75 timbers was washed ashore in connection with any other timber, the angles of some of the outer planks' hoods and the position of some of the fasteners allowed the matching of nineteen individual timbers, forming a portion of the ship's runs (Castro *et al.* 2015).

A fourth type of drawing was produced from the edited files and used in the tree reconstruction process. On these files, the layers containing the wood conversion were hidden, and the natural wood features were highlighted (this process will be explained in detail in the section on tree reconstruction below). In this way, the drawings obtained reproduce a set of diagnostic features with precision, revealing growth patterns, natural edges, branches, and knots.

Sample collection, wood identification, and dendrochronological results

After completion of the recording process, a selection of timbers was sampled by either coring or sawing, yielding a total of fifteen samples. Sampling was performed with care to minimise its impact on the timbers. Increment borers were used to sample timbers which possessed good dendrochronological potential, namely substantial number of tree-rings and presence of sapwood, but which would lose integrity if sampled with a saw. The remaining elements were sampled by sawing their ends, thus, mitigating the impact on the integrity of the timbers. Wood samples were sent to different laboratories within the ForSEAdiscovery network where they undertook a variety of analyses, particularly for dating, wood anatomy studies, and geochemical analysis purposes.

The visual inspection of the samples allowed the identification of twelve of them as deciduous oak (*Quercus subg. Quercus*). Two other samples correspond to conifer species, although the observation of anatomical features with a microscope in the radial section has not led to the identification of the timber species. Finally, one sample from a timber of uncertain origin (possibly not part of the ship structure) was found to belong to a tropical species and was excluded from further analysis.

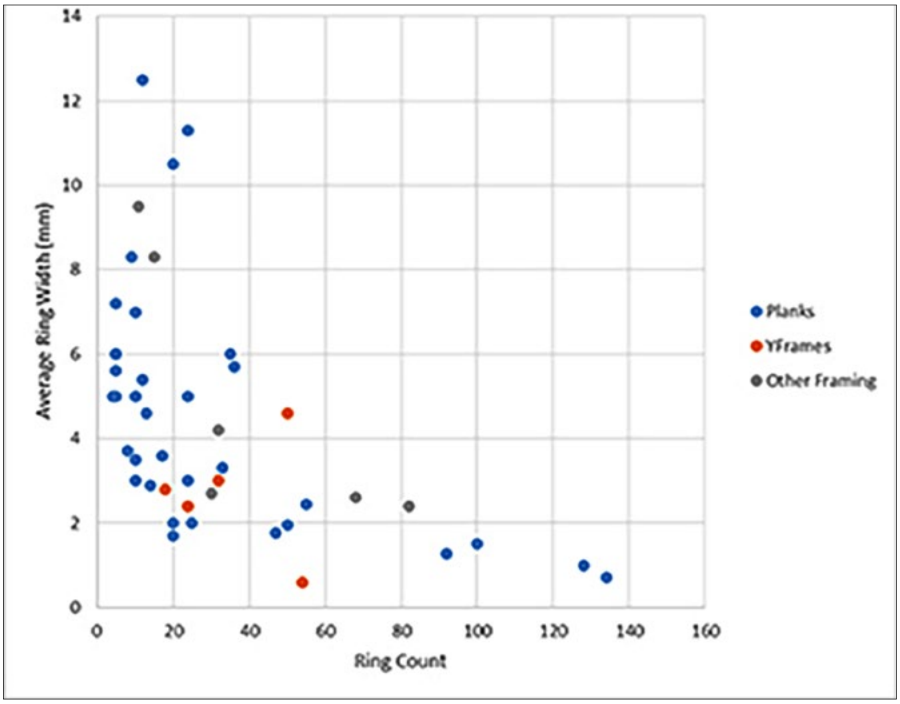

Figure 3. Statistical analysis on the average ring width and ring counts of timbers (Graphic developed by A.M. Martins based upon data collected by N. Nayling, P. Groenendijk and M. Domínguez-Delmás).

Only five of the twelve samples identified as belonging to the oak group were considered for dendrochronological analysis, as they contained more than 80 rings, with six samples having less than 60 rings (Figure 3). Two of the samples (from plank fragments BEL01-013W and BEL01-024W) with most rings showed a very strong statistical and visual crossdating with each other (correlation coefficient: 0.64; Student's *t*-value: 8.95; percentage of parallel variation, %PV: 74.5%; significance level of the %PV: p<0.001; overlap: 104 years). This indicates that the timbers were very likely derived from the same parental tree possibly fragments from the same timber). The lack of more internal matches with and between the other samples, together with the strong variability in growth rates (i.e. mean ring widths in the oak samples range from 0.60mm to 2.62mm per year), indicates that the wood could have been sourced from different areas, or from a large area where tree growth rates varied. Another explanation for the lack of matches between the timbers could be that the samples are not contemporary, i.e. some timbers could be repairs. Furthermore, the fact that the ship timbers had washed ashore hinders the certainty that all timbers here examined are part of the same wreck. This makes drawing conclusions challenging, especially for the tropical timber present among the samples, which cannot be regarded with certainty as a part of the ship's assemblage (Domínguez-Delmás *et al.* 2015b).

The comparison of all the tree-ring series with European reference chronologies and oak chronologies from the north of Spain have failed (for the moment) to produce statistically sound results. Therefore, all samples remain for now undated, and the provenance of the wood remains unknown.

Ship timbers

Due to the high-level of erosion caused during site formation process, some key features such as scarves, timber edges and original surfaces were eroded in many timbers. Despite this problem, the characteristics of some timbers and the fastening patterns suggest a possible origin for this ship in the north of the Iberian Peninsula. Below is a quick characterisation of the ship timbers recorded in the summer of 2015.

Hull Timbers

A total of 75 timber fragments washed ashore from 2013 to 2015. As mentioned above, they were divided into five groups, according to their purported structural function (Castro *et al.* 2015).

Longitudinal structure

The first group consisted of timbers from the longitudinal structure and encompassed portions of the keel (BEL01-071W), sternpost (BEL01-073W), stern knee (BEL01-073W), and mast step (BEL01-051W).

The keel segment preserved was rabbeted (around 8.5cm), measured 879cm in length and its section was 22–24cm sided and 19cm moulded. There were no signs of scarves on either end of the keel segment. Twelve 2.7cm circular bolt holes were preserved along with the timber length, connecting some floor timbers to the keel, spaced around 70cm on average, if we exclude the distance between bolts 5 and 6, which was 115cm. The bolt heads, with diameters around 5.5–6.0 cm, were lodged in countersunk holes 6–7cm in diameter, and 2.5cm deep. Marks of 1.1cm square iron nails, fastening the garboards to the keel, were preserved along the rabbets, and spaced 70cm on average. The fasteners' pattern on the planking suggested a room and space around 35cm and indicated that the keelson was bolted to this portion of the keel through every other floor timber, except between bolts five and six where there were probably two-floor timbers between bolts.

The *sternpost segment* was preserved along 290cm, and its section was 20cm sided and 21cm moulded. Three 2.7cm bolt holes were preserved, spaced 70cm and 53cm, which correspond to the spacing of the bolt holes preserved on the stern knee (*coral*). The deep rabbets (31.4cm deep) presented 1.1cm square nail holes and 2.5cm preserved treenails, which fastened the hood ends of the hull planks to the sternpost. These fastening holes allowed the re-positioning of seven hull planks, which had washed ashore separately. The after face of the stern post preserved nail marks that suggest that the sternpost was covered with sheathing, and a protruding tenon with two diagonal nail holes the function of which is not yet clear.

A *stern knee* washed ashore as well, 281cm long and 20cm high. Its moulded dimension varied between 12.3cm and 8.7cm and its sided dimension was 20cm. Four iron bolts indicate that it was fastened to the keel although the spacing of these bolt holes does not correspond with those found on the surviving fragment of the keel. In contrast, three bolt holes on the upper part of the stern knee match those on the sternpost. Again, two or three 11mm square nail holes, and two 25mm treenail remains indicated the fastening pattern of the hull planking to the stern heel side faces.

The remains of a *mast step* bear signs of long exposure to the actions of marine life and were heavily eroded. It is an expanded portion of the keelson, 197cm long, 45cm sided, and 30cm moulded. The step mortise is 86cm in length, 18cm sided, and 10cm deep. Two bolt holes allow a tentative positioning of this portion of the keelson between the 7th and 8th bolt holes of the keel. The mast step is notched to fit over the frames.

Transversal structure

The second group of timbers found at the Belinho 1 site included seven Y-frames (*picas*), five floor timbers, three frame fragments that appear to be the lower extremities of first futtocks, two timbers that were tentatively identified as fragments of deck knees, and a broken frame fragment.

The central framing timbers presented square sections around 18cm sided and moulded, and the same pattern of nails and treenails for the fastening of the hull planking. They showed central trapezoidal limber holes positioned slightly to the side of the keel axis, and some had dovetail joints in the preserved extremities, in the area overlapping with the futtocks. The floor/futtock fastening pattern seems to have been two treenails and two iron nails.

Floor timber BEL01-045W did not have an apparent dovetail scarf on its preserved arm but showed a step on the face opposite to the futtock, where a nail was inserted, in a manner similar to those found at Highborn Cay (Oertling 1989). Floor timber fragment BEL01-041W presented a foot with a central limber hole and only one treenail mark, on its foreword and after faces. One of its arms seems to have been around 30cm long, suggesting that this timber may have been a reinforcement placed between the inner extremities of two first futtocks, reinforcing the floor timber in the keel area. Floor timber BEL01-042W presents similar features to the timber described above. The maximum length surviving has 321cm, and its section was 17cm sided and 18cm moulded. On one of the sides this timber has a dovetail scarf measuring 23cm on the top and 28cm on base. Evidence shows that at least one nail was inserted on the futtock through is step. The floor timber also possesses an inscription 'II', which probably indicates its location on the framing system.

The futtock extremities preserved varied in length, mostly near 1m, and presented sections 16–18cm sided and moulded. Some of the futtocks showed dovetail scarves with a pattern of two or three nails and two or three treenails in the floor/futtock connection. The two purported deck knees are eroded pieces with fastening patterns and notches that suggest this function, but so far it is not possible to definitely identify them as such.

Stern planking and other longitudinal timbers

The third group of timbers washed ashore at Belinho included a portion of a waterway, three fragments of port side hull planks with their aft hoods preserved, four fragments of starboard hull planks with their aft hoods preserved, and five plank fragments difficult to position at this stage.

Planks BEL01-053W, BEL01-056W, BEL01-060W, and BEL01-059W angles, fastening holes, and dimensions match the marks and angles on the starboard side of the sternpost. Similarly, planks BEL01-055W, BEL01-054W, and BEL01-057W match port side angles and fasteners' marks of the sternpost (Castro *et al.* 2015).

A curious feature observed in these hull planks is that they were carved with triangular notches 5–7mm deep, and grooved on their outer surfaces coated with a resinous substance, and sheathed with either lead or sacrificial wood, although no traces of lead were picked up in several XRF analyses performed on coating samples (Castro *et al.* 2015).

Has expected, the planking conversion type presents evidence of tangential conversion, although at this time it is not possible to identify which tools were used for the process. The level of erosion affected the timbers' surfaces, and made difficult to identify tool marks, although some carpentry marks, such as the number 'II' on floor timber BEL01-042W.

The group of the twelve best preserved hull planking timbers was cut from oak trees bearing a maximum of 128 tree-rings and a minimum of 36 annual rings. One of the eroded timber fragments from this group (BEL01-061W) was sampled for dendrochronological analysis. It was not possible to identify the *Quercus* sub-species at the present stage of the project. Planks BEL01-053W, BEL01-056W, BEL01-060W, BEL01-059W, BEL01-055W, BEL01-054W and BEL01-057W, already mentioned above, do not show evidence of large knots, suggesting that they were cut from straight stem trees.

Plank Fragments and unidentified wood

The fourth group of timbers consisted of 27 small fragments of planks, impossible to place in any particular position in the hull at this stage of the project (Castro *et al.* 2015). A fifth group consisted of 11 small fragments of wood from unidentified timbers, also impossible to a position at this stage of the project (Castro *et al.* 2015; Figure 4).

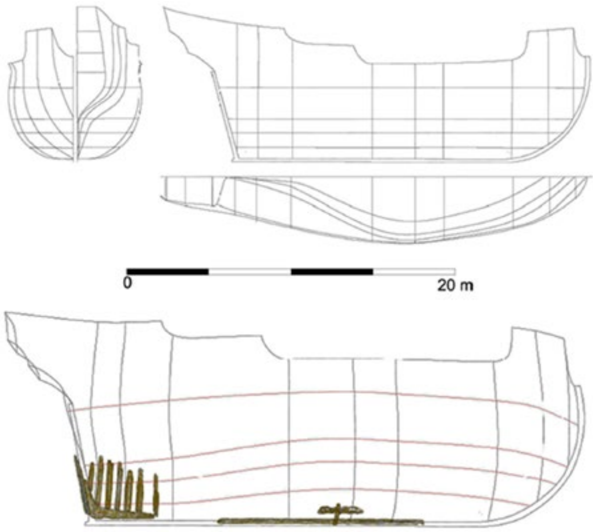

Figure 4. Geometric plans from the Belinho 1 ship (above) and the timber assemblage in correlation to the 3D model of the vessel (conceptualisation and drawings by Adolfo Miguel Martins and Filipe Castro).

Tree reconstruction

As already mentioned, the Belinho 1 timber assemblage suffered significant levels of erosion, which increased the difficulty of the recording process. Despite this, the timbers analysed offered relevant data for advanced dendrological studies. The seven Y-frames, a complete floor timber, the stern knee, the sternpost, a portion of the keel and the fragment of the keelson (mast step) were selected for careful recording using digital techniques due to their potential to provide relevant data for tree reconstruction.

Evidence of knots, cracks, and growth patterns was used to plot the location of the timber pith along the full length of each timber. The tree-rings visible at end of the Y-frames clearly indicated the points where the tree stem split into two or more branches. The grain lines on the floor timbers were useful for identification of the curvature of the parent tree.

The timber recording methods employed, both manual and with a FARO-Arm, reproduced with precision the wood features that led to the tentative tree reconstructions. The 3D digital models produced followed specific recording protocols, which enabled the identification of exact angles of curvature, and potentially diameter of the parent trees, in comparison with the shape and size of the selected individual timbers. This method proved to be effective and allowed us to identify the particularities of the parent tree of each timber, namely ring widths, grain curvature on the main stem, as well as position, density, and angles of branches.

As mentioned above, once the 3D digital models were edited and re-inspected, it was possible to hide the layers related to the work performed by the carpenters with Rhinoceros software. The resulting models represent only the wood features, which give a clear view of the wood anatomy on each timber surface. The grain lines and the inclination of the knots are essential to identify the direction of the tree (roots and canopy). Once the growth direction is identified, the next step is to find the pith location in the stem and branches, which was possible in the case of the stern knee and Y-frames. The maximum width can be defined by the pith and the preserved waney edges on the timber surface. The ring-width and natural heartwood edges can also provide additional information. After achieving the maximum width on each surface and identifying the growth direction, it is possible to recognise the shape of the tree and some of its morphological characteristics. Sapwood was only observed on timber BEL01-001W, which made it impossible to identify the maximum diameter of each timber. Either bark and sapwood removed during woodworking, in keeping with the advice given in broadly contemporary shipbuilding treatises, such as the *Liuro da Fabrica das Naos* (Oliveira *c.* 1580), or the *Livro Primeiro da Architectura Naval* (Lavanha *c.* 1600), or it was lost, eroded after the shipwreck.

The Belinho 1 ship timbers were tangentially cut from the parent trees and then shaped using a variety of tools to meet the required shape. The Y-frames presented shapes consistent with the transverse and longitudinal angles of the hull. The y-frames' feet were cut at angles that fit over the stern knee where they stood, and their height formed a plausible shape of the transition between the ship's runs and the wider portion of the upper hull in that area. The progression of the angles of branches of each of the Y-frames positioned on the inboard face of the stern knee showed a consistent pattern and formed a smooth, fair and, thus, plausible shape of that part of the hull:

- Y-frame BEL01-037W angle of the branches is 3°, the length of the stem 99.2cm, abundant knots along the stem;
- Y-frame BEL01-036W angle of the branches is 8°, the length of the stem 148.3cm, not having knots along the stem;
- Y-frame BEL01-039W angle of the branches is 12°, the length of the stem 145.7cm, abundant knots along the stem;
- Y-frame BEL01-001W angle of the branches is 22°, the length of the stem 149.2cm, not having knots along the stem;
- Y-frame BEL01-040W angle of the branches is 24°, the length of the stem 127.1cm, abundant knots along the stem;
- Y-frame BEL01-043W angle of the branches is 21° but reduces the length of the stem to 83.9cm, abundant knots along the stem; and,
- Y-frame BEL01-032W angle of the branches is 15°, the length of the stem 184.6cm, not having knots along the stem.

The longitudinal structural timbers revealed the following features:

- To shape the stern knee carpenters needed a tree with a larger stem and branches having an angle of about 105º between each (in comparison the timbers previously mentioned); and,
- To obtain the keel carpenters needed a long tree with the minimum of 900cm in length and 22.3cm in width. This timber also presents a larger branch on its inboard face. Many other relatively small size branches can be observed along each surface of the keel full extension.

Evidence has also shown that to build the Belinho 1 ship carpenters needed at least four types of trees:

- Y-frames—straight stemmed oak trees ending with at least two branches in the canopy forming symmetrical angles from vertical;
- Floor timber and futtocks—long stem or branches having a smooth curvature;
- Stern knee—large stem and branches with an angle closer to 105º; and,
- Keel—long straight stem having the minimum of 900cm in length.

At this stage, this study allowed the following conclusions:

BEL01-001W (Y-frame):

- Minimum diameter of the stem is 74cm, minimum diameter of the port side branch is 18cm, angle of the stem to the branch is 15º, the minimum diameter of the starboard side branch is 21.4cm, the angle stem to the branch is 156º, and the maximum length of the stem with the absence of knots is 149cm;
- The absence of knots along the main stem;
- Specific V-shape of the canopy;
- The width of the stem is consistent with the other timbers in the ship´s stern;
- The pith, growth pattern and the split of the stem into two branches provided the shape required for ship construction;
- The growth rate (i.e. average ring width) is consistent with higher levels of moisture (precipitation/groundwater levels); and,
- The sapwood was removed to shape the timber, but the heartwood seems to preserve its maximum extent (some traces of sapwood).

BEL01-003W (floor timber):

- Clear growth orientation of the timber (crown/stem);
- The abundance of knots at one end;
- The curvature of the timber is consistent with the natural curvature of the tree;
- Fast-growing timber suggests a landscape abundant in water and minerals;
- The grain at the lower end of the timber suggests the existent of forest practice to encourage the growth of multiple branches (pruning/pollarding); and,

- At the bottom of the timber, the growth pattern is consistent with forest management techniques.

The process of tree reconstruction involves a complex data analysis in which every wood feature needs to be carefully inspected. In this particular case it is a still ongoing study, undertaken within author Miguel Martins' doctoral studies as a Marie Curie-ForSEAdiscovery Project fellow.

Timber analysis requires that archaeologists acquire experience in both shipbuilding characterisation and dendrology. The recording process should aim at acquiring compounded information related to shipbuilding and wood anatomy. This study is a contribution to the development of a methodology that will hopefully become mainstream in nautical archaeology within a few years. The recording protocols we will develop in the incoming years will allow for new forms of 3D recording, manual samplings, visual observation, and any other methods available, such as X-rays or magnetic resonance. The 3D digitiser arm proved to be an extremely efective tool, mostly when compounded with Rhinoceros software. Budget and fieldwork time constrains most probably dictate that only a selection of timbers will be digitally recording and analysed (as was the case in the Belinho 1 Project).

We opted to convert the 1:10 scale drawings into 3D digital representations later, in order to manipulate the timbers and try to match them against an hypothetical model of the hull, developed from the only diagnostic measurements we could obtain from the archaeological data: the flat of the floor timber near amidships, and the probable height of the ship's runs. Our reconstruction is hypothetical and should looked upon as a preliminary attempt at making sense of the timbers that washed ashore at Belinho in 2014 and 2015 (Figure 5).

Conclusions

The main conclusions of this study can be summarised along two main lines. The first is that this study setup clearly the need for protocols to standardise the recording of both nautical information (Castro *et al.* 2018), and that these protocols must include dendrological analysis. The second is that although at this time neither archaeological nor dendrological evidence have shown a strong correlation between the Belinho 1 timber assemblage the shipwreck discovered in the archival research, there is no reason to change our methodology. Dendrochronological evidence has not yet yielded any matches, and the artefact collection doesn't seem consistent with the ship's route.

The studies carried out on the Belinho 1 ship timbers allowed us, however, to conclude that from the 12 samples that underwent dendrochronological research, both framing and planking elements presented fast and slow growth rates, suggesting that there was an unspecific selection of trees in terms of growth types for the construction of this ship. Although in order to draw conclusions relative to the quality of the timber supply we will need to carry out further analysis, this is an important piece of information the incomplete multidimensional puzzle that every shipwreck presents.

The tree reconstruction attempts carried out on the Y-frame BEL01-001W and floor-timber BEL01-003W allowed the characterising of their parent trees with a good degree of certainly, yielding information on the forest where the timbers originated from. Straight stems with a low number of knots were sought by shipwrights for their strength and are typical of trees that have grown in high-density stands.

The structural timbers analysed presented evidence of having been selected in accordance with the wood grain flow orientation to avoid cracking by tension, and show that both straight and compass timber—trees and branches—were available in the forests where they were cut.

The sample of deciduous oaks showing variable growth rates and lacking internal cross matches suggests that the wood was sourced from different areas or an extensive area where tree growth was variable. The growth pattern seemed to be consistent with oak trees of about 60 years (average of annual 50 rings plus rings lost by erosion, or removal sapwood and bark). The Y-frames also seem to be consistent in terms of growth pattern, and the floor timber and futtocks present the same correlation within each typology. Equally, the absence of a significant number of knots along the timbers presented evidence of the areas in which the trees were planted. The ring-width average has also demonstrated in which extent trees were supplied with abundant water and minerals (precipitation/groundwater levels).

As already mentioned, given the relatively small number of timbers sampled there is a possibility that some of the analysed timbers may not be contemporary, corresponding to possible repairs. Again, this piece of information is relevant for the ongoing study of the ship.

Although the nature of the Belinho 1 shipwreck site, located in a high energy area which poses serious risks to diving, has determined the slow pace of this study, mostly commanded by the atmospheric conditions and the natural movement of sediments of the bottom, the information already gathered allows us to emphasise the importance of this site. The ship timbers' shape and assemblage techniques are consistent with an Iberian architectural provenance, and even though the

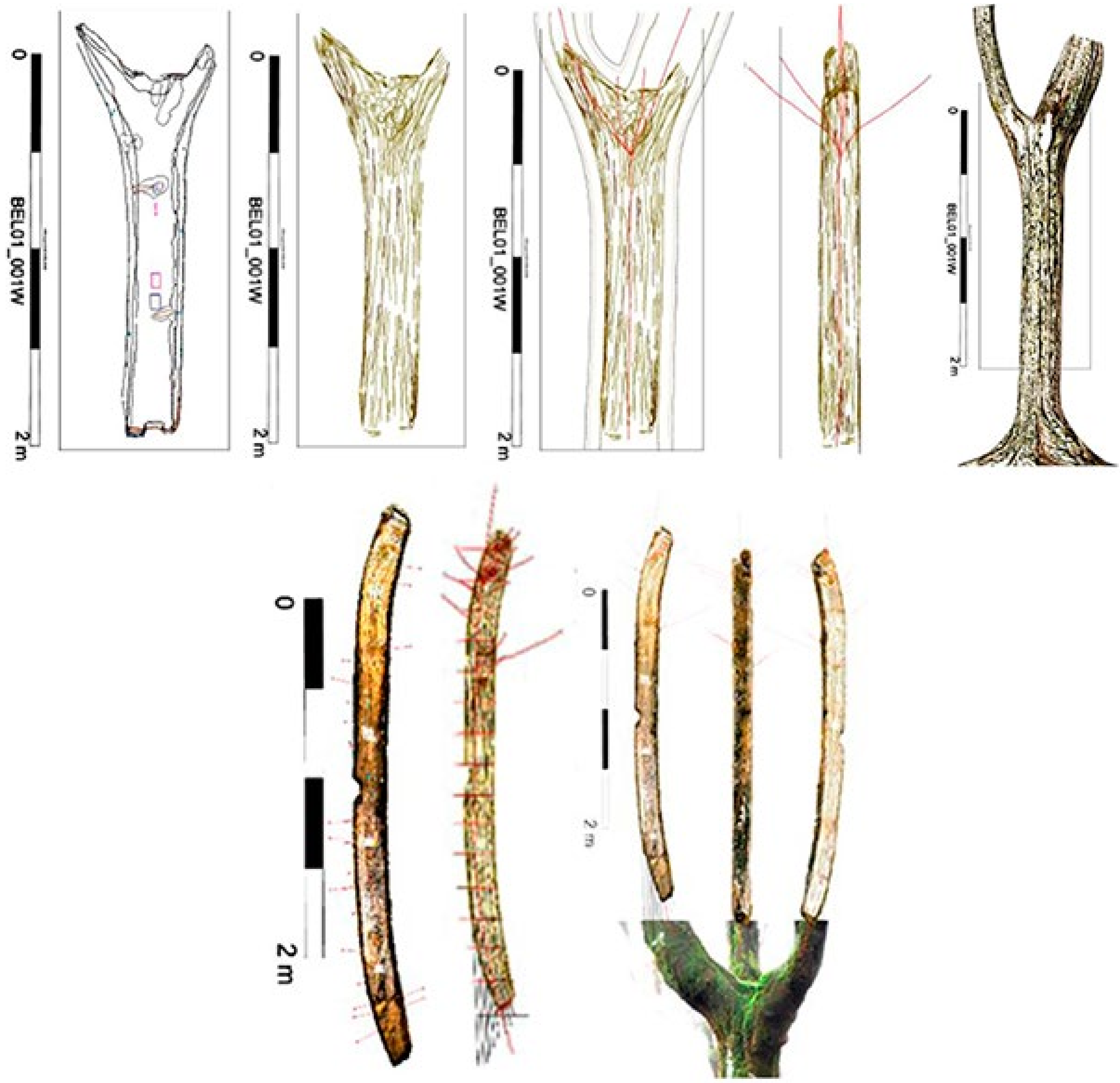

Figure 5. Tree reconstruction based on evidence collected on Y-frame timber BEL01-001W (above) and Floor-timber BEL01-003W (below), showing different forest management practices (drawings and tree reconstruction by A. Miguel Martins).

tentative chronologies established for the artefacts do not permit a tentative dating within a few decades, it is likely that this ship dates to the second quarter of the 16th century, making it a precious testimony to the European shipbuilding techniques of that time.

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From Forests to the Sea, from the Sea to the Laboratory: the Timbers of the Frigate *Santa Maria Magdalena* (18th Century)

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Abstract

The case study of the 18th-century Spanish frigate *Santa Maria Magdalena* constitutes one of the opportunities given to the ForSEAdiscovery ("Forest resources for Iberian Empires: Ecology and Globalization in the Age of Discovery" - Marie Curie Actions Initial Training Network) project team to approach the subject of shipbuilding and timber supply in the Iberian Empires of the early modern age. This was to be achieved in an interdisciplinary way through the combination of three different disciplines: history, through the research of written sources; archaeology, through the collection and study of the material evidence of ships; and, wood science, though the analysis of timber samples from archaeological sites and old living trees.

Keywords

18th century, Spain, interdisciplinarity, archives, timber

Introduction

Driven by the increased demands on seafaring defense, the Spanish Crown launched the *Santa Maria Magdalena* frigate from the Esteiro shipyard of Ferrol (Galicia, north-west Spain) in 1773. In 1810, the ship was wrecked at the Bay of Viveiro (Figure 1), in the context of the Spanish War of Independence (1808–1814). In June 2015, the ForSEAdiscovery project team organised an underwater timber sampling campaign on this shipwreck site. Through various wood provenance studies (i.e. dendrochronology, inorganic and organic chemistry), combined with historical research in national archives and international sources such as the Sound Toll Registers, the frigate's timbers promise to shed light on late 18th-century Spanish naval construction, forestry practices, and timber supply in relation to shipbuilding in northern Spain. As a highly interdisciplinary project, ForSEAdiscovery integrates research fields in the humanities and life sciences. This paper presents the joint efforts of historians, archaeologists and wood scientists to determine: 1) what kinds of trees were used to construct which parts of the *Santa Maria Magdalena*; 2) their provenance; 3) the timber trade networks and state management involved in supplying wood to the Ferrol shipyard; and, 4) best-practice methodologies to reach these conclusions.

Historical background

In the early 1770s, King Charles III (1759–1788) was developing the policy of shipbuilding initiated by his predecessors as part as the so-called Bourbon Reforms. These consisted of a programme of economic and administrative restructuring in which a new conception of a centralised Navy took a prominent role, as the key factor of the maintenance of a vast and spreading colonial Empire. In this context, the arsenals at Cartagena, Cadiz, Ferrol and Havana became the centres of the state-controlled shipbuilding industry (Merino Navarro 1981).

On 1 August 1772, a Royal Order announced a programme of construction of three *urcas afragatadas,* and one frigate to be carried out by the Esteiro shipyard (arsenal of Ferrol), and this is when the story of *La Magdalena* begins (AGS, SMA, 349, 1 August 1772). According to payment orders of salaries to the

Figure 1. Viveiro Bay.

shipwrights, its construction began in September and continued for the next ten months (AGS,TMC, 4207: 16 October 1772; AGS,TMC, 4207: 17 November 1772; AGS,TMC, 4207: 16 December, 1772; AGS,TMC, 4208: 22 January 1773; AGS,TMC, 4208: 20 February 1773; AGS,TMC, 4208: 18 March 1773; AGS,TMC, 4208: 20 April 1773; AGS,TMC, 4208: 20 May 1773; AGS,TMC, 4208: 21 June 1773; AGS,TMC, 4208: 24 July 1773; AGS,TMC, Marina, 4208: 28 August 1773). The official launch took place in Ferrol on 7 July 1773, and the document of its announcement described the vessel as a 26 to 34 gun frigate, 145 feet long (AGS, SMA, 350: 7 July 1773).

After 37 years serving the Spanish Navy in Atlantic waters, the *Santa Maria Magdalena* sunk in Viveiro bay (Lugo province, Galicia, Spain), along with the *bergantín Palomo*, in the context of the Spanish War of Independence (1808–1814). In November 1810, these Spanish vessels took part in an Anglo-Spanish squadron which fought against the French occupation of Santoña (Santander, Spain). On the night of 2 November, after being hit by a severe storm, the *Magdalena*, *Palomo* and a few other vessels had to evacuate Santoña and took shelter in Viveiro. The damage inflicted by the storm such as the loss of the anchors, determined the fatal outcome: the *Magdalena* collided with the English frigate *Narcissus* and later crashed against the Reef of Castelos and sunk soon after, taking the lives of 20 members of the crew (Fernandez Duro 1867: 220–25; Filliat 1976: 313).

History: timber supply in Ferrol (1771–1773)

The historical research aimed to obtain information about the construction process and main features of the *Magdalena*, as well as the model of timber supply in Ferrol during the late 18th century.

The archival research was mostly centred on the Spanish sources of the Navy administration corresponding to the section of the Navy Ministry (SMA) and state accounts of the court of auditors (*Tribunal Mayor de Cuentas,* TMC) from the Archivo General de Simancas (AGS), in Valladolid, Spain.[1] In order to further investigate the subject of timber import from northern Europe, the research involved cross-reference with the Danish database of the Sound Toll Registers Online (STRO, last viewed 31 March 2017), which records the passages of merchant vessels and their products, from Baltic ports to their destinations, through the Danish Sound (Gøbel 2010).

Besides the information regarding the shipbuilding process and main features of the frigate, the researched sources did not contain any further data specifically related to the *Magdalena*, namely the timber used in its construction. Therefore, the team decided to work

[1] Secretaría de Marina, sub-section Arsenales (units 347, 349, 350), sub-section Asientos (unit 621), sub-section Registros (unit 788); Tribunal Mayor de Cuentas, subs-section Marina, Ferrol (units 4207, 4208), in a total of 97 documents.

with historical documents dated from 1771 to 1773[2] about all the aspects of timber supply to the Ferrol Department in order to identify the whole context of timber acquisition. These documents cover the period of construction (1772–1773) and the previous years, in which some of the timber used in the *Magdalena* might have arrived.

Thus, the sources from AGS allowed the identification of three major regions of wood supply: northern Spain, northern Europe, and the Caribbean. Each of these major regions provided specific species and types of ship elements, and that is related, not only to the inherent qualities of the different woods, but also to the economic and technological strategies behind this model of supply.

Timber from northern Spain

The volume calculations[3] indicate northern Spain as the main area of provenance of the timber used in Ferrol by the time of the *Magdalena* construction, corresponding to 73% (sum of 17,020 m^3, during the years 1771 to 1773) of the total supply (23,418 m^3) (Figure 2-A). Such preponderance is expressed, as well, in the diversity of species, from oak to ash (Figure 2-B) and, especially, in the diversity of the typologies of ship pieces (Table 1). However, the quantification of pieces by units shows that northern Spanish timber is not used for the majority of the pieces. This place is occupied by northern Europe with pine planking, masts and spars. In terms of units, northern Spanish timber corresponds to 35% in a total of 19,781 pieces out of 56,005 (Figure 2-B, Table 1). This discrepancy between volume and quantity is explained by the nature of the ship elements. In fact, northern Spanish timber was, by far, the preferred choice when it came to the structure of the hull, reinforcements and other elements below the waterline, which correspond to very sizeable elements when compared to planks, the most abundant type of piece (Table 1).

Oak (*Quercus*) grew in northern Spain's forests in special abundance, and this was the primary timber for those kinds of ship elements (Aranda y Antón 1990; 1999: 23–24), contributing to this region´s tradition as a strong Peninsular centre of shipbuilding at least since the 16th century (Goodman 1997). Proximity to timber sources was an obvious criterion of choice since it not only facilitated transport (costs and infrastructures) but also allowed the close control of trees by the naval engineers and shipwrights in order to assess quantities and quality in terms of material, shape and size (Aranda y Antón 1999: 15–16; Wing 2015: 178–87). The multiplicity and specificity of typologies of the structural elements of the hull and other pieces to be placed below the waterline, the measurements of which varied according to the size, scantling, typology and shipbuilding technique can be seen in the treatises, wood regulations[4] (Gautier 1769; Fernandez de Landa 1784) as well as reports of shipwrights and engineers boards. These required closer supervision than the pine planks, deals, masts and spars used in the upper works, which were mass-produced and purchased from the Baltic region in varied but rather standardised measurements for multiple purposes (Gallagher 2016).

Following the proximity criterion, Asturias's forests appear as the main region of supply, followed (in this order) by Cantabria, the Basque Country[5] and Navarra. There was also a significant group of endogenous timber pieces with undetermined origin, which was constituted by spare timber from Guarnizo shipyard (Figure 2-B). Each of these regions had a contractor who operated the felling, carving and transport of timber by land and final delivery by boat: Andres Garcia Quiñones, António Francisco Quiñones and Juan Gonzalez Pola, for Asturias; Francisco Caetano Iglesias, for Cantabria; Real Compañia Guipuzcoana de Caracas for Guipuzcoa and Navarra.[6] Oak, the predominant timber with 14,091 units, could be found from Asturias to Navarra and was, once again, mostly used for planking (4,218 units) followed by framing elements such as futtocks and beams, uncategorised pieces and then a great variety of types (Table 1).[7] Beech (*Fagus sylvatica*) had a similar regional distribution and was used for planking, beams and also came in as raw timber. Holm oak (*Quercus ilex*) was identified as coming from Cantabria but for the most part its origin is not specified. It was used for axles of gun carriages and other non-identified applications. Black poplar (*Populous nigra*), walnut (*Juglans regia*),

[2] except in the case of the data from TMC and STRO that was used in the cross-reference of northern European timber trade, which was extended to 1770.

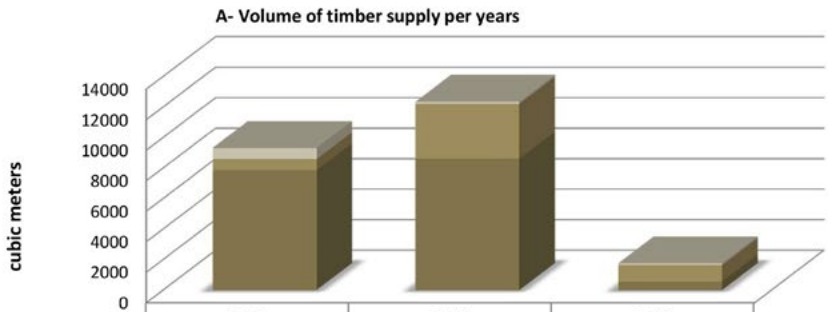
[3] this quantification involved 58 documents from the following sections and subsections: Secretaría de Marina, sub-section Arsenales (units 347, 349, 350), sub-section Asientos (unit 621), sub-section (unit 788); Tribunal Mayor de Cuentas, subs-section Marina, Ferrol (units 4207, 4208); the documents exclusively used for the accounts are not mentioned at the final references to avoid having an exhaustive list; the quantitative data provided by the Spanish sources was unevenly presented in units and volume (cubic cubits); in order to calculate the volume of units, we searched for its approximate measurements in cubits, within the Pie de Burgos measuring system, according to piece typologies (Gautier 1769; Fernandez de Landa 1784); the volume of Nordic pine pieces was calculated according to the measurements of the masts, spars and planks listed in the information about timber needs for 1772 and 1773 (AGS, SMA, 621: 15 November 1771; AGS, SMA, 621: 15 September 1772); for the calculation in cubic metres: Marien y Aróspide 1789: 28; Aranda y Antón 1999: 107; all these calculations are merely indicative.

[4] Reglamentos de Maderas.

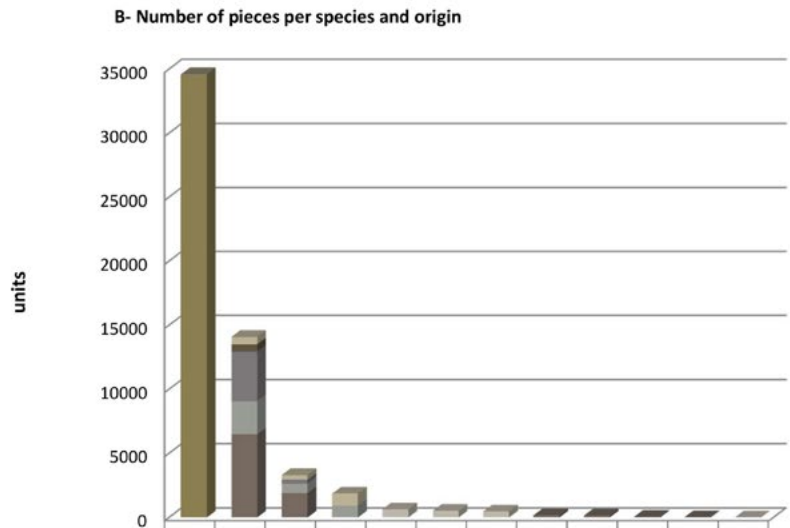
[5] sources of this group of timber are unclear about the specific provenance and just refer to the contractor, who was operating in both regions.

[6] references are the same as those used in the counting of timber from northern Spain.

[7] in order to facilitate the statistic study, the piece typologies were aggregated within main functional groups, in order to avoid an exhaustive list (e.g. first and second futtocks count together just as futtocks).



	1771	1772	1773
Caribbean	743	134	127
Northern Europe	732	3598	1064
Northern Spain	7845	8612	563



	P.	Q.	F. G.	Q. I.	C. O.	G.	Trop Und	P. N.	J.R.	A. G.	F. E.	T. E. L. L.
Caribbean					653	526	475					20
Northern Spain Und.		572	355	942								
Navarra		568										
Northern Spain: Guipuzcoa / Navarra		3858	307									
Northern Spain: Cantabria		2593	754	924								
Norther Spain: Asturias		6500	1901					183	155	72	38	
Pyrenees	59											
Northern Europe	34550											

Figure 2. Volume and number of pieces per origin, Ferrol—1771-1173 (AGS, SMA, 347, 349, 350, 621, 788; AGS, TMC, 4207,4208).

alder (*Alnus glutinosa*) and ash (*Fraxinus excelsior*) came from Asturias and were sporadically delivered in small quantities. Except in the case of walnut planking, these types of timber arrived as unprocessed timber. Pyrenean pine has a low representation within the overall northern Spanish timber accounts, corresponding to only 2% (402m^3). This supply is the result of technical experiments with the aim of reducing dependency from northern Europe imported pine (AGS, SMA, 349: 20 November 1771; AGS, SMA, 349: 25 July 1772; AGS, SMA, 349: 23 September 1772; AGS, SMA, 349: 14 November 1772) (Figure 2-B, Table 1).

The data indicates the secondary role of timber import through the Baltic trading networks, as these constitute 23% in terms of volume (total of 5,394m^3 along the 1771–1773 period), even if, in terms of unit quantities, northern European timber corresponds to 64%, with 34,550 pieces (Figure 2). This material is exclusively made up of pine, consisting of planking, the largest group of pieces in 34,338 units[8], 45 main masts, and 167 minor masts and spars[9] (Table 1), revealing the import

[8] excluding 32 from the Pyrenees.
[9] excluding 27 from the Pyrenees.

Table 1: Number of pieces per species and type, Ferrol—1771-1773 (AGS, SMA, 347, 349, 350, 621, 788; AGS, TMC, 4207,4208).

species / type of piece	pine (P.)	oak (Q.)	beech (F.G.)	holm oak (Q.I.)	cedrela (C.O.)	guyacán (G.)	tropical (und.)	black popplar (P.N.)	walnut tree (J.R)	alder (A.G.)	ash tree (F.E.)	chicharrón (T.E.) / sabicú (L.L.)
planking	34370	4218	2436						16			
futtocks		3859			602							
undetermined		1058		924		502		97	5	72	3	
unprocessed timber		582	686			24		86	134		35	
beams		1278	195									
axis for gun carriages				942								
knees		562										
wales		486					68					
waterways		367										
stringers							333					
floor timbers		327										
pegs		306										
masts and spars	194											
ledges		190										
top timbers		150			31							
stanchions		137										
keels		30			14		26					14
counter timbers		65										
pieces for hawse holes		55										
inner stern posts		49										
main masts	45											
cruchers		45										
shelf beam		40										
sheer bitt		38										
keelson		26			6							6
anchor stocks							35					
stern knees		32										
buttocks		25										
stern posts		20										
masts steps		19										
riders		19										
v-frames		17										
chocks		16										
bill step and the foremast partner		16										
spritsail yards		16										
fashion pieces		14										
stern panel timbers		9										
bitts		4					5					
tillers		2					6					
stern deadwoods		6										
sternson s		2										
cathead		2										
bulwarks		2										
stern timbers		2					2					
TOTAL	34609	14091	3317	1866	653	526	475	183	155	72	38	20

of highly specialised products. In a time of economical protectionism, the Maritime Departments would limit the acquisition of exogenous raw material to timber that could not be found in the Iberian Peninsula in abundance with the proper sizes, and that was strictly necessary for building vital and substantial parts of the vessels. That was the case of the pine species from northern Europe such as *Pinus sylvestris*, which exhibited long, wide and straight trunks making it especially suited for masts, spars and planks (Aranda y Antón 1999: 23).

This mass-produced timber served the European market (Astrom 1988) and Spain became a substantial importer, purchasing this material increasingly from the 1740s (Gallagher 2016; Reichert 2016). Spanish agents took part in the timber trade networks through supply contracts with the Navy, the so-called *Asientos.* By the time of the *Magdalena's* construction, Pedro Chone, a Bilbao resident, was the provider of masts, spars and planking for the three Maritime Departments of Cartagena, Cadiz and Ferrol (AGS, SMA, 788, 2 January 1772). Aided by representatives in Spain, the contractor operated from the Baltic ports of Saint Petersburg, Riga and Danzig, negotiating with the local suppliers and coordinating the shipments through Dutch captains and merchant vessels such as *urcas* and *galeotas* (AGS, SMA, 621: 1 September 1772; AGS, SMA, 621: 29 May 1773; AGS, SMA, 621: 20 August 1773; AGS, SMA, 788: 2 January 1772). As the stocks seemed to be constantly running out of pine, the Navy from time to time sought for alternative suppliers when the contractor was not able to fulfill orders in time (AGS, SMA, 350: 15 May, 1773; AGS, SMA, 621: 16 November 1771; AGS, SMA, 621: 20 May 1773).

According to STRO there were 35 passages containing timber destined for Ferrol via the Danish sound between the years 1770 and 1773. Only seven of these[10] can be matched to records in the TMC.[11] Possible reasons for this are that the timber may have been redirected or re-exported to another port, or that the wood was purchased by someone other than the Navy. After all, timber was also needed for general carpentry, private construction, and private shipbuilding. Indeed, six of the unmatched passages contained timber that was designated for shipbuilding, such as masts and spars, or accompanying products such as hemp or sailcloth.

Of the matched records, all were carried by Dutch captains, representing Ameland, Amsterdam, Hoorn, and Warns as homeports. Three of these passages originated from Danzig, and four from Riga. Products brought from Danzig were fir deal (*fyrre dehler*), thick planks (*bohler*), and unspecified wood products (*trævahre*). Products brought from Riga were boat-hook shafts (*baadshagestager),* balks (*bielker*), ordinary deals (*gemeene dehler* or *ord. dehler*), masts (*master*), spars (*spirrer* or *raaer*), and planks (*planker*). Only two shipments matched closely with the products and numbers given in both the TMC and STR.

These discrepancies make it difficult to conclude how much Baltic timber noted in the STR was destined for the Spanish Navy. Out of 50 payment orders in the TMC for the department of Ferrol concerning the acquisition of timber within Europe between the years of 1770 and 1773, only six could be confirmed to concern timber that came directly from the Danish Sound (representing seven STR records). Only two other shipments were re-exported via Amsterdam, and, thus, are not reflected in the STR. This suggests that the majority of the Navy's trade with the Baltic was direct by this time, rather than passing through a 'middle person' port such as Amsterdam.

An important aspect which the Sound Toll Register corroborates is that the imported timber was never oak, or any of those pieces necessary for the framing elements of the hull. Instead, they mostly consisted of spars for rigging and various sizes of pine planking, which were used in the final construction steps of a ship, such as upper hull planking, deck planking, and sacrificial outer planking.

The Caribbean supply corresponds to only 3% of the total volume with 1004m^3 and 1674 pieces (Figure 2). This timber had its origins in Cuba and Mexico, and its supply was locally operated by shipbuilding contractors of the arsenal of Havana, and then the Navy and Crown colonial officers would transfer part of this material to Spain, through the ships of the *Carrera de Indias,* among other goods in its cargoes, such as sugar, which was the possible the reason for the low volume of each shipment. Cadiz was the destination port of this route from 1717 and worked as a redistribution hub, by sending material to Ferrol, as well as Cartagena (AGS, SMA, 347: 6 February 1771). Sometimes, the transport was made by charted private ships, which would deliver the material directly to Ferrol (AGS, SMA, 347: 4 May 1771; AGS, SMA, 347: 24 August 1771).

The tropical timbers such as guayacán (*Guaiacum*), cedro real (*Cedrela odorata*), chicharrón (*Terminalia eriostachya*) and sabicú (*Lysiloma latisiliqua*) are very hard, dense and resistant types of material, particularly suited

[10] Sound Toll Registers Online viewed 31 March 2017: STR270070, 5 September 1770; STR257963, 23 September 1770; STR256454, 24 October 1770; STR301893, 2 August 1771; STR260730, 2 August 1771; ST260841, 3 August 1771; STR269696, 14 September 1772.

[11] matches between the TMC an STR were found by looking for the captain, year, port of origin, port of destination and then at the transported products; the captain and the year are the most reliable elements for cross-referencing, since the products were categorised differently in the STR and the TMC, and sometimes show completely different numbers.

for the crafting of structural pieces and those, which are subject to aggressive elements, such as constant friction and exposure to corrosion by shipworms such as *Teredo navalis* (Aranda y Antón 1992: 7–31; Aranda y Antón 1999: 27). Thus, the lists of deliveries contain cedrela futtocks, stringers, wales and anchor strocks of undetermined tropical species, keels made of cedrela and chicharrón /sabicú, cederela top timbers, guayacán logs for further carving, chicharrón/ sabicú and cedrela keelsons, among other typologies, and a vast group of undetermined typology of guayacán pieces (Table 1).

Some 1771 and 1773 documents may contain the explanation for such small deliveries, as they mention that the Spanish arsenal's stocks were already well supplied with guayacán (AGS, SMA, 347: 19 July 1771) due to the constant shipments and low use of this material and, therefore, new shipments should be suspended (AGS, SMA, 350: 4 June 1773; AGS, SMA, 350: 10 July 1773).

Archaeology: sampling the *Santa Maria Magdalena* timber assemblage

The remains of a vessel constitute the ultimate evidence of how ships were built (Steffy 1994). As mentioned above, the frigate *Magdalena* was built in the shipyards of Ferrol and sailed for about 37 years in the service of the Spanish Navy. During that time, the vessel benefited from repairs and adjustments that made her unique in many ways. *La Magdalena*'s unique features are a testimony to a specific moment in naval history in which several countries were at war and were in direct competition for the expansion of their overseas power.

Also at this time, shipbuilding technology was shifting into the experimental. Shipwrights and shipbuilders were developing and testing building techniques using wood species other than oak and pine, which had been the woods of choice for hundreds of years. According to Enrique García-Torralba Perez (2011: 257, 258), the *Magdalena* was part of an experiment and, therefore, built following specific procedures. Under the same geometric plans, four vessels were constructed in the shipyards of Cartagena and Ferrol: *Magdalena*, *Margarida*, *Marta* and *Clara*. Despite sharing the same drawings and architecture, different wood species were employed allowing shipbuilders from the Spanish Royal Navy to identify and analyse each prototype and use the most reliable as a model to replicate. In order to better understand the decisions made in the forest and in the shipyard prior to the construction of the *Magdalena*, the ForSEAdiscovery dive team undertook an archaeological campaign in Viveiro, Galicia.

Over the course of seven days in June 2015, the ForSEAdiscovery dive team removed 22 wood samples from the hull remains of the *Magdalena* at the bottom of the Viveiro Bay (Figure 3-A) in order to elucidate the circumstances of her construction—how she was built, with what kinds of wood, and from where that wood originated. In cases like the *Magdalena*, historical sources can be highly suggestive of where shipbuilders procured their timber, but taking timber samples from shipwrecks has several advantages over relying solely on the historical sources, even in well-documented cases like the timber supply for the arsenal of Ferrol:

1. Providing wood scientists with samples for further study is the only way to develop scientific methods of dendroprovenance so that they can be used in cases without historical documentation;
2. The scientific method allows for 'proofs' of provenance that frequently challenge so-called reasonable assumptions as well as historical documents made in error;
3. Timber sampling campaigns permit an individual study of elements used in shipbuilding, such as wood types, scantlings, joinery and fixings used, as well as gathering the extent of the remains and their level of preservation and risk.

One of the outcomes of the ForSEAdiscovery project has been to generate a set of protocols for the removal of wood samples from historic shipwrecks, and the fieldwork done at the *Magdalena* has been instrumental in this development. The sampling protocol defined that the impact on the remains of the vessel should be minimal. Therefore, it was only after mapping, sketching, positioning and using other non-invasive recording methods that timbers were finally sampled. To gain the highest volume of provenance data while creating the least amount of damage to the shipwreck, certain timbers were targeted for sampling while others remained untouched. Elements likely to represent the original structure of the vessel, such as planks, beams, and frames, were preferred to minor elements which were frequently replaced and/or which would be unlikely to contain sufficient or reliable data for provenance.

In general, archaeological evidence of Iberian ships (Castro 2008; Oertling 2001) demonstrates a common practice of utilising the parent tree's growth pattern for the required timber shape. This technique, alone, promises to help gain a better understanding of the relationship between Iberian shipbuilding and forest management. For one, it demonstrates that shipbuilders were well aware of the properties of the wood they selected, and that this knowledge at the disposal of the shipbuilder led to the creation of more reliable vessels (although this is not to say that this knowledge was always actually put to use). For example, fast-grown deciduous oak was frequently used for vertical elements like frames, while slower-grown oak could be used for

A

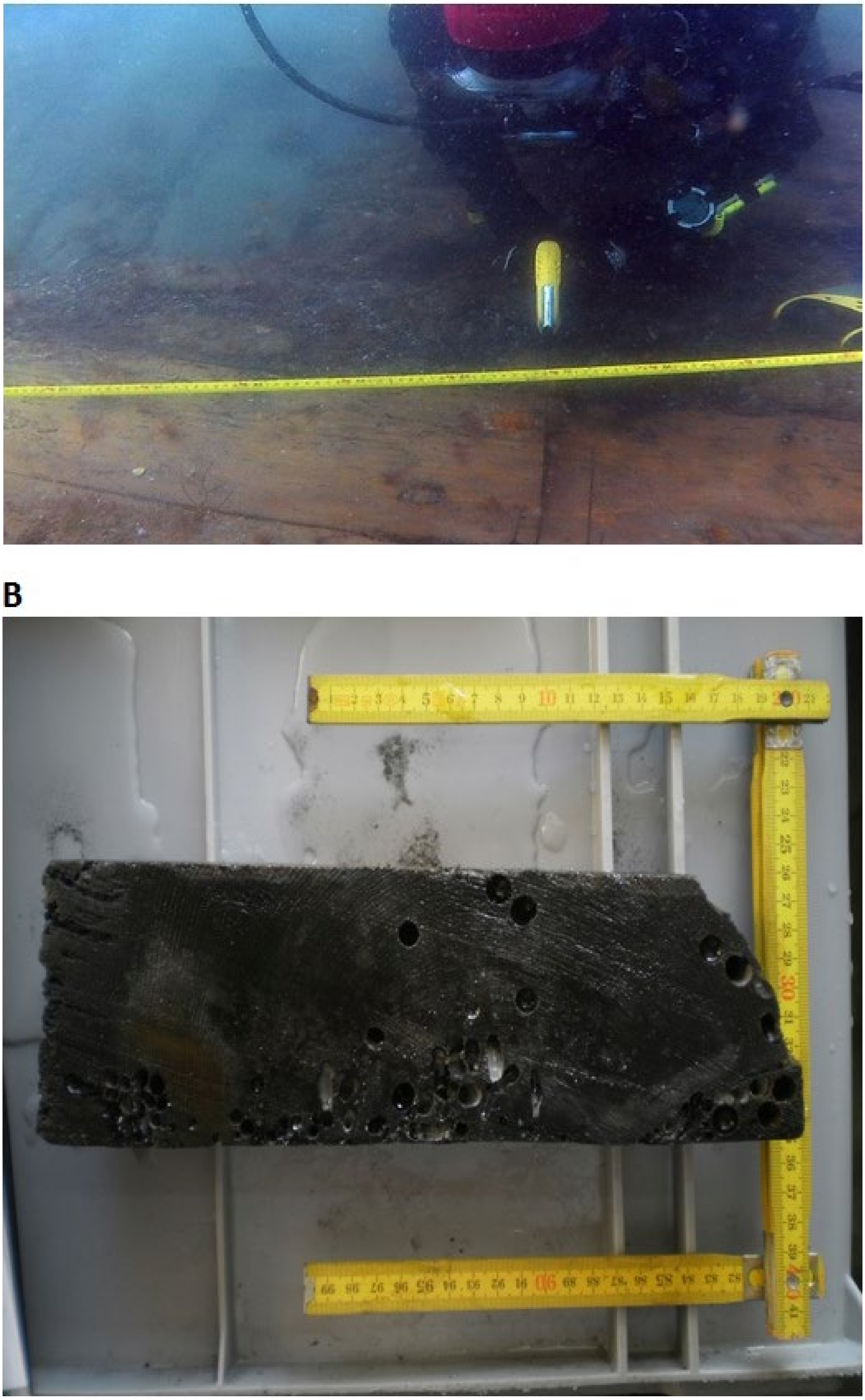


Figure 3. Sampling the *Magdalena* timber assemblage:
A) 2015 underwater archaeology campaign.
B) Sample of pine ceiling planking.

horizontal elements. Because oak is ring-porous, each ring represents a potential breaking point, so the more rings a tree and its derivative timber has, the more vulnerable it is to splitting with vertical pressure, as would be experienced by frames and stanchions (cf. Rich *et al*., this volume). Horizontal elements on the other hand do not experience the same kind of pressure against the cross-section. Therefore, to provide samples to wood scientists reliant on high numbers of annual growth rings (e.g., dendrochronology), planks were targeted over frames, the latter of which tended to represent the parent tree well but were often only a couple decades old when felled. Figure 3 is a sample of ceiling planking that was converted from a slow-grown pine tree and preserves 146 annual growth rings, which made it an ideal candidate for wood provenance analyses. Another factor in its suitability for our study is that even after 200 years underwater, this wood sample is very well preserved with very few bore-holes introduced by *Teredo navalis* and other xylophagic organisms that would increase the difficulty of taking accurate measurements of tree-ring widths or of chemical composition.

Each of the 21 samples taken from the *Magdalena* was treated as an artefact. They were cleaned, measured, photographed, drawn, and entered into the ForSEAdiscovery database before being stored in fresh clean water and delivered to their destination—the wood science lab. The recording of each sample was performed with a tablet and stylus to produce detailed record sheets to hand over to the wood analysts along with the samples themselves, which are often destroyed over the course of analysis. These primary records are also retained in the database for studying the scantlings, tool marks, and joinery methods of sampled ship components, as well as the conditions of the wood when it was sampled, which may be useful for future conservation and site formation process analyses.

Wood science: aiming to establish the provenance of the wood

Once the shipwreck samples arrived at the laboratory of dendrochronology of the University of Santiago de Compostela (Spain) a selection was made, setting aside the best preserved samples (i.e. showing the fewest galleries caused by *Teredo navalis*) to divide them into subsamples that would be used for organic and inorganic geochemical studies of wood composition and characterisation. The main aim of the wood science team of the ForSEAdiscovery project is to develop reference methodologies and datasets to enable us to establish the provenance of Iberian ship timbers. These comprise tree-ring-based datasets (ring-width, earlywood, latewood, vessel and latewood density chronologies), stable strontium isotopic data, and data about the organic composition of different wood species in different areas. All these datasets have been developed for pine (*Pinus nigra* and *P. sylvestris*) and oak species (*Quercus robur, Q. petraea, Q. faginea* and *Q. pyrenaica*) in key areas of the Iberian Peninsula that supplied timber for shipbuilding during the early modern period (Domínguez-Delmás *et al.* in prep.). The techniques used for organic and inorganic wood characterisation have been conducted in a smaller group of samples of the trees used for dendrochronology and wood anatomy. Once the reference datasets have been concluded, it has been possible to cross-check the shipwreck timbers with them in order to try and identify the origin of the wood. In this work we present results of the dendrochronological analyses and preliminary data from infrared spectroscopy on the *Magdalena* shipwreck samples, researches carried out at the University of Santiago de Compostela (USC, Spain).

Dendrochronology: determining timber date and provenance through tree-rings

Samples from 21 different timber elements of the *Magdalena* shipwreck were sent to the laboratory of dendrochronology of the Department of Botany at the USC.

A preliminary inspection was carried out to determine the suitability of the samples for dendrochronological dating. Such samples should contain a sufficient number of tree-rings to allow for sound statistical results (e.g. 80 to 100 tree-rings). Exceptionally, timbers with as few as 30 tree-rings could be researched to attempt cross-dating with other samples from the same structure and, thus, all timbers with more than 30 tree-rings were analysed in this study. The transverse surface of the samples was cleaned with razor blades from the inner- to the outermost ring to perform a ring count and register the presence of pith and sapwood. This preliminary inspection also served to identify samples corresponding to the group of deciduous oaks (*Quercus* subg. *Quercus*) and chestnut timbers (*Castanea sativa*), as both present large early wood vessels placed in a ring-porous disposition although the deciduous oaks show large multiseriate medullary rays that distinguish them from the chestnut. These characteristics make them distinguishable by the naked eye. The identification of other species was attempted through observation with an Olympus BX40 microscope of wood anatomical features on thin slices of the radial and tangential section of the wood and using the identification key proposed by García Esteban *et al.* (2003). Ring-width acquisition was done with a TimeTable measuring device (University of Vienna) coupled with PAST5 software (SCIEM).

Table 2: Species identification and tree-ring analysis. 1) *Quercus* subg. *Quercus*; 2) *Pinus sylvestris/nigra*; 3) *Castanea sativa*; 4) conifer (unidentified); pith: present (+1)/absent (-); bark edge (WK): present (+)/absent (-)/estimated; MRW: mean ring width (cm); σ: standard deviation (cm).

Sample number	Type of timber element	Species	Dendro code	N rings	Pith	Sapwood	Bark Edge	MRW	σ
MAG01-001W-02S	Frame at bow	1	MAG00011	47	-	0	-	0.68	0.24
MAG01-001W-03S	Frame at bow	1	MAG00012	82	-	0	-	1.43	0.49
MAG01-002W-01S	Ceiling plank at stern	2	MAG00020	100	+	0	-	2.14	1.34
MAG01-003W-01S	Ceiling plank at stern	2	MAG00030	146	-	66	-	1.28	0.36
MAG01-006W-01S	Frame at stern	2	MAG00041	35	+	0	-	2.90	0.78
MAG01-007W-01S	Frame at bow	1	MAG00050	216	-	28	WK?	0.67	0.41
MAG01-008W-01S	Frame at bow	1	MAG00061	67	-	0	-	1.56	0.82
MAG01-009W-01S	Frame at bow	1	MAG00070	49	+	0	-	2.33	0.71
MAG01-010W-01S	Frame at bow	1	MAG00080	144	+	0	-	1.16	0.46
MAG01-011W-01S	Frame at bow	1	MAG00090	78	-	0	-	1.63	0.65
MAG01-012W-01S	Frame at bow	1	MAG00100	49	-	6	-	2.65	0.87
MAG01-013W-01S	Frame at bow	1	MAG00110	125	-	38	-	0.88	0.50
MAG01-014W-01S	Framing element from bow	1	MAG00120	51	-	-	-	1.69	0.72
MAG01-015W-01S	Hull plank from bow	4	MAG00130	32	+	-	-	3.64	1.06
MAG01-016W-01S	Sacrificial hull planking	2	MAG00141	100	+	-	-	1.66	1.20
MAG01-017W-01S	Wedge sample of frame at stern	1	MAG00151	65	-	-	-	2.18	0.82
MAG01-018W-01S	Frame section	1	MAG00160	78	+	-	-	1.91	0.83
MAG01-019W-01S	Frame section	1	MAG00170	119	-	-	-	1.24	0.51
MAG01-021W-01S	Chiseled block samples from outer hull planking	1	MAG00180	79	-	-	-	1.04	0.19
MAG01-001W-01S	Frame at bow	1	-	Unkown	-	0	-	Severely damaged by *Teredo navalis*	
MAG01-004W-01S	Stringer at stern	3	-	20	+	0	-	Not suitable dendro	
MAG01-005W-01S	Wedge sample from oak frame at stern	1	-	8	-	0	-	Not suitable dendro	
MAG01-020W-01S	Frame section	1	-	28	+	0	-	Not suitable dendro	

Wood identification and dendrochronological results

Fifteen samples were identified as deciduous oak (*Quercus* subg. *Quercus*), five as conifers (four of which are *Pinus sylvestris/nigra*), and one as chestnut (*Castanea sativa*) (Table 2). The oak samples MAG01-001W-01S, MAG01-005W-01S and MAG01-020W-01S, as well as the chestnut sample MAG01-004W-01S were discarded for tree-ring analysis, as they contained fewer than 30 tree-rings (Table 2).

Cross-dating with oak and pine reference chronologies from Spain, central and northern Europe resulted in the absolute dating of three samples: MAG01-018W-01S (dated after 1667 C.E.), MAG01-019W-01S (after 1716 C.E.), and MAG01-021W-01S (after 1702 C.E.) with chronologies of *Q. petraea* of the north of Spain, being a *Q. petraea* composite chronology (made with seventeen trees from Cantabria and two trees from Asturias, QUPE19MC, Domínguez-Delmás unpublished) the one providing the best statistical results (Figure 4). The provenance of these timbers is, therefore, some forests in the north of Spain (regions of Asturias, Cantabria or Basque Country), but the dendrochronological results do not allow to pinpoint an exact location. The absence of sapwood in the samples hampers estimating the felling date of the trees, hence, the dates can only be presented as *terminus post quem* (dates after which the tree was cut). The tree-ring series of those samples have been averaged into the object mean curve MAG3MC that spans the period 1590–1716. The rest of the samples did not produce statistically sound results between them nor with the reference chronologies, therefore, their date and provenance remain uncertain.

Geochemical fingerprinting of *Magdalena* shipwreck: relevance of the initial FTIR results

Wood is a complex polymeric material composed by polysaccharides and lignins. These lignocellulosic macromolecules are responsible for most of the physical and chemical properties that result on differences between wood types (Hedges 1989). The variety of wood types is not only associated with the taxonomies and the environmental factors of the growing location but also to decay factors associated with the storage environment, particularly for archaeological woods (Fritts 1976; Hedges 1989). The characterisation of the molecular structure of wood chemistry allows detailed understanding of wood properties. Although considerable studies have been done using diverse types of techniques, much more effort is still needed for us to fully understand the preservation of the chemical composition of archaeological wood (Pandey 1999).

Fourier transform infrared spectroscopy (FTIR) is a widely used vibrational technique for wood analysis (Colom and Carillo 2005; Traoré *et al.* 2016). Unlike conventional chemical analysis, it has the advantage of time efficiency and does not require sample destruction (an important aspect when analysing archaeological artefacts). It has been used to differentiate between soft- and hardwood, showing that softwood lignin is essentially composed of guaicyl moieties, whereas hardwood lignin is composed of guaiacyl and syringyl moieties (Colom and Carillo 2005; Evans 1991). FTIR has been more often used to evaluate archaeological wood in order to choose the appropriate conservation method. It is a useful technique for studying chemical changes that have occurred during the decay process undergone on ancient wooden artefacts. In this work we applied FTIR to some wood fragments from *Magdalena* shipwreck timbers in an attempt to evaluate the potential of this technique for allowing the identification of the provenance of waterlogged samples.

Four *Pinus* sp. (MAG02, MAG03, MAG15 and MAG16) and two *Quercus* sp. (MAG10 and MAG21) fragments were analysed by FTIR. The samples were oven-dried for two weeks at 30°C, and then the surfaces were cut in order to visualize tree-rings. Measurements were recorded on consecutive individual rings, from the outer part (recent rings) to the inner part (older rings) of each fragment. The FTIR-ART equipment used was an Agilent Cary 630 FTIR Spectrometer equipped with a single-reflection diamond crystal. The spectra were collected in the absorbance range from 4000 to 400 cm−1 over 100 scans per sample, at a resolution of 4cm^{-1}. To get a first impression on the collected data, average and standard deviation spectra were calculated on the relative absorbance spectra. Average spectra reflect the dominant spectral bands, whereas the standard deviation indicates which are the largest relative variations (Traoré *et al.* 2016). For the purpose of this study, the samples were grouped according to the wood specie.

Figure 4 represents FTIR spectra of the two type of wood. The average spectra showed several peaks at identical bands for the two types of wood but according to the relative peak intensity there were differences. Very high peaks with lower intensity for oak woods were recorded at a band near 1030cm^{-1}, which is attributed to C-O stretching in primary alcohol in cellulose (Popescu *et al.* 2007). Moderate absorption peaks were recorded near region assigned to symmetric CH_2 valence vibration at bands 2925 and 2860cm^{-1} (Schwanninger *et al.* 2004). Several lower peaks were presented at region for bands absorption associated to aromatic molecular structures vibrations with lower intensity for pine woods at 1590 cm^{-1} and lower intensity for oak sample at 1690, 1510 and 1260cm^{-1} (Colom and Carillo 2005). The standard deviation spectra showed higher variability in pine wood than in oak wood. The largest variabilities in

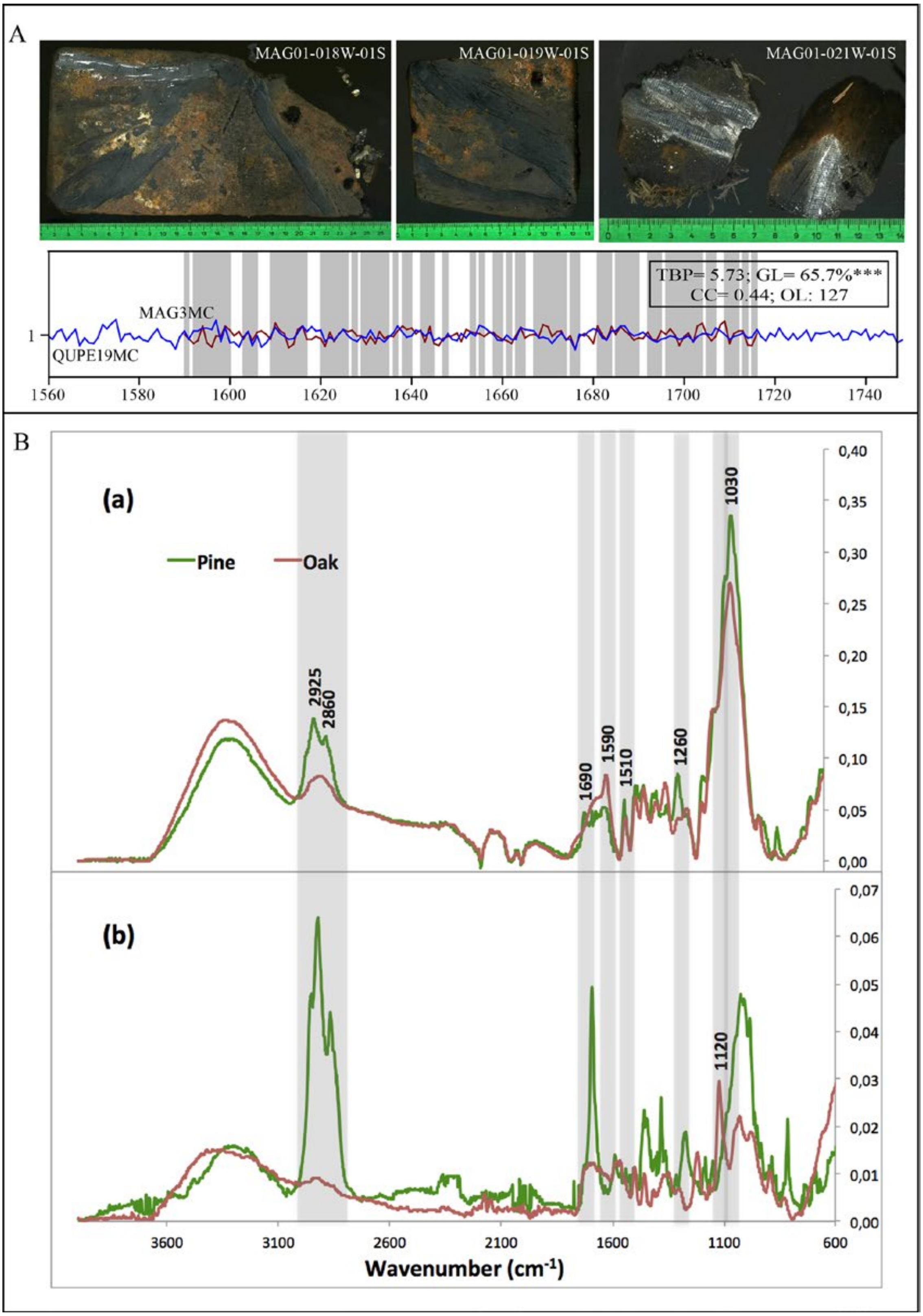


Figure 4. A) *Magdalena* oak samples dating. Tree-ring series averaged into mean curve MAG3MC, which dates against a *Quercus petraea* composite chronology (QUPE19MC). Legend: TBP: Student's *t* adapted according to Baillie and Pilcher (1973); asterisks represent signification GL level (***, p<0.001); GL: percentage of parallel variation as defined by Eckstein and Bauch (1969), and indicated by the shaded background; CC: correlation coefficient; OL: overlap between the series; X-axis: calendar years. B) Average (a) and standard deviation (b) spectra obtained by FTIR. 4_9.jpg .

pine wood were highlighted at bands near 2925, 2860, 1690 and 1030cm^{-1}. These bands are due to absorption respectively C-H stretch, carbonyl bond vibration in carboxylic structure and C-O bond vibrations; these bands are main peaks for terpenoid compounds (Faix and Böttcher 1992, Schwanninger *et al.* 2004). The highest variability in oak woods was presented at band near 1120cm^{-1} a related typical syringil unit C-H bond vibrations (Popescu *et al.* 2007).

Conclusions

Despite the lack of data specifically related to the wood used in the construction of the *Magdalena,* written sources provide exhaustive information about the overall supply to the arsenal of Ferrol. These allow the characterisation of the context within which the frigate was constructed and, therefore, give relevant clues for the archaeologists and wood scientists about the species, provenance and application of timber in the crafting of different ship elements. In fact, the results of the analysis of the historical documents indicate the high probability that the remaining framing elements of the hull and other elements placed below the waterline contain a preponderance of northern Spanish timber, particularly oak, followed by the other less represented endogenous species, as well as a minor usage of tropical timber. On the other hand, aside from sacrificial planking, any northern European pine timber that might have been used in the ship's construction was most likely applied in the upper works and, thus, has been destroyed through erosional and biodegradational processes over time on the archaeological wreck site. The documentary evidence about the use of Pyrenean pine is a significant factor for the identification of the provenance of the extant pine elements.

To supplement the historical data and to provide a scientific basis for the relationship between forestry and shipbuilding practices in 18th-century Ferrol, an underwater archaeology campaign was enacted. A primary aim of the campaign was to remove wood samples from *La Magdalena*'s remaining hull timbers for dendro-provenance. In accordance with the protocols for *in-situ* ship timber sampling (currently in development), specific timbers were targeted based on the likelihood that they would be able to provide sufficient provenance data to justify their removal from the shipwreck assemblage. Qualifying factors included the timbers' function within the ship (i.e., original structural elements such as planks, frames, beams, etc.) and their condition (i.e., lowest levels of biogenic degradation). Timbers were fully recorded before sampling, and the 22 samples retrieved were treated as artefacts and equally recorded in great detail; these primary records are held in the ForSEAdiscovery database for further research into Iberian shipbuilding methods. The wood samples were then dispersed to partner laboratories for dendro-provenance.

Carrying out an appropriate sampling protocol is crucial for the success of dendrochronology. In the case of *La Magdalena* shipwreck, eleven out of the 21 samples retrieved presented almost 80 rings or more, and three of them could be absolutely dated with a provenance in the regions of Asturias, Cantabria or Basque Country in the north of Spain. This provenance is consistent with the information found in the historical archives about the origin of some of the wood supplying the Ferrol shipyard when *La Magdalena* was built. The lack of internal matches between more oak samples could indicate that the wood was sourced from different areas, which is also consistent with the archival information.

The preliminary results from the application of FTIR to *La Magdalena* shipwreck show the potential of using this technique to study waterlogged woods. The use of the average and standard deviation spectra enables us to obtain details about the chemistry of shipwreck timbers. From these results we can conclude that the combination of FTIR with powerful statistic methods is promising and may allow the identification of organic markers for the distinction between species and provenance of wood from shipwrecks.

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Maritime Archaeological Timber Sampling: Methods and Results from the Silty Solent

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Abstract

A focal point for shipbuilding and maritime activity for millennia, the Solent is the strait that separates the Isle of Wight from southern England. Today, it is a busy shipping lane that also hosts several wooden shipwrecks, submerged prehistoric sites and drowned forests. This paper focuses on underwater timber sampling in the Solent, where the sixteenth-century Yarmouth Roads shipwreck lies adjacent to the submerged forest and Mesolithic site of Bouldnor Cliff. The shipwreck's well-preserved timber assemblage is an archive, not only of shipbuilding and carpentry, but also of climatic fluctuations, forestry practices and international trade that can cast light on broad socio-environmental changes of the early modern period. Likewise, the oak forest at Bouldnor Cliff can help develop long-term Holocene climate records and determine how plant and human species reacted to rapidly rising sea levels. Methodologically, this paper presents an *in situ* timber sampling protocol developed by archaeological divers working within a problematic underwater environment featuring strong currents and extremely limited visibility. The protocol is being further developed so that researchers can obtain the greatest amount of data for lab-based wood characterisation (tree-ring, geochemical, DNA, etc.) studies while doing the least amount of damage to the site. It presents preliminary results from analyses of the samples, highlighting the need to identify and characterise timber remains within the context of the archaeological artefact (shipwreck and/or forest).

Keywords

Bouldnor Cliff, dendrochronology, dendroprovenance, DNA, shipwrecks, Yarmouth Roads

Introduction

The Solent is the strait that separates the Isle of Wight from southern England, an area that has been a focal point of shipbuilding for millennia. Maritime activities in the Solent and Southampton Waters benefit from double tides so, not surprisingly, it is still today a busy shipping lane. While recreational and commercial maritime activities are practically incessant on the surface, the Solent is also host to several sites of archaeological importance, including wooden shipwrecks, submerged prehistoric landscapes and drowned forests. Ongoing research over the last few decades has included the early modern shipwreck at Yarmouth Roads (Figure 1) and the submerged forest and Mesolithic site of Bouldnor Cliff (Figure 2), which are located near to each other. Each site, although differing in every other conceivable manner, shares one commonality: an extraordinarily rich timber assemblage located in an environment that is somewhat hostile for scientific researchers. This paper presents a protocol for *in situ* timber sampling that has been developed by archaeological divers working within a problematic underwater environment characterised by strong currents and extremely limited visibility. Dives are undertaken primarily during neap tides and slack water because the current in this part of the Solent frequently reaches four knots. Dives must be carefully planned with multiple contingencies in place to allow for quickly changing underwater circumstances that can result in zero visibility and dangerous currents just metres beneath the shipping activities at the surface. In addition, because the dive window is so limited, multiple dive teams are frequently working on site simultaneously in dark, murky conditions, which can occasionally present safety concerns when divers are wielding saws to cut timber samples. Workstations must be carefully considered and clearly allocated well before dive teams are in the water.

Besides demonstrating how field methods must be adjusted to such a challenging environment, a timber-

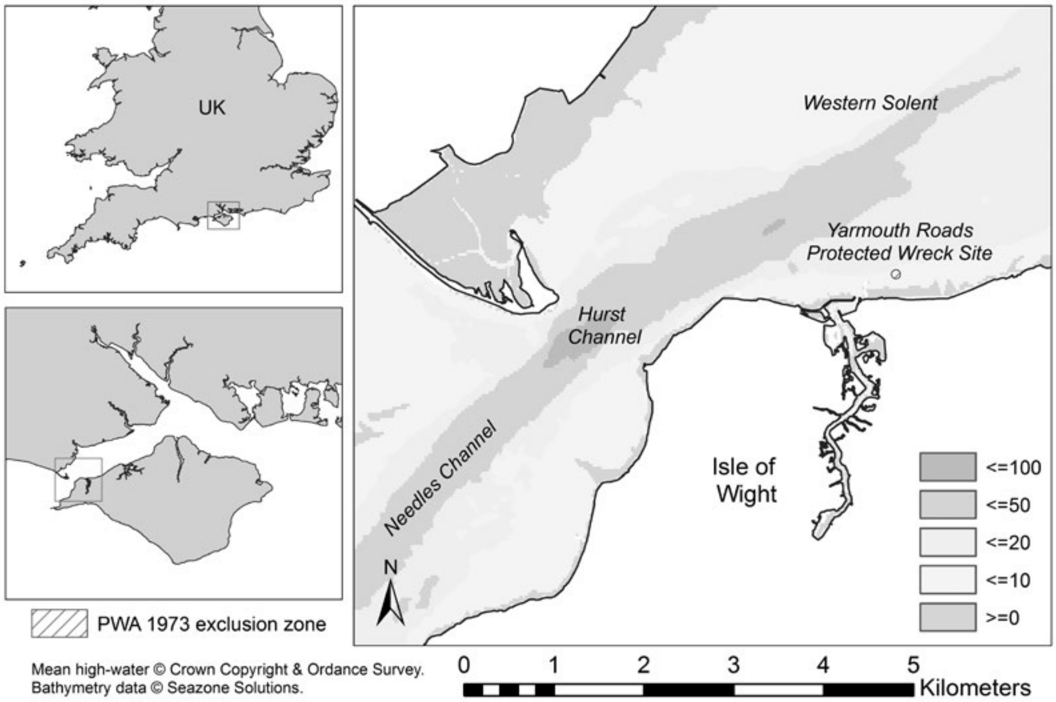

Figure 1. Map with the location of the Yarmouth Roads Protected Shipwreck, off the southern coast of the United Kingdom (Maritime Archaeology Trust).

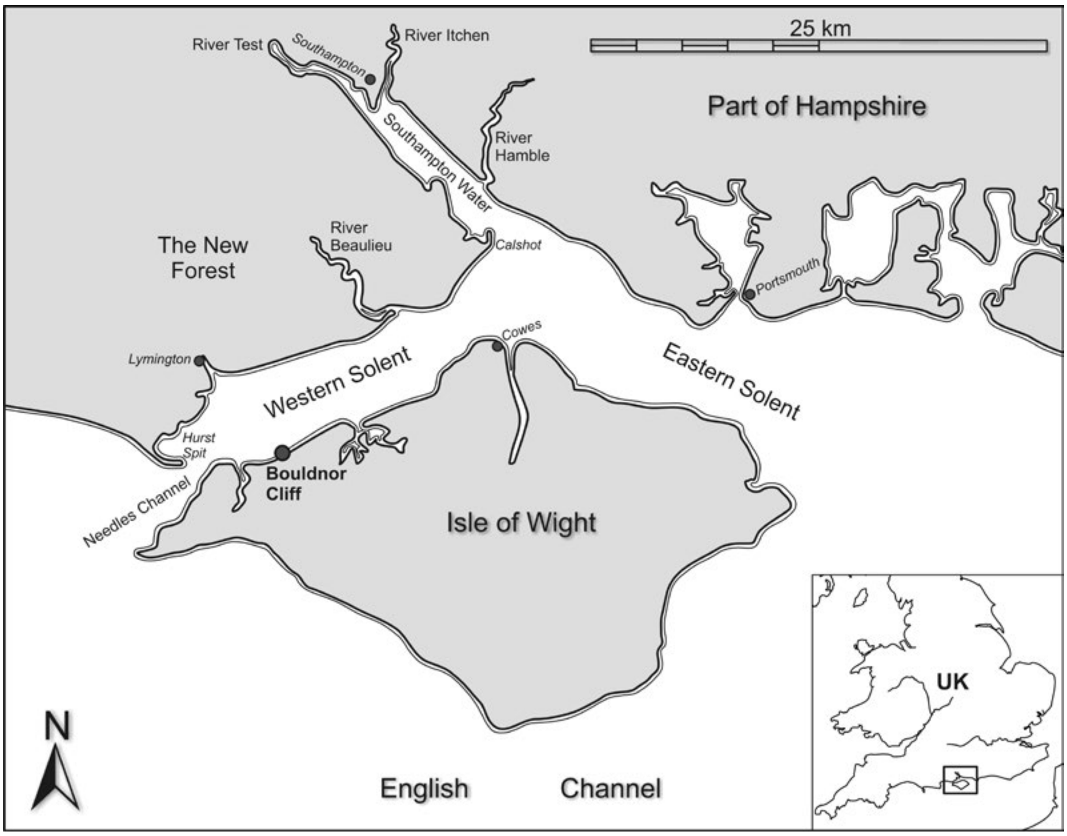

Figure 2. Map with the location of Bouldnor Cliff, off the southern coast of the United Kingdom (Maritime Archaeology Trust).

sampling methodology is primarily being developed so that researchers are in a more informed position to obtain the greatest amount of data for lab-based wood characterisation (tree-ring, geochemical, DNA, etc.) studies while doing the least amount of damage to archaeological sites. Preliminary results from analyses of the wood samples taken from Yarmouth Roads and Bouldnor Cliff are also presented below. These results underscore the need to identify and characterise timber remains within the context of the archaeological 'artefact,' whether a human-occupied forest or shipwreck with timbers that originated from a forest much further afield.

Organic remains in the archaeological record are often elusive due to their ephemeral nature. Substances like leather, cloth, bone, and wood are quick to decay in most depositional environments, being subject to erosional forces as well as macro- and micro-organisms that feed upon such material. However, like other organic remains, wood can survive for thousands of years in anaerobic environments that repel xylophagic organisms. Underwater, wood may be protected from teredo (*Teredo navalis*), gribble (Limnoriidae), and piddock (Pholadidae) by lying beneath layers of mud or peat, for example. Even large wooden watercraft or entire forests can also be preserved in intertidal zones or in rivers, frequently those that have been in-filled with clayey sediments.

Wood origin has been the focus of several scientific investigations in recent years, stemming from advances in dendrochronology and wood characterisation studies, and realising the potentials and limitations of each (Eckstein and Wrobel 2007; Bridge 2012; Rich *et al.* 2016a, b). In response, new scientific methods have been developed and old ones adapted to address common historical assumptions and the general lack of accurate information about anthropogenic fluctuations in world forests. These methods were also advanced to better understand alterations in species distribution and the complexities of trade networks. Current lab-based dendro-provenance techniques include DNA studies, dendrochronology, dendro-archaeology, trace element and isotopic analyses, and anatomical/structural markers. Each of these methods is consistently being further developed and improved so that the current range of applications can be expanded temporally and spatially, and to include more wood types in varying conditions. Dendrochronology and dendro-archaeology are the two most cost-effective, but each analytical method comes with its own set of limitations and benefits, so that ideally, multiple methods should be pursued for any given sample.

At the same time, UNESCO regulations for underwater cultural heritage make clear that even scientific activities 'shall not adversely affect the underwater cultural heritage more than is necessary for the objectives of the project' (UNESCO 2013, 37, rule 3). In order to ensure that the impact of scientific activities is proportional to the potential knowledge gained,

> A cautious step-by-step approach and phased decision-making may be the best way to avoid disproportional impact. Due to the constraints of proportionality of impact, archaeological research is continually caught between sampling strategies and total excavation. In order for science to progress, a combination of both strategies is needed. Sampling and excavation are complementary. One is not necessarily less radical than the other. Sampling the construction of a ship's hull for example, is extremely radical. It is perhaps more radical than a total excavation in which a hull is left intact, because that is deemed more 'consistent with protection'. Such sampling is not necessarily less proportionate or responsible, however, as it also yields other information (UNESCO, 2013, 39).

In sampling a site's timbers, the information gained can include fundamental data, like dates and provenance but ring widths, DNA, and isotopic data from wood samples can also contribute to ongoing studies of global concern. For example, the Yarmouth Roads shipwreck's well-preserved timber assemblage is an archive not only of early modern shipbuilding and carpentry, but also of climatic fluctuations, forestry practices and international trade that can cast light on broad socio-environmental changes. Likewise, the oak forest at the Mesolithic site of Bouldnor Cliff can help develop long-term Holocene climate records and determine how plant and human species reacted to rapidly rising sea levels, an issue which is again of concern today as we face unprecedented levels of global warming and sea-level rise. Clearly, the potential data gained from sampling is proportional to the impact on both sites; even so, our sampling strategies were formulated with the idea of minimising destructive impact in mind.

The Yarmouth Roads protected shipwreck

Located at a depth of approximately 6m below mean sea level, the discovery of the Yarmouth Roads wreck took place during an archaeological survey of the seabed off Yarmouth in 1984 (Figure 1). That search had been undertaken to locate the source of Roman pottery trawled up by local fishermen in the course of oyster dredging (Fenwick and Gale 1998: 46). Subsequent archaeological investigation in conjunction with historical research has suggested that the wreck may correspond with the shipwrecked *Santa Lucia*, a Spanish merchant ship recorded as being lost 'thwart of Yarmouthe' in 1567 while bound for Flanders with a cargo of wool (Fenwick and Gale 1998: 46–7; Dunkley 2001). Excavation of the *in situ* remains of the site indicate a vessel of around 32m in length, carvel-built and fastened predominantly with iron and interpreted as a large full-rigged ship, possibly a carrack or galleon of Mediterranean origin (Watson and Gale 1990: 186). The Yarmouth Roads shipwreck is one of only 52 shipwreck sites currently protected under the *Protection of Wrecks Act 1973* in the United Kingdom. It was first designated after its discovery by Historic England (then English Heritage) for its international historical significance and the unique nature of this ship type in English waters.

Archaeological work was first undertaken at the site in 1986 (Watson and Gale 1990) and has continued intermittently since then (Ferrari and Adams 1990; Hamel 2013; Plets *et al.* 2007), with the Maritime Archaeology Trust being the primary licensee. Since 2014, investigations have been conducted under the aegis of the Marie-Curie ITN project ForSEAdiscovery (Forest Sources for Iberian Empires: Ecology and Globalization in the Age of Discovery) due to the hypothesis that the wreck is of an Iberian, possibly Spanish, merchant vessel (Solana 2015). In order to better characterise the ship that wrecked at Yarmouth Roads, a programme of *in situ* timber sampling was enacted during the 2015 and 2016 field seasons (Rich, Satchell and Mason 2015; Rich and Satchell 2016).

In 2015, the preliminary timber sampling campaign produced three samples of very well-preserved structural timbers, which were removed by handsaw from the hull: cross-sections of two frames and one stanchion, each located in the bow section of the shipwreck. Each timber faced upwards so that the cross sections were already exposed just beneath the substrate of loose sand overlaying a dense clay matrix. Substrate from around the timbers was removed so that samples could be taken (after which they were re-buried), and because the protruding parts of the timbers had already eroded away, sample removal caused minimal damage to the shipwreck assemblage. All three samples were identified as *Quercus* subg. *Quercus* includes a wide variety of deciduous oaks around the world (Domíngez-Delmás 2015), therefore, knowing the genus is insufficient to understand the provenance of the timbers or where the ship may have been built. While other dendro-provenance analyses are still underway, the dendrochronology cross-dating results were inconclusive because of an insufficient number of rings to create statistically viable matches with regional reference chronologies (Domíngez-Delmás 2015). To increase the statistical probability for a match and to help generate a site-specific geo-chemical signature, it was recognised that a further 12–20 samples should be taken from other sections of the shipwreck; these additional samples would also serve to represent the entire vessel and to increase the chances of producing samples with higher ring counts (cf. Nayling and Susperegggi 2014).

Because deciduous oak wood is ring porous, the more rings a tree has, the more vulnerable its wood is to fracture along those lines of pores in the early wood; therefore, fast-grown oaks with fewer rings and fewer vulnerable areas were often selected for vertically-placed framing elements. By the same token, slower-grown oaks with more rings may have been delegated for horizontally placed planks where the potential line of fracture was less problematic. For this reason, in 2016, we focused on the starboard area as it was more likely to yield well-preserved planks that would maximise ring-count and potential for facilitating statistically viable dendrochronological, molecular and wood anatomical analyses (Domíngez-Delmás *et al.* 2013a; Traoré *et al.* 2015). However, to test this hypothesis, and again to have samples representative of the whole vessel, framing elements from the stern were also targeted. The bow timbers were also sampled in 2015, structural timbers at the stern also proved to be converted from young, fast-grown oaks (Domíngez-Delmás 2016). Despite an insufficient number of rings for dendrochronology, these samples may still be utilised in other scientific studies, such as DNA (Speirs *et al*. 2007) and geochemical analyses (Rich *et al.* 2016a), which do not require high numbers (>50) of annual growth rings or wood from any particular period of the tree's life. Geochemical analyses, particularly those using the $^{87}Sr/^{86}Sr$ isotope ratio of strontium—another demonstrated method for provenancing shipwreck timbers (Rich *et al.* 2016b)—may still prove successful. The results of these analyses are pending but are expected within the coming months and should form part of our next communication.

Initially, in 2016, three areas of exposed timber remains were selected for the focus of the field season's timber sampling campaign: starboard amidships (Area A), starboard stern (Area B), and port amidships to bow (Area C; Figure 3). Despite initially very poor visibility of 0.25–0.5m, the site was located and a baseline established that stretched from the stern to the bow along the starboard side.

Area A: The area of exposed planking and framing timbers at starboard amidships was quickly located, and work began there first to expose and define the timbers, their relationships with each other, and select those that would be sampled. All excavations were undertaken by hand without the use of an airlift or dredge. The area where some hand fanning of surface sediment was required measured a maximum of 4.5m long (bow to stern) by 2.5m wide. This allowed timbers

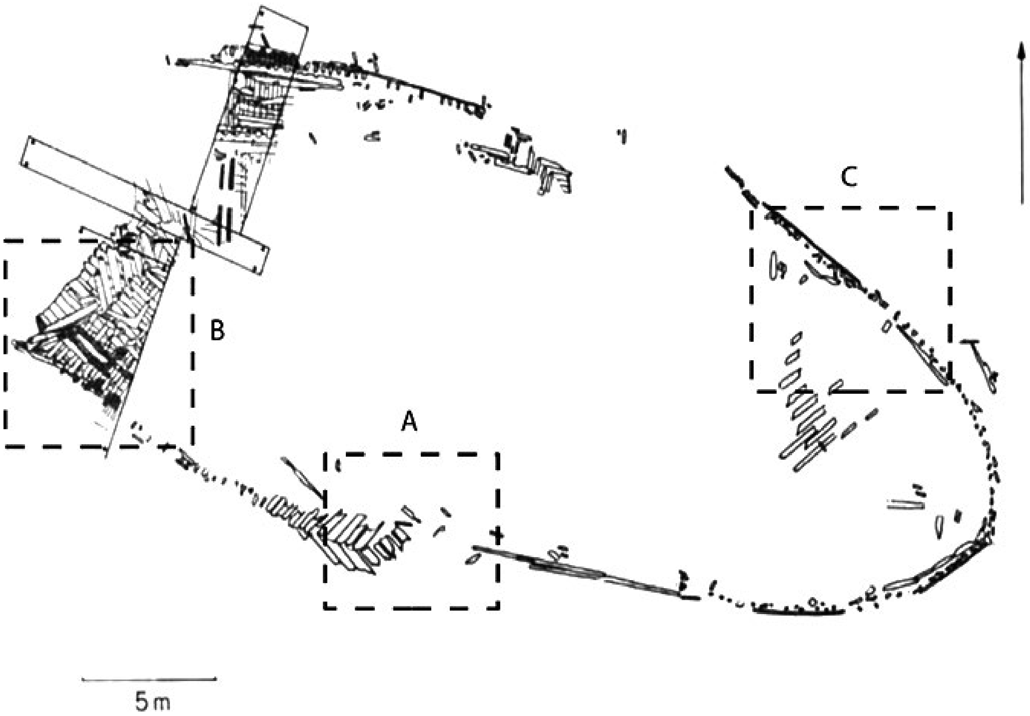

Figure 3. Site plan of the Yarmouth Roads Protected Shipwreck, with focus areas A, B, and C indicated (Maritime Archaeology Trust).

to be targeted for sampling. Around these timbers, small areas of up to 0.3m below the seabed were excavated to expose the eroded ends of hull ceiling planking that could be sampled with minimal damage to the vessel structure (Figure 4).

Figure 4. Sampled hull planking at Area A of the Yarmouth Roads protected shipwreck. Planks were converted tangentially and retain a minimal number of the parent tree's annual growth rings (Maritime Archaeology Trust).

Area B: The stern section was also quickly located as it remained covered with sandbags from previous excavation seasons. These were removed systematically to access the protected wooden structure beneath them, and replaced at the end of the campaign. The area re-exposed at the stern by temporarily moving the sand bags was a maximum size of 2.5m long (starboard to port) by 1.5m wide. Where the eroded ends of framing elements were exposed and selected for sampling, localised excavations around these timbers removed sediment to a maximum of 0.5m from the surrounding seabed level. This, again, ensured minimal impact on the seabed sediments and the overall vessel structure. Unfortunately for the purposes of the ForSEAdiscovery project, although short notched sill planks, or *albaolas*, characteristic of Portuguese and Basque shipbuilding were spotted in the site plan at the stern (Figure 3), this feature was not witnessed *in situ*.

Area C: On the final day, greater visibility of up to 7m permitted investigation of the port side primarily for reconnaissance but also to continue the photogrammetry survey that had been started in 2015. Timbers visible at the surface were dusted using hand fanning, and biological growth was reduced to mitigate interference with photography. No excavations were conducted in Area C. Of particular interest, a single very well-preserved pine plank was seen and photographed amidships on the port side, but it was not sampled due to time constraints. It is hoped that future campaigns will re-locate and sample this timber, as pine tree-ring chronologies are becoming increasingly more developed in northern Europe and in the Mediterranean.

Although unlikely to inform researchers as to when the ship was initially constructed, or from where exactly the parent tree was growing (due to tele-connections between pine chronologies in Spain: Domíngez-Delmás *et al.* 2013b), this cross-dated pine sample could potentially provide an absolute date for when this ship may have stopped for repairs. Furthermore, historical data produced by ForSEAdiscovery research partners indicate that Spanish shipbuilders often procured oak locally and pine from the Baltic, so if this pine sample were to match Baltic chronologies, it could be another indicator of an Iberian origin.

In all, 25 additional timbers were sampled using Stanley Fat Max handsaws with BladeArmor coating. These saws were elected for use due to a very effective tooth pattern, which maximised sawing efficiency, and a coating that resisted rusting in the marine environment. These features were particularly important, as the use of oil to protect and/or lubricate the saw could have contaminated samples destined for chemically sensitive studies. Timbers sampled included eleven from framing elements at the stern, and fourteen from the exposed area of hull planking and framing elements located amidships on the starboard side. All of the timbers seen and sampled in the two trench areas were oak (*Quercus* subg. *Quercus*; Domíngez-Delmás, pers. comm.). Upon surfacing, the samples were cleaned with fresh, clean tap water and recorded by scale photography, measurements, sketches, and text-based descriptions of condition, shape, function, etc. These samples are currently being subjected to a range of scientific analyses to determine date and provenance of the wood. As supported by the ForSEAdiscovery project, these analyses include dendrochronology, DNA, stable isotope geochemistry, wood anatomy, and molecular studies (Solana 2015).

The stern section (Area B) yielded timber samples very similar to the bow section that was sampled in 2015. These timbers were converted tangentially from extremely fast-grown oak trees, with some samples having no more than ten or twelve annual growth rings, each spaced roughly 1cm apart. It is possible that these were cut from coppiced oaks, as the rings are suggestive of a highly regulated forest that provided timber for the shipyard where the Yarmouth Roads was constructed. Preliminary dendrochronological results have been able to assign a relative match between Samples 6–7 and 19–20, indicating a common growth environment (Domíngez-Delmás, pers. comm., May 2016). Another relative match can be found between samples 1–5 and 8–10, again suggesting that these timbers were derived from the same forest environment (Domíngez-Delmás, pers. comm., May 2016). Fast-grown oaks were in high demand for shipbuilding. As noted above, their conversion into vertical framing elements had a structural function, as the fewer the number of growth rings, the fewer weak areas a timber would have; the porous wood produced during spring growth means that a timber with twenty rings is less likely to split under pressure than a timber that preserves 200 rings.

On the contrary, these functional considerations did not apply to planks, where the pressure would be lateral rather than vertical. It is not entirely surprising that the timbers with the highest number of growth rings came from planking on the starboard side amidships (Area A). Even so, the vast majority of planks were converted tangentially, so the ring count in samples remained very low and inauspicious for dendrochronological results (Figure 4). However, one sample, which was radially converted, preserves over 160 rings, making it an ideal candidate for dendrochronological and anatomical analyses. This sample also preserves fifteen sapwood rings, another factor that aids in dendrochronological dating, and by extension, provenance. Unfortunately in cross-matching the data from this sample with existing European oak chronologies, there were no significant correlations (Domíngez-Delmás, pers. comm., May 2016). However, it should also be noted that there is no existing chronology for Iberian oaks, so the fact that it does not match other European chronologies means that an Iberian origin cannot be ruled out. Therefore, the existing hypothesis that the vessel was of Iberian or Mediterranean origin cannot yet be modified and remains the leading interpretation of the shipwreck site.

The submerged Mesolithic site of Bouldnor Cliff

Bouldnor Cliff was discovered in 1984 when oyster trawlers pulled up an array of worked flints from the Solent seabed off the Isle of Wight (Figure 2). The flint assemblage was dated to the Mesolithic, and subsequent diver ground-truthing produced additional stone tools (some of which were 'excavated' by a lobster burrowing into the clayey sediments of the south-facing cliff; Momber *et al.* 2011). The site is located approximately 11m below mean sea level and is characterised by a peat shelf that overlays a thick layer of marine clay sediments. The combined forces of the peat and marine clay have preserved organic remains in this layer to an exceptional degree for the last 8000 years. Preserved plant matter includes hazelnuts, tree stumps, leaves, sticks, string of nettle or hemp, and a remarkable assemblage of worked wood (Momber and Rich 2015; Momber *et al.* 2011; Rich *et al.* 2016). On the eastern side of the cliff, radiocarbon dates have provided a *terminus ante quem* of 6020–5980 cal BC (95%), with inundation of the site occurring shortly after 5990–5890 cal BC. Radiocarbon and wiggle-matching of woody material have provided evidence for a *terminus post quem* of 6280–6240 cal BC for deposition (Momber *et al.* 2011: 59–

61, 74–75, 93, 102–04), and the oak ring-width sequence cross-matched against a comparable series from the Severn Estuary in south-west Britain (Nayling in Momber *et al*., 2011; Nayling and Manning 2007). Taken together with the archaeological evidence, Bouldnor Cliff can be estimated to have been occupied *c.* 8000-8200 yBP. It is hypothesised that the archaeological remains indicate a logboat construction site or similar area of large-scale industry. Recent sedaDNA analyses have demonstrated the presence of einkorn wheat some 2000 years before agriculture is thought to have been developed in Britain (Smith *et al*. 2015a, b).

Annual survey and monitoring of the site is conducted by Maritime Archaeology Trust, who was contacted in 2015 by the project Treepeace based at the University of Bordeaux. The project is seeking to reconstruct floral responses to Holocene climate change by considering long-term variations in DNA signals among ancient northern European deciduous oaks. Providing an ideal contributor to this project, samples of oak stems from Bouldnor Cliff were removed from the archaeological horizon as well as the layers on either side of it to provide the greatest temporal range. Samples were taken from limbs and other pieces of roundwood and from tree stumps (Figure 5).

Figure 5. Diver holds a sample from an oak tree stump at the site of Bouldnor Cliff (Maritime Archaeology Trust).

Sawing underwater is especially precarious at this site because of the fragility of the remains in combination with the challenging working conditions. As seen in Figure 5, the diver has lodged their elbow into the clay substrate for stability but also to keep from being washed off site by the strong current. Because of the parallel direction of tidal currents in relation to the archaeological horizon, using fins or knees for stability would have disturbed the archaeology, which would then equally run the risk of being washed from the Solent eventually into the English Channel. Even though the task of removing samples from the submerged oak forest is a relatively simple one in theory, in practice, detailed dive planning and continual awareness of one's position and movements are necessary when working on this site of extraordinary importance.

In 2016, the Maritime Archaeology Trust dive team along with students from ForSEAdiscovery and the University of Alexandria (Egypt) returned to the site to record and rescue worked wood elements that were protruding from the seabed and in danger of being washed away through continuous tidal erosion. Excavations at the most vulnerable area of the site revealed a previously unknown feature, which is thought to have been part of a platform or perhaps a dock composed of planks converted from oaks from the surrounding forest environment (Figure 6). These planks were recorded *in situ* through photogrammetry and then lifted individually. Each is currently undergoing a series of 3D recording techniques in order to eventually reconstruct the feature in relation to the rest of the site. The timbers will then undergo conservation processes.

Figure 6. Worked wood feature at the submerged Mesolithic site of Bouldnor Cliff (Maritime Archaeology Trust).

Conclusions

Superficially, the underwater sites of Bouldnor Cliff and Yarmouth Roads have little in common—one is a submerged Mesolithic landscape and the other an early modern shipwreck. However, they do share circumstances that have facilitated exceptional preservation of wood artefacts beneath thick substrates of anaerobic clay. These clay strata, while deposited under different geological circumstances, are located next to each other several metres deep in the Solent strait. While these depositional circumstances are ideal for the preservation of archaeological and paleobotanical materials, their position beneath busy shipping lanes, in dark, murky waters running at speeds up to four knots, makes for less-than-ideal working conditions. Nevertheless, each site has been the focus of successful *in situ* timber sampling campaigns during the 2015 and 2016 field seasons.

At the Yarmouth Roads Protected Wreck, a total of 28 structural timbers were sampled to provide data on the provenance of the ship, which is presumed to have been of Iberian origin. The samples taken indicate that the ship was built of oak (*Quercus* subg. *Quercus*) wood, and that her framing elements were tangentially converted from young, very fast-grown trees that were possibly managed through coppicing. Very few planks and other horizontal elements were converted from slower-grown oak trees featuring narrow annual growth rings. While dendrochronological results have so far been inconclusive, results of other dendroprovenance methods are pending. Presently the hypothesis of an Iberian origin and a date of the sixteenth century for the ship wrecked off Yarmouth cannot be modified and remains the leading interpretation of the site.

At Bouldnor Cliff, a small-scale sampling campaign was conducted in 2015 to gather information on oak responses to Holocene climate change. Six samples were collected from the site, from strata corresponding to before, during and after the Mesolithic human occupation and the relatively sudden inundation of the landscape by encroaching marine waters. Excavations in 2016 continued to remove samples of worked wood that are continually being threatened by the aggressive tidal erosion experienced along the southern channels of the Solent.

Work at these two sites and others within the framework of the ForSEAdiscovery project has contributed to establishing a set of protocols for *in situ* timber sampling campaigns (Rich *et al.* 2018). These protocols offer guidelines for where to remove samples from shipwrecks, what to look for in a timber that will potentially be sampled, and for which types of dendroprovenance or wood characterisation analyses where certain kinds of samples may be used. In effect, the protocols hope to assist researchers in removing samples that will provide the greatest amount of temporo-spatial and climate data while minimising the negative impact on the assemblage, all in accordance with the UNESCO Convention on the Protection of Underwater Cultural Heritage 2001.

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The Maritime Archaeological Survey of Oman—Building Capacity for a Sustainable Future

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Abstract

The Marine Archaeological Survey of Oman (MASO) project was initiated by the Ministry of Heritage and Culture of Oman in 2014, and involved the Western Australian Museum and the University of Southampton. The objective was to investigate possible sites of maritime archaeological significance along the coast of Oman. The project comprised six main parts: archival research (to identify potential sites for investigation); desktop survey (to identify areas along Oman's coast that are likely to have significant underwater cultural heritage (UCH) material; coastal reconnaissance (field survey of targeted coastal areas identified by the desktop assessment that have high archaeological potential or are threatened by coastal development); remote sensing survey (to survey particular areas selected from the coastal reconnaissance survey); diver and underwater visual search and survey (to survey areas identified by the coastal reconnaissance and investigate sites located by the remote sensing survey); and, training and capacity-building (to assist the Omani Ministry of Heritage and Culture's underwater archaeological team in developing expertise). In addition, it was to raise awareness of the significance of Oman's UCH for government agencies and NGOs that have responsibilities for the maritime environment. This paper reports the findings of this project.

Keywords

Oman, survey, shipwrecks, coastal assessment, capacity-building

Introduction

In 1996, His Majesty Sultan Qaboos declared 'We express our great pride in Oman's seafaring history, which was written by those great ships that traversed the broad oceans carrying the pride and power of our country and its desire to foster friendly relations with all nations' (Ministry of Foreign Affairs 1996).

Oman has enormous archaeological potential, as has been amply demonstrated by the results of terrestrial archaeological investigations conducted over decades under the guidance of the Ministry of Heritage and Culture. The maritime archaeology of the sea, however, has hardly been explored. Maritime history provides the material basis for planning a comprehensive and productive maritime archaeological programme. For example, as conditions in the Holocene turned more arid, people would naturally look to the sea as a resource for sustenance. Oman has no navigable rivers, and travel over desert and mountain is difficult; therefore, it is understandable that coastal populations would engage directly with the sea, building boats to facilitate travel and exploitation of the marine biosphere.

This maritime tradition extends back for millennia. Recent research confirms seafaring across the Bab Al Mandeb to southern Arabia directly out of Africa in the Palaeolithic (Rose 2010; Rose *et al.* 2012). Neolithic coastal sites reveal that coastal populations were engaged in intense exploitation of marine resources (Méry and Charpentier 2002). In the Bronze Age, sea routes linked major civilisations of the region such as Mesopotamia, the island of Bahrain (ancient Dilmun) and the Indus Valley, with the Oman Peninsula (David 2002). Oman was, indeed, a nexus for regional trade and cross-cultural contact within the Gulf, to southern Arabia, and even as far as the Horn of Africa (Cleuziou and Tosi 1997; Cleuziou and Tosi 2007). The Iron Age also reflects maritime connections beyond the shores of the Oman Peninsula, evidenced at sites such as at Khawr Rori (Avanzini and Orazi 2001) and the sheltered bay at Bandar Al Jissa, where Iron Age occupation is revealed from the Lisq period (1000–100 BC) through the Samad period (100 BC–AD 600) (Possehl 2009).

In the early years of Islam, the arena of maritime contact expanded, encompassing India, Sri Lanka, East Africa, South-east Asia and China. Over the centuries,

Figure 1. Sites in Dhofar east of Mirbat (after Owen 1997, Google Earth).

populations gradually expanded the range and sophistication of their maritime and boat-building skills. Omani shipwrights and sailors acquired a reputation for excellence in seafaring, navigation and shipbuilding. In later centuries, the maritime exchange network created by Omani sailors became well established. By the beginning of the seventh century, what was then the longest sea-trading route in the world, the 6000 miles from Oman to China, was thriving.

Over the millennia the maritime connections have shaped the character, economy and politics of Oman. One can see these influences reflected in the broad ethnic, racial, religious and cultural diversity of its modern population.

Archaeological background

Despite a relative paucity of investigations directly related to maritime archaeology, some attempts to identify and record the maritime archaeological resource have been made. Bitumen slabs discovered at the mid-third millennium site of Ras Al Jinz, the source of which has been traced to Iraq and which once coated sea-going watercraft, attest to international trade and seafaring, and constitute the oldest direct evidence for seafaring in Oman (Cleuziou and Tosi 1994: 745). A coastal survey in Dhofar in the 1990s, revealed stone anchors and other artefacts associated with maritime trade (Owen 1997) (Figure 1), and a coastal–terrestrial archaeological survey ahead of planned development in the region revealed several small sites with maritime connections (Insall 2013). Dozens of timbers from Islamic-period sewn ships have been discovered at Al Baleed in southern Oman. These timbers were being recycled in architecture, having been salvaged from ships which had been wrecked or were undergoing repairs. At Qalhat in the Sharqiyah region, the largest number of stone anchors at any site of the entire Arabian Peninsula (Figure 2), were located (Vosmer *et al.* 1998: 15). Joint Omani-Chinese remote sensing surveys were undertaken at the Straits of Hormuz. These surveys revealed fourteen targets of interest, but so far, no follow-up investigation has taken place (Ministry of Heritage and Culture 2009).

More recently, a joint project of the Ministry of Heritage and Culture and Blue Water Recoveries has been working at the site of two ships from Vasco Da Gama's fleet of 1503 off Hallaniyat Island (Mearns *et al.* 2016). This is an enormously important find, promising to add significantly to knowledge about ships of the early European exploration period.

Whilst awareness is building of the huge potential for maritime archaeological discoveries in Oman, this is set alongside a combination of challenges to which the maritime resource is increasingly subject. Whilst legislation does exist to protect the cultural heritage of the Sultanate, the underwater component is not adequately supported and is, therefore, vulnerable to destruction. Likewise, whilst the Ministry of Heritage and Culture has management systems in place to tackle terrestrial development, the underwater archaeological resource is not accounted for. Currently, no investigation is conducted in advance of offshore development, and

Figure 2. Views of Qalhat showing stone anchor positions (Patrick Baker and Google Earth).

there is limited capacity to undertake such assessment in the face of increasing levels of coastal and offshore development that is currently occurring in Oman.

Recognising both the great potential for maritime archaeology and the responsibility of oversight and supervision for protecting the resource, the Ministry of Heritage and Culture is determined to create an underwater archaeology unit, the first in the Arabian Gulf region. Archaeology staff were recruited from within the Ministry and trained to dive, and supplemented by divers from outside the Ministry. This nascent team is gradually being expanded to include conservators, researchers and archivists.

Our project, the subject of this paper, was commissioned by the Ministry of Heritage and Culture in 2014 to further extend capacity to identify and manage the maritime archaeological resource of Oman. The underwater unit of the Ministry of Heritage and Culture was integrated with our Executive Management Team consisting of people from the University of Southampton's Maritime Archaeological Stewardship Trust (MAST) and from the Western Australian Museum's Department of Maritime Archaeology. That integrated team comprised the staff for the Maritime Archaeological Survey of Oman, or MASO. External volunteers were also recruited to assist with research, fieldwork and report writing.

Objectives

The project had a number of fundamental aims and objectives. To achieve these objectives, the basic project methodology included a desktop assessment, training and capacity-building for the Ministry of Heritage and Culture staff as well as for other ministries and private sector companies, coastal terrestrial surveys to evaluate the archaeological potential and gather information from fishermen, shipbuilders and abalone divers. Overseas archivists were hired to search archives in the United Kingdom, India, Portugal, the Netherlands and Oman. The project team had hoped to locate archivists in China, Turkey and Zanzibar as well, but this proved impossible.

In addition, underwater surveys using appropriate remote sensing devices as well as diver surveys, were conducted. The areas selected for underwater surveys were guided by desktop assessment and evaluation of areas with high probable archaeological potential. With more than 1700km of coastline, these initial underwater surveys obviously barely scratched the surface, but did provide valuable feedback about diving conditions and the challenges of deployment and logistics, as well as archaeological returns.

Desktop assessment

The basic foundation was a desktop assessment of the potential of the maritime archaeological resource. The aim of the desktop assessment was to help understand what research had already been conducted, where and to what level of investigation. This would help prevent future duplication of effort, and also the form the basis upon which subsequent research and survey would be prioritised. The desktop assessment would also lay the foundation for a GIS database, providing a cross-referenced, indexed and searchable database, which would form the basis of a framework from within which an efficient and productive programme of maritime archaeological research and exploration could be planned and executed.

In order to achieve these desktop assessment goals, the MASO project:

- Collated all known information relating to UCH and related data that are available in Oman. This information included all published archaeological reports relating to coastal and maritime activities (terrestrial as well as maritime), grey literature, historical texts—particularly those associated with coastal sites or underwater expeditions—annals of sea-trading, fishing and aquaculture, naval warfare, migration, cultural exchange and maritime technology. Data on weather patterns, climate history, currents, coastal and seabed topography, the results of commercial underwater surveys, aerial and satellite photographs, ordnance surveys maps, and Admiralty charts, were also collected;
- Recruited archivists to conduct archival research in countries that have historical maritime connections with Oman (e.g. UK, Netherlands, Portugal, India, East Africa, and China); and,
- Generated a GIS to support an assessment of the maritime heritage of Oman in order to target further survey and investigations.

Resources for the desktop assessment included:

- Terrestrial archaeological reports;
- Underwater surveys conducted by commercial and government organisations;
- Bathymetric surveys and seabed characterisations;
- Weather, currents and tidal records;
- Fisheries records;
- Dangers to navigation;
- Coastal ordnance survey maps, Admiralty charts and Royal Navy of Oman charts;
- Satellite and aerial images of the entire coast;
- Information from sports divers, fishermen and abalone divers;
- Information from pilot books for Omani waters;
- Multi-beam and side-scan sonar surveys, LIDAR surveys, sub-bottom profiles and magnetometer surveys done by the government and private sector; and,
- Future and current coastal development plans of the government or private sector.

Attempts were made to obtain these data from a number of sources including several government ministries, the private sector, the National Survey Authority of Oman, the Department of Meteorology, the Royal Navy of Oman Hydrographic Office, and the Special Economic Zone at Duqm (SEZAD). Despite initial apparent enthusiasm from most sources, success in obtaining data was uneven and not as productive as hoped or expected, but it is anticipated that further efforts will be made to gather additional information in the future. SEZAD, an umbrella organisation comprising private sector and government developers, did provide a great deal of information. A workshop held with SEZAD which included a number of engineers, GIS specialists, environmentalists and the MASO team, was very productive, raising awareness and covering such subjects as the importance and fragile nature of the maritime archaeological resource as well as mechanisms for reporting finds. As most of these organisations had collected data for purposes other than archaeology, it became evident that one of the keys to obtaining useful data was to describe in detail what exactly was required in data collection, and to what resolution and depth of detail.

Fieldwork

Fieldwork consisted of terrestrial coastal surveys to seek indications of maritime connections and potential, side-scan sonar and magnetometer surveys of selected areas (Figure 3), and targeted diver surveys based on results from remote sensing surveys or earlier discoveries. Fieldwork augmented the desktop research and expanded our knowledge base. Anomalies that were identified as part of the marine remote sensing survey were ground-truthed, enabling evaluation of whether or not some sectors warranted further investigation or were unlikely to reveal much additional information.

Awareness-raising

The MASO programme was also determined to extend awareness, knowledge and understanding of the extent

Figure 3. Side-scan sonar tracks north of Masirah (Google Earth, J. Green).

and value of the maritime archaeological resource, and to dispel the pernicious view of underwater archaeology as treasure-hunting. These goals were accomplished by the training of Ministry of Heritage and Culture staff. Through convening a series of workshops and lectures targeting ministries such as Tourism, Environment, Agriculture and Fisheries, Housing, Education and Higher Education, as well as the private sector. The long-term aim is to extend the programme to the general public.

Education and capacity-building

Capacity-building was a prime aim of the MASO project, with three primary elements:

1. Education in primary, secondary and tertiary institutions;
2. Training activities (for all levels and organisations, including the Ministry of Heritage and Culture staff, academic, other ministries, developers, fishers, professional and recreational divers); and,
3. Social capital. The project also focused on the social capital, that is, it tried to identify the right people and organisations for future success. Building partnerships and developing sustainable and genuine partnerships among government ministries and between government and the private sector was an important goal.

Best practice

Linking to education and capacity-building was the goal of developing a comprehensive holistic approach to maritime heritage management. Additionally, the MASO project aimed to build a sustainable strategy for the future, with government and the private sector, and to institute best-practice strategies and working routines.

All these activities were aimed at creating a completely self-sufficient Omani maritime archaeological team and a productive and sustainable programme of the highest professional standards within the Ministry of Heritage and Culture.

Refining target areas

From the outset, a long-term, broad-based survey was proposed of a number of different coastal locations of Oman. Specific areas that appeared promising were targeted, but it was also recognised that the desktop assessment would refine, and perhaps change, the proposed areas of survey. Initially, five areas were proposed for closer investigation (Figure 4):

1. Musandam was chosen because of its historically heavy maritime traffic through the Straits of Hormuz, as well as the strong currents and unpredictable winds that could cause ships to become wrecked. The

Figure 4. Regions initially targeted for survey (Google Earth).

deep inlets (*khawrs*), characteristic of the Musandam Peninsula, also provided shelter for ships. It was known that Bronze Age ships had traversed this strait *en route* from the Arabian Sea and Gulf of Oman into the Arabian Gulf to the ports of Dilmun and Mesopotamia. Persian ships plied the waters during the late Iron Age, and during the Islamic period that traffic was sustained through connections to Siraf (Whitehouse 2009: 342; Whitehouse and Williamson 1973: 35) and later, Hormuz (Teixeira 1902).

2. Batinah Coast. With its historic ports such as Sohar and Muscat, the Batinah Coast was an obvious choice. Evidence for international maritime connections with Sohar go back to at least the 3rd century AD (Hiebert, pers. comm. 2011). Muscat has played a major role through much of the history of Oman, most particularly in the late Islamic period.

3. Sharqiyah. Along the Sharqiyah coast, at virtually every place where a wadi meets the sea, there is evidence of ancient settlement (Cleuziou and Tosi 1993). The earliest direct evidence of sea-going ships has been found at Ras Al Jinz, while Khawr Hajar, the inlet of Ras Al Hadd has been utilised by ships from at least the Bronze Age to the present (Cleuziou *et al*. 1990: 34; Reade 1997: 409). Ports of the Sharqiyah region, such as Ras Al Hadd, Ras Al Jinz, Qalhat and Sur clearly make this region attractive for maritime archaeological investigation. The inlet of Khawr Jaramah is a natural protective harbour and served as a transit centre where cargoes from ships too large to cross the bar at Sur were transferred to smaller craft (Blue *et al.* 2016: 66; National Geospatial Intelligence Agency 2011: 220).

Qalhat, allegedly founded in the 2nd century AD by the Azd tribe under Malik bin Fahm, has yielded evidence of prehistoric and historic activity (Dartus *et al.* 2013: 5). Lithics from the 5th and 4th millennium BC indicate coastal activity at that time (Vosmer 2003: 18), and excavations have uncovered an Iron Age grave and other pre-Islamic material (Vosmer 2003: 8, 18). In the late Islamic period, Qalhat was a satellite capital of the Hormuzi Empire and a major maritime entrepôt until its destruction by the Portuguese in 1508. During the 13th and 14th centuries AD, Qalhat annually exported thousands of horses to India, growing wealthy on the trade (Bhacker and Bhacker 2004: 40). Connections with South-east Asia and China are clearly demonstrated by the thousands of sherds of pottery and numerous Chinese coins scattered across the site.

In their drive to control maritime trade in the region, the Portuguese deemed the coastal settlements from Ras Al Hadd to Muscat such as Sur, Qalhat, Tiwi and Quriyat, valuable enough to Arab trade to destroy or capture.

4. Masirah to Madrakah. Along the Indian Ocean coast the region from Masirah to Ras Madrakah sustained maritime traffic from the Bronze Age, Iron Age, and Islamic period through the 20th century. Masirah was a source of copper thousands of years ago, contributing to the export trade in that valuable metal (Charpentier *et al.* 2012: 14; Charpentier *et al.* 2013: 87, 93; Cleuziou and Tosi 2007: 265). The strong currents through the Masirah Strait suggested that shipwreck material may be found there, while the cape at Ras Madrakah is notorious for shipwrecks. The Dutch East Indiaman *Amstelveen* became wrecked near Ras Madrakah in 1763 (Doornbos 2013), but a search for the remains of *Amstelveen* have so far been unsuccessful (Bouman *et al.* 2013).

5. Dhofar. Evidence of intense maritime activity in the Dhofar region stretching back more than 2000 years suggested that this region may be fruitful (Comfort 1960: 15; Yule and Kervran 1993: 91; Zarins 2001: 137–41).

The Iron Age site of Sumhuram (Khawr Rori), home to a South Arabian culture, was a stopover in the India-Roman trade pattern (Avanzini 2008: 617; Avanzini and Sedov 2005: 11) and the natural harbour there could hold promise of discoveries. The area around the port of Hasik has settlements from as early as the Bronze Age (Tosi, pers. comm. 2000) and is mentioned in the first century *Periplus* (Schoff 1912: 62), and stone-built structures are extant along the coast at Islamic-period

Figure 5. Aerial view of Al Baleed [Al Balīd] (Digital Globe and T. Vosmer).

Hasik Qadim slightly to the south of Hasik. Excavations at Al Baleed in Salalah have revealed an extensive walled port city active mainly during the 13th–14th centuries, but dating back to pre-Islamic times (Blue *et al.* 2016: 114; Newton and Zarins 2012) (Figure 5). Numbers of ancient sewn boat timbers continue to be discovered there, reused in the architecture (Belfioretti and Vosmer 2010: 111). Reference has already been made to the Portuguese ships wrecked off the Hallaniyat Island group but these islands also hold evidence of Bronze Age settlement, clearly indicating seafaring activity during that period.

Stakeholders

The stakeholders in this enterprise include a large number of organisations such as:

- Ministry of Heritage and Culture
- Ministry of Education
- Ministry of Higher Education
- Ministry of Agriculture and Fisheries
- The Office of the Adviser to His Majesty the Sultan for Cultural Affairs
- The Royal Navy of Oman (RNO)
- Ministry of Defence
- Hydrographic Office of the RNO
- National Survey Authority (NSA)
- Environmental Society
- Historical Association of Oman
- Companies in the private sector, developers, and dive clubs
- The Ministry of Information
- Ministry of Environment and Climate Affairs
- Ministry of Transport and Communications
- Ministry of Tourism
- Ministry of Housing
- Ministry of Regional Municipalities

The need for the involvement of the Ministry of Heritage and Culture is obvious, as is the participation of Agriculture and Fisheries, The Cultural Affairs Office, the Navy and Ministry of Defence and the Hydrographic Office. The last six on the list might be less obvious. The Ministry of Information should be involved because of their control of the media and their ability to promulgate information and public service announcements. Environment and Climate Affairs were involved because that ministry had already done a number of underwater surveys and were in contact with fishermen and abalone divers. The Ministry of Transport and Communications are key players because they develop and control transportation infrastructure such as roads, railways, ports and harbours, any of which can impact coastal archaeology. The Ministry of Tourism could promote Oman through highlighting maritime archaeological projects. Oman's dive clubs could be urged to introduce awareness of maritime archaeology and help valorise the resource. Their diving customers could also be engaged as extra eyes for the Ministry of Heritage and Culture. The Ministry of Housing and the Ministry of Regional Municipalities have direct control over coastal developments, which could seriously and negatively impact the archaeology.

MASO site priorities

Coastal development can obviously have a significant impact on the identification of UCH so priority was given to those coastal sites slated for imminent development or those having development already underway. This was the case at Ad Duqm, where an Indian Ocean port was under rapid development. Hence, the Ministry of Heritage and Culture directed that an initial reconnaissance be undertaken at Ad Duqm and the surrounding area.

Ad Duqm: A terrestrial coastal survey in the area that covered over 35km, logged more than 200 sites north and south of Ad Duqm and confirmed that most of the archaeology in the area was Palaeolithic, Neolithic and Iron Age in date (Blue *et al.* 2016: 81; Jagher *et al.* 2007), suggesting little likelihood of there being surviving maritime material offshore.

The coast in the region of Ad Duqm is very active during the south-west monsoon, which tends to scatter shipwreck material. Additionally, several reefs with minimum depth of 1.8m north of Ad Duqm, as well as the shallows around the island of Hamar An-Nafur, were thought to offer possibilities of wreck material. Regrettably, however, the boats that had been offered by the private sector turned out to be unavailable and, thus, diving at these potential offshore sites was postponed, earmarked for future survey.

Mirbat: The imminent development of a bay on the Dhofar coast, east of Mirbat, prompted terrestrial and underwater archaeological investigations, largely based on results of a prior terrestrial survey surrounding the bay that had logged 54 archaeological sites (Vosmer *et al.* 2014: 17). As a result, the entire coast in the area was surveyed on land by the MASO team for a distance of approximately 5km, with discoveries of 80 additional archaeological sites including two villages (one Islamic at the head of the bay; one aceramic, thought to be Iron Age to the east), a large number of lime processing pits, some ceramics and numerous shell middens.

The bay to be developed was systematically surveyed by divers who discovered a number of artefacts such as stone anchors and ceramics. Three of these stone anchors—two of Indo-Arabian style and one ring stone—were raised by the MASO team and taken to the fort museum in Mirbat. Attempts had been made to use side-scan sonar in the area but the bottom proved to be too rocky for reliable interpretation. High-resolution side-scan images that had been offered by the Hydrographic Office never materialised.

Masirah Island: From desktop research and previous terrestrial surveys (Blue *et al.* 2014), Masirah Island appeared to hold promise. Several areas were selected for diving and remote sensing surveys.

Remote sensing, both side scan and magnetometer, revealed some possible targets off Masirah but no new major discoveries came to light in diver ground-truthing operations. However, many ceramic shards of local and international origin were logged, which indicate trade patterns and perhaps can serve as guides for future expeditions.

Outcomes and achievements

Reflecting on the challenges that the MASO project faced, both the Ministry of Heritage and Culture and the MASO team can identify certain achievements that have been made in recent years with regard to protecting and promoting the maritime cultural heritage resource of Oman. These include:

- The MASO project was the first of its kind not just in Oman but in the entire GCC (Gulf Corporation Council);
- Oman is the first GCC country to enlist maritime archaeologists within the government department and the first to provide comprehensive training of government archaeologists;
- The MASO project has produced the first comprehensive repository of digitally related data concerning coastal and underwater sites in Oman; and,
- In effect, the MASO project represents a turning point. It extends an awareness of UCH, the importance of maritime cultures in Oman both past and present, and also the imminent threat that many coastal and offshore sites now face.

Recommendations and the future

At the end of the year-long project, after gathering as much background data as possible, and with fieldwork completed at Ad Duqm, Masirah, and along the Dhofar coast east of Mirbat, a foundation for future investigation has been laid that we hope the Ministry of Heritage and Culture of Oman will continue to expand, building their programme of maritime archaeology on this foundation. In addition, besides a number of specific recommendations that related to chronological and/or regional archaeological priorities that were identified as a result of the desktop assessment, a series of more broad-reaching recommendations were made that helped to build capacity on a number of levels:

Legislation. Soon after Sultan Qaboos took power in Oman in 1970, His Majesty outlined the importance of national heritage, established the Ministry of Heritage and Culture, and issued royal decrees for the protection of heritage. More can still be accomplished and a new heritage law is in development. This new law must cover maritime as well as terrestrial archaeology, make pre-disturbance surveys and reports mandatory, and outline effective penalties for destruction or non-reporting of archaeological finds.

It is also important that the Sultanate commits to the ratification of the 2001 UNESCO Convention for the Protection of the UCH.

Archaeological skills, maritime archaeologists and researchers. The underwater unit of the Ministry of Heritage and Culture is still in development and will benefit from additional training and more maritime archaeological staff. Redundancy needs to be built into the staff so that tasks can continue to be carried out when members are on leave.

Overall, the number of dedicated researchers addressing issues of UCH and skilled maritime archaeologists in Oman is limited and could be expanded.

Training. There is limited capacity within educational and museum systems for training. This needs to be expanded, with staff sent on training courses and engaged in on-the-job training alongside experienced maritime archaeologists, surveyors and conservators.

Education. Curricula need to be developed by the Ministry of Heritage and Culture in partnership with the Ministries of Education and Higher Education. PowerPoint and 'show and tell' presentations should be developed by the Ministry and delivered by Ministry staff at all levels of learning in the schools, colleges and universities. Hands-on activities can be developed for schools to engage students directly in the experience of archaeology. These activities could be artificial constructs, simulations of archaeological research activities, or direct involvement in actual projects.

Stakeholder awareness. Stakeholder awareness can be raised through an array of approaches. Workshops scheduled by the Ministry of Heritage and Culture, and offered to developers, other ministries, and dive shops, would be one approach. Approaches to ministries such as Tourism and Environment, would encourage the development of mutually beneficial projects and cooperation. Staff from the Ministry of Heritage and Culture should develop several presentations on maritime archaeology in general, as well as on specific projects, both completed or underway. These presentations could be given to other ministries and companies in the private sector, particularly dive clubs and companies involved in coastal development.

Public awareness. The educational opportunities mentioned above could be expanded with additional workshops, or by engaging the public in projects. Publicity and the resulting public awareness and respect for the archaeological resource can be the greatest ally in efforts to preserve and learn from the fragile and finite resource. Publicity through the media of current projects, as well as television advertising spots created specifically to alert and remind the public about the national value of the archaeological resource and their responsibility to preserve and promote it, could potentially reach a large audience. Making the research results available would help to engage stakeholders as well as to educate the wider public.

The Ministry should produce awareness-raising public service bulletins and disseminate them through all media platforms. Television and radio mini-programmes would be very useful. Brochures produced by the Ministry and made available in every museum in the Sultanate would be an inexpensive but effective way to communicate with the public.

Publication. Ministry of Heritage and Culture staff should be encouraged to write up and publish their work in English in order to reach a wider audience. Staff should attend courses to improve writing and English language skills. They should also be encouraged, and supported, to attend international conferences, present papers and engage with international colleagues.

Management systems. At present there is little or no site monitoring. Formal reporting and enforcement procedures need to be implemented. A mechanism needs to be developed for the reporting of finds by the public, developers and ministries. The existence of a reporting system should be disseminated through the media and through workshops. An initial step would be to establish a dedicated phone contact number and email address to facilitate reporting.

Additionally, more pro-active measures, such as coastal and underwater surveys and site priority measures, need to be adopted by the Ministry of Heritage and Culture. Integrated Coastal Zone Management plans need to be commissioned, and, when development is proposed, Environmental Impact Assessments (EIAs) should be undertaken for both the coastal and the offshore environment prior to development going ahead. Within these proposed management measures, the GIS platform that was established as part of the MASO project should be developed and enhanced to form the primary management tool. Finally, these management systems should form part of an integrated policy and protection framework that works alongside other ministries and government agencies, to promote a comprehensive, integrated management and legislative framework.

Conservation. A comprehensive conservation programme must be developed, with new facilities and training. Ministry staff should be sent overseas for training, and/or be taught by participation with qualified conservators working within the Sultanate.

Partnerships with other ministries. Collaboration with other ministries, government offices and the private sector to facilitate efficient and timely exchange of information and data are to be encouraged. Mutually beneficial programmes with other ministries such as Tourism and Environment could be developed.

The programme of development of maritime archaeology in Oman is nascent and many challenges remain but are being addressed. As seen, several recommendations have been made by the MASO team in order to enhance the success and further development of maritime archaeological research. These recommendations are intended to address difficulties encountered, as well as providing guidelines and suggestions for future research and fieldwork. Moving forward, the future vision for sustainable development aims would be to:

- Raise stakeholder awareness of, and involvement in, maritime heritage;
- Enhance national and cultural identity;
- Encourage marine tourism, maritime museum initiatives and promote public outreach;
- Assess the legislative framework, promote adoption of the 2001 UNESCO Convention on the Protection of the UCH;
- Establish a holistic approach to maritime heritage management;
- Establish a future research framework;
- Continue to build experience, specialisation and expertise; and,
- Develop a lasting legacy for the protection and promotion of UCH.

With the foundation provided through the Ministry of Heritage and Culture, and the MASO project, there is much to look forward to for maritime archaeology in Oman.

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From Try Dive to Wreck Documentation: Archaeological Research and Capacity Building in Saudi Arabia

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Abstract

In 2015, with the participation of the Saudi Commission for Tourism and National Heritage (SCTH), the Kingdom of Saudi Arabia ratified the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage. This has not only been an important step towards the protection of cultural heritage underwater, but it has also been a significant responsibility to implement this convention on a lasting basis. In a country where maritime archaeology is still in its infancy, and ancient underwater archaeological sites are particularly under threat from looting and construction projects, a series of actions needs to be implemented in the short and long term. These include the training of archaeologists and other experts in maritime archaeology and the establishment of a complete infrastructure, ranging from restoration and conservation facilities to a museum where maritime artefacts can be presented to the public. Furthermore, it is desirable to establish networks between the archaeologists, coast guard and dive centres, including an effective public relation, which increases the public's awareness about the importance and protection of cultural heritage underwater whilst providing access to it.

Keywords

2001 UNESCO Convention, capacity building, *in situ* protection and public access

The state of underwater archaeological research

Archaeological exploration of Saudi Arabia is closely linked to the exploitation of oil sources by the companies Standard Oil of California and Arabian-American Oil Company (ARAMCO), since the 1930s and 1940s. These companies not only contributed to the spread of information about archaeological sites but they also supported foreign researchers. In the 1970s, it became common for foreign scholars to work for the Saudi Arabian antiquities service; and Saudi students travelled to Great Britain and America to study archaeology (Potts 1997: 79; Potts 1998: 197). Yet underwater archaeology of the Saudi Arabian coastal regions remained unaffected by these developments.

As early as the 1950s and 1960s, the first archaeological excavations of shipwrecks were carried out in the Mediterranean, and the first Institute for Underwater Archaeology was founded under the direction of George Bass. Today, around 2000 ancient shipwrecks are estimated to be in the Mediterranean, while in the Red Sea it is not a dozen (Parker 1992). Reasons for this are to be found especially in diving tourism, research programmes, and different preservation conditions.[1] Most of the ancient shipwrecks in the Mediterranean were discovered by sport divers, sponge divers or fishermen and often looted (UNESCO 1997). However, large parts of the Red Sea coasts are still unexplored, both by diving tourism and underwater archaeological research.

In contrast to terrestrial archaeology, which is already firmly established, maritime and underwater archaeology in Saudi Arabia is still in its infancy. The importance of underwater sites for the investigation of trade routes, migration processes and settlement behaviour has become a focus for scientific interest during the last decade (Cooper and Zazzaro 2012; Pedersen 2015; Lambeck *et al.* 2011; Bailey *et al.* 2015). At present, there are no trained archaeologists who would be able to independently conduct research underwater, or laboratories where finds from underwater archaeological contexts can be treated. The cooperation between the Philipps University Marburg and the Saudi Commission for Tourism and National Heritage (SCTH), which has existed for five years, aims to change this situation through the training of SCTH archaeologists in underwater archaeology as part of a long-term research project. In addition, colleagues from the SCTH are supported in setting up an infrastructure for the protection, treatment and presentation of their cultural heritage underwater in an advisory capacity.

[1] The conditions relating to shipwreck preservation in the Red Sea are discussed below.

Figure 1. The Bab Al-Bunt Palace (background) with remains of the former quarantine pier (M. Reinfeld).

Modern construction projects versus the preservation of cultural heritage

In view of the tremendous building activities that have probably irretrievably destroyed much of the maritime heritage of Saudi Arabia, the formation of an expert team for the protection of this cultural heritage is an urgent necessity. Thus, for example, the two major port facilities of the pre-Islamic and Islamic periods, Al-Shuʿayba and Jeddah, are now completely overbuilt. Al-Shuʿayba is located about 90km south-west of Mecca and 120km south of Jeddah on the Red Sea coast. As one of the few good anchorages along the east coast of the Red Sea, Al-Shuʿayba probably served as an entrepôt for goods on the way to Mecca during the pre- and early Islamic period (Jandora 1995: 334–35). However, since the 7th century AD, Jeddah took over the role as a harbour for Mecca and became the most important pilgrimage and trading port in the Red Sea (Hawting 1984: 321). In addition to its economic importance for the rise of Mecca, Al-Shuʿayba still has an important religious significance today. In the year AD 605 , after the destruction of the holy Kaaba, an Egyptian ship capsized near Al-Shuʿayba. The wood from the ship was used to rebuild the Kaaba by Muhammad and other members of the Quraysh tribe (Wüstenfeld 1861: 84–85). Despite its importance for the history of Islam, the site of Al-Shuʿayba serves as a huge power station and a seawater desalination plant today.

A similar fate also befell the pilgrimage harbour of Jeddah, of which only a few remains are visible today in the middle of large modern buildings and parking lots. Still active in the 19th century, the quarantine pier received numerous pilgrims on the local sambuks before their onward journey to Mecca. Today, the Bab Al-Bunt Palace, together with the last building of the original sea front and part of the former quarantine pier, has been transformed into a pilgrim museum (SCTA 2013: 83, 202) (Figure 1). It can be assumed that there are still numerous shipwrecks, which could testify to the maritime pilgrimage history of Jeddah under the ‘Jeddah Islamic Seaport’. The approximately 10km long port area is located about 1.5km west of the former pilgrimage harbour on reclaimed land (Figure 2). Built in the 1970s, the port is the largest modern port in the Red Sea (SCTA 2013: 29; Kingdom of Saudi Arabia—Ports Authority 2014).

Jeddah also benefited from the annual crowds of pilgrims that brought the harbour city an economic and cultural boost, especially during the 19th century. This period of prosperity is still visible in the old town of Jeddah (Al-Balad), which has been declared a World Heritage Site in 2014. The more than 300 surviving multi-storey houses were built by the mercantile elite of the city in the late 19th century. The locally quarried coral stone, also called ‘*mangabi* stone’, is characterised by its good insulation properties and is a typical building material for the tower houses, which are up to seven stories high. Imported hardwood (Shorea and teak) was used for floors, roofs, doors and the elaborately decorated wooden casements (*roshans*). Both the Municipality of Jeddah and the SCTH have been responsible for

Figure 2. View from the Bab Al-Bunt Palace to the modern Jeddah Islamic Seaport (M. Reinfeld).

the reconstruction and preservation of the historical buildings for several years (SCTA 2013: V–VIII. 34. 50–51).

Sport divers and underwater cultural heritage

Dive tourism in Saudi Arabia is primarily aimed at the local population and and includes men and to a much lesser extent woman. Foreigners staying in the country for employment or tourism reasons, are in the minority amongst divers. The dive centres often do not have the required safety standards such as a supply of oxygen and a functioning chain of survival. Fatal accidents involving spear fishermen, a popular sport in Saudi Arabia, happen frequently (Bakhidar *et al.* 2009). Lack of training and overconfidence are other factors that cause diving accidents.[2] However, information or reliable statistics regarding diving practices or diving accidents do not exist. Dive centres offer tours to wreck sites but provide their guests with more information about the wrecks only in exceptional cases. Management plans that include both tourist development and ensuring that sport divers are sensitive to the correct handling of the cultural heritage underwater, are therefore urgently needed.

In the past, looting of ancient and historically relevant wrecks by foreign employees and local people repeatedly occurred. A well-known example is the so-called 'Silver Coin Wreck', which was plundered by Americans. The artefacts returned to Saudi Arabia only through the successful intervention of the Saudi authorities. Under these circumstances, an *in situ* preservation of historically significant sites seems extremely difficult. Nevertheless, well-organised tourism, which takes account of the protection of cultural heritage, can have a positive impact on the country's economy, which currently is heavily dependent on its oil resources.

Current developments in the implementation of the 2001 UNESCO Convention

In recognition of the importance of underwater cultural heritage for the history of the Kingdom of Saudi Arabia as well as for Islam and the history of humankind (Bailey and Flemming 2008: 2162), Saudi Arabia ratified the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage in 2015. Prior to the ratification, a department for underwater archaeology was established within the SCTH. This department is responsible for ongoing and planned research projects, reports and publications, cooperation with other stakeholders, museums and public relations.[3] In this context, since 2003, cooperation projects with foreign universities and research institutions have been initiated to explore cultural heritage under water.

Nevertheless, cooperation with foreign institutions is not sufficient to ensure long-term establishment of underwater archaeology in Saudi Arabia. For this reason, a team of six archaeologists and a conservator were selected from the permanent staff of the SCTH;

[2] Personal communication with sport divers.

[3] Personal communication with team members of SCTH.

Figure 3. Documenting a modern wreck site (M. Reinfeld).

within the framework of the cooperation projects, this team is trained in underwater archaeology. Through their connection to the headquarters of the SCTH in the capital of Riyadh and the branch in Tabuk, the underwater archaeologists will be able to operate in different provinces around the country. Of course, we expect the present generation of maritime archaeologists to pass on their acquired knowledge to the next generation of archaeologists. In addition, there are plans for the construction of facilities for conservation and restoration of maritime artefacts, and also museums for the presentation of cultural heritage under water.

Capacity building as the basis for sustainable establishment of underwater archaeology

In 2012, the Philipps University Marburg and the SCTH signed a Memorandum of Understanding, which included exploration of the coastline between Rabigh and Al-Shuʻayba. Basic prerequisite for the research project was, among other things, that the colleagues from the SCTH are involved in the underwater archaeological work. In order to ensure the safety of the underwater archaeological activities and to involve the team colleagues from the SCTH quickly in the tasks, solid dive training according to the guidelines of CMAS was a basic requirement for the following research work.[4] At the beginning of the training, four of the six team members were non-divers and for the two experienced divers, both the practical and theoretical lessons constituted useful revision. Parallel to the diving education, lectures were held on various maritime archaeology topics as well as the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage and its Annex.

These were followed by practical exercises on land and underwater, including survey methods (surveys with divers, survey with side scan sonar, scooter and tow camera system), non-invasive techniques for identification of sites, methods for documentation of sites (locating a site, offset and trilateration, photography and video), and strategies for the monitoring of sites and handling of maritime artefacts (preventive and curative conservation and restoration, analysis of finds). At the end of the day, the dive logs, tables and survey data as well as photos and videos were analysed together and collected. During the course of the survey, all exercises could be applied to both ancient and modern sites in order to train and improve the practical skills of the team members (Figure 3). A special emphasis was placed on identifying and promoting individual strengths and interests of the teammates.

In the coming years, the combined underwater archaeology and diving education is going to continue until the status of the CMAS Scientific Diver has been achieved. The aim of this training is to prepare SCTH

[4] CMAS: Confédération Mondiale des Activités Subaquatiques.

Figure 4. View along the Sharm Abhur (M. Reinfeld).

colleagues for their role as an independently acting research diver group, and to lay the foundations for a long-term establishment of underwater archaeology in Saudi Arabia. The present generation of young underwater archaeologists will have the responsibility to pass on acquired knowledge and skills to future generations of underwater archaeologists.

The research project 'Seafaring and Trade in the Red Sea'

In addition to the underwater archaeological training of the Saudi Arabian team, a further important focus of the cooperation project 'Seafaring and Trade in the Red Sea' is the systematic mapping and documentation of archaeological sites in the area between Rabigh and Al-Shuʻayba. This corresponds to a coastline of about 240km with the centre in Jeddah. The aim of the project is the reconstruction of maritime trading and transport routes in the Red Sea, based on archaeological evidence to be combined with literary and epigraphic sources. Within the project, in addition to the available resources, trade commodities and trading partners, the importance of imports and exports, regional and long-distance trade routes as well as the seasonal use of harbours and shipping routes are in the focus of ongoing investigations.

Many areas of high potential for maritime legacies (shipwrecks, anchorages, harbour facilities) are now built over, including Al-Shuʻayba, Jeddah and Sharm Abhur, the ancient mouth of Wadi Alkura in the north of Jeddah. This natural creek certainly was a safe harbour already in ancient times. Today, it is unfortunately contaminated with rubbish and built over on both sides (Figure 4). For this reason, previous research campaigns have focused on the numerous reefs off the coast of Jeddah, for example the area of the Eliza Shoals north-west of Jeddah. The selection of reefs depended on possible sailing routes, as well as known or possible hazardous areas. Thus, areas where modern wrecks are noted on nautical charts are potential sites for ancient shipwrecks.

For safety reasons and in order to increase the impact on training, the team was divided into groups of three or four divers. Each diving group had an experienced archaeologist and scientific diving supervisor, as the leader. The operation depths of the groups depended on the experience of each team member from the SCTH, which varied between 10m and 30m. In this way, reefs and the adjacent sea floor could systematically be investigated at different depths. The survey tracks were recorded with a standard handheld GPS attached to a buoy. Archaeologically interesting finds were also marked with a buoy, to be measured, drawn and photographed later.

The dive time of each survey team depended on the operation depth of the groups. Operation depth and survey time were planned by the supervisor for scientific diving according to the natural conditions. The dives were performed in a way that no decompression stops were needed to ensure the highest possible security. Only an obligatory safety stop was conducted at 5m.[5] Over the five years, neither a diving accident nor any other serious incident occurred.

An exploration of the entire survey area including the offshore reefs based solely on diving surveys is impossible due to the extent of the area, partial large water depths, the strong coral growth and sedimentation. In contrast to the Mediterranean,

[5] All dives were conducted according to the rules of the 'GUV-R 2112. Rules for Safety and Health Protection' for scientific diving.

temperatures in the Red Sea are about 22°C in spring and up to 32°C in summer. This stimulates the growth of reef-building corals, so an ancient shipwreck can be completely overgrown (Rasul *et al.* 2015: 21; Sawall and Al-Sofyani 2015: 498). In the 1970s, Avner Raban already pointed out the difficulties of the discovery of ancient wrecks, as these are covered with corals and sediment. At the same time, he mentions the successful use of a sub bottom profiler at the coast of Jezirat Phara'un (Raban 1973: 179). Cheryl Ward, following the survey work of INA-Egypt, points to the use of geophysical prospecting methods as probably the most important tool for finding ancient shipwrecks in the Red Sea (Haldane 1994: 5). To this day, no systematic underwater archaeological surveys have been carried out using geophysical remote sensing techniques in the Red Sea. The strong coral growth and numerous reefs render the use of remote sensing methods such as magnetometer, side scan sonar or sub bottom profiler—which are very effective in sandy areas—very difficult as reefs have a highly reflective, dense and hard surface.

With this in mind, the first tests with various survey methods were carried out last year. In addition to the traditional inspection with divers, the use of a scooter, a tow camera and a side scan sonar were tested. Unfortunately, the use of a tow camera appeared not to be very promising in the Red Sea. Steep coral reefs were too large a risk of collision for the camera, which is towed by the survey ship across the sea floor. More promising was the use of a scooter, an underwater vehicle, which moves the diver up to eight times faster than his own muscle power.

In combination with the necessary diving experience and a trained eye, the use of scooters can be very helpful for underwater archaeological surveys. This assumption was confirmed by the discovery of a late antique or Islamic amphora, which might indicate the presence of a wreck. The site was discovered in spring 2016 as the third archaeological site within the project, and will be further investigated in the following campaigns along with further tests of survey techniques.

Results of the underwater archaeological survey

A systematic exploration of the reefs of Eliza Shoals at the entrance to Sharm Abhur in the north of Jeddah already resulted in the discovery of three sites with amphorae. This fact suggests that Sharm Abhur was a trade harbour already in antiquity. However, if a port, a quay or similar structures had been located within the Sharm, it cannot be verified due to modern building development now.

Even in the area of present-day Jeddah, a harbour might have existed already in pre-Islamic times (Hawting 1984: 318–21; SCTA 2013: 67). Jeddah is one of the few places off the east coast of the Red Sea, where the numerous offshore reefs form a gap and, thus, allow a safe entry into the harbour. The harbour of Jeddah thus became the most important harbour in the Red Sea since the Islamic period (SCTA 2013: 68). Nevertheless, the city is not mentioned in ancient sources. In the 1st century AD, the author of *Periplus Maris Erythraei* explicitly advises a wide circumnavigation of the Arabian coast due to the lack of harbours, poor anchorages, dangerous reefs and other hazards (Casson 1989: 62–63). The detection of the three sites with amphorae is, therefore, of great importance as it proves existence of a sea route along the eastern coast of the Red Sea, at least since the late Roman period.

The site 'Red Buoy I'

The 'Red Buoy I' wreck site was discovered during the 2012 season in the sandy area of the so-called 'Red Buoy Reef' pedestal zone. 'Red Buoy I' is located at the entrance to Sharm Abhur, suggesting that the ship crashed on the reef during its voyage to the Sharm. The site consists of scattered amphorae and ballast stones and is located at a depth of about 15m. Some of the stones may be of a later date, as large stones, bricks or even stone slabs were used until modern times by small fishing boats as anchor stones and are also found at other sites. Most of the ship and the cargo seem to be hidden under the sand. Furthermore, two large fragments of amphorae were recovered and passed on to the National Museum in Riyadh for further treatment and analysis.

The investigations of the site 'Red Boy I' are not yet completed. The preliminary assumption that the amphorae belong to the cargo of a late Roman shipwreck from the western Mediterranean (Held *et al.* 2017) probably needs to be revised, as during the restoration, the removal of the marine encrustations from the surface of the amphora uncovered traces of an Arabic graffito (Figure 5).

The site 'Red Buoy II'

On the other side of the 'Red Buoy Reef', at a depth of about nine to 15m, more amphorae were found which obviously have no connection to 'Red Buoy I'. Ceramic vessels, sherds and ballast stones were scattered over an area of about 450m². A stone anchor found at the site is obviously modern since the anchor rope was still attached. The ceramic vessels found so far consist of two groups.

The first is a carrot-shaped type (Figure 6) with regular horizontal ribs which corresponds to the late Roman 'Aqaba amphora (Melkawi *et al.* 1994: 459, fig. 10e; 460; Whitcomb 1994: 23, 24, fig. i). Archaeometrical studies that were conducted on ceramic samples from 'Aqaba/

Figure 5. Exposing an amphora at 'Red Buoy I' (H. Sjöholm).

Ayla and Ẓafār confirmed the port city ʿAqaba as production centre of these amphorae (Raith *et al.* 2013: 321). A macroscopic examination of ceramic samples from 'Red Buoy II' resulted in the identification of a variety of fabrics, ranging from a dark red over a sandy colour to a yellow-greenish fabric and, thus, also points to ʿAqaba being the place of production (Raith *et al.* 2013: 322–24). At the moment, the samples are being analysed archaeometrically to verify this assumption. The amphorae may have been used to transport garum, oil, wine or other products such as fruits or nuts (Dolinka 2003: 95–95; Melkawi *et al.* 1994: 463; Parker 1998: 389; Tomber 2004: 398; Whitcomb 1994: 24). Residue analysis, which is currently being carried out on the ceramic samples of the site 'Red Buoy II', will hopefully contribute answers to this question.

The second vessel type is a large pilgrim flask, characterised by an almost globular body. This vessel also belongs to the typical transport vessels from ʿAqaba (Melkawi *et al.* 1994: 456, 459, fig. 10l; Whitcomb 1994: 23, 24 fig. h). According to our current knowledge, the presumed wreck site gives evidence for a trade of agricultural products which took place between the 5th and the 7th century AD. 'Red Buoy II' is one of few pieces of evidence for a sea route leading from ʿAqaba through the Gulf and along the east coast of the Red Sea towards the Indian Ocean, while another route followed the west coast of the Red Sea, as ʿAqaba amphorae were also found in Egypt, Eritrea, Ethiopia and Yemen, and were traded as far as India until the 7th century AD (Raith *et al.* 2013: 339; Tomber 2008: 166).

Research on Modern Wrecks

Modern wrecks are partially marked on nautical charts or known among local divers. The documentation of modern shipwrecks, which could fall under the 2001 UNESCO Convention due to their age, therefore, is also a focus of the project. The aim of this research is the monitoring and assessment of the historical significance of the wrecks, even if these shipwrecks are no ancient legacies but rather popular destinations for tourist divers.

Conclusion

With the ratification of the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage and the training of underwater archaeologists, Saudi Arabia has made an important step towards sustainable implementation of the Convention. Within the framework of various cooperation projects with foreign research institutions, a foundation was also laid for the study of maritime cultural heritage. Projects such as the German-Saudi cooperation project can also be ground-breaking for other countries as the inviting host institution—in this case, the Saudi Commission for Tourism and National Heritage—benefits from the expertise of foreign partner institutions and jointly develops, conducts and publishes research projects.

The objectives of this cooperative project are both the exploration of Saudi Arabia's maritime heritage, of which is particularly endangered by construction

Figure 6. Drawing exercise at 'Red Buoy II' (H. Sjöholm).

projects and uncontrolled recreational diving tourism, as well as the underwater archaeological training of Saudi Arabian colleagues. In the future, they will carry out underwater archaeological projects independently and pass on their knowledge to the next generation of maritime archaeologists. The successes of the past five years have confirmed that the concept of combining training and research works successfully. SCTH colleagues were trained in diving and underwater archaeology. There are also plans for infrastructure establishment for the treatment of maritime artefacts, employment of specialised conservators and restorers, as well as the construction of museums to make the underwater cultural heritage accessible to the public.

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Maritime Archaeology in Post-War Lebanon: Trade, Challenges, and Future Prospects

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'A people without a coherent past can only have an uncertain future'

(Seeden 1987)

Abstract

Lebanon's strategic location in the eastern Mediterranean has made it a thriving hub for maritime activities since at least the Bronze Age. Despite Lebanon's rich seafaring history, maritime archaeology in the country remains in its infancy and is limited in scope. Related academic education is non-existent, as is a national strategy to develop the field. Furthermore, there is a lack of national laws pertaining to maritime archaeology and Lebanon has only accepted but not ratified, the UNESCO 2001 convention.

Since the end of the Civil War in 1990, Lebanon's coastal heritage has been continuously threatened by the chaotic reconstruction of the seafront by real estate corporations and influential individuals who bypass the prerogatives of the Directorate General of Antiquities (DGA). Indifference of the population towards their underwater cultural heritage (UCH) does not help mitigate this situation. Hence, local capacity building is needed to develop archaeological skill base and raise awareness of the significance of Lebanon's UCH. Such an initiative would adopt a sustainable staged approach with key strategic points pertaining to the expansion of the education basis, encouraging research, community engagement schemes and cooperative specialised training.

This paper will, thus, present an overview of the development of the field in Lebanon; the challenges it faces; past initiatives related to building the capacity of UCH and archaeology as a whole; as well as their sustainability. It will also explore why the suggested capacity-building model would suit the needs of Lebanon and its specific challenges to ensure the study and preservation of the country's maritime cultural heritage.

Keywords

Capacity-building, post-war, Lebanon, underwater cultural heritage, awareness

Contextualising the study

A geographic introduction

Lebanon's strategic location in the eastern Mediterranean basin and its natural topography afforded the development of harbours and anchorage sites and has made it a prominent trading hub in the Mediterranean since the Bronze Age, if not before. Lebanese topography is characterised by the alternation of lowlands and highlands running parallel on a NNE- SSW axis, roughly divided into four physiogeographic units, which are, from west to east, the coastal strip, Mount Lebanon (the western chain), the Beqaa (central plateau) and Anti-Lebanon (the eastern chain) (Figure 1).

Several geologic faults run across the terrain with the major ones, from west to east, being Roum, Yammouneh, Rachayya and Serghaya. These faults generated a series of dynamics that over time influenced differential changes in sea-levels along the Lebanese coast. The narrow coastal strip varies in width between 6.5km and 1.5km and stretches 220km along the eastern Mediterranean shore. It is oriented NNE-SSW roughly parallel to the Mount Lebanon chain to its east. This narrow territory is crossed by rivers that flow through transverse valleys whose average length from east to west does not exceed 30km. The shoreline is rocky towards the north and sandy towards the south with three major headlands: Tripoli, Beirut and Tyre. Generally, the coast is open and exposed to the dominant south-westerly winds with few natural shelters.

Bays are relatively modest with the widest being, from south to north, St George in Beirut, Jounieh Bay, Chekka Bay and Akkar Bay. All these bays are protected from the dominant south-westerly winds and, thus, offer adequate shelter for anchoring. There are also small coves in Tabarja, Byblos and Anfeh, which are relatively well-sheltered (Sanlaville 1977:6).

The bays and headlands are mostly located at, or in the vicinity of, one of the fifteen main rivers (Figure 2). From north to south these are: Nahr al Kebir, al Ostouane, Arqa, al Bared, Abu Ali (Qadisha upstream),

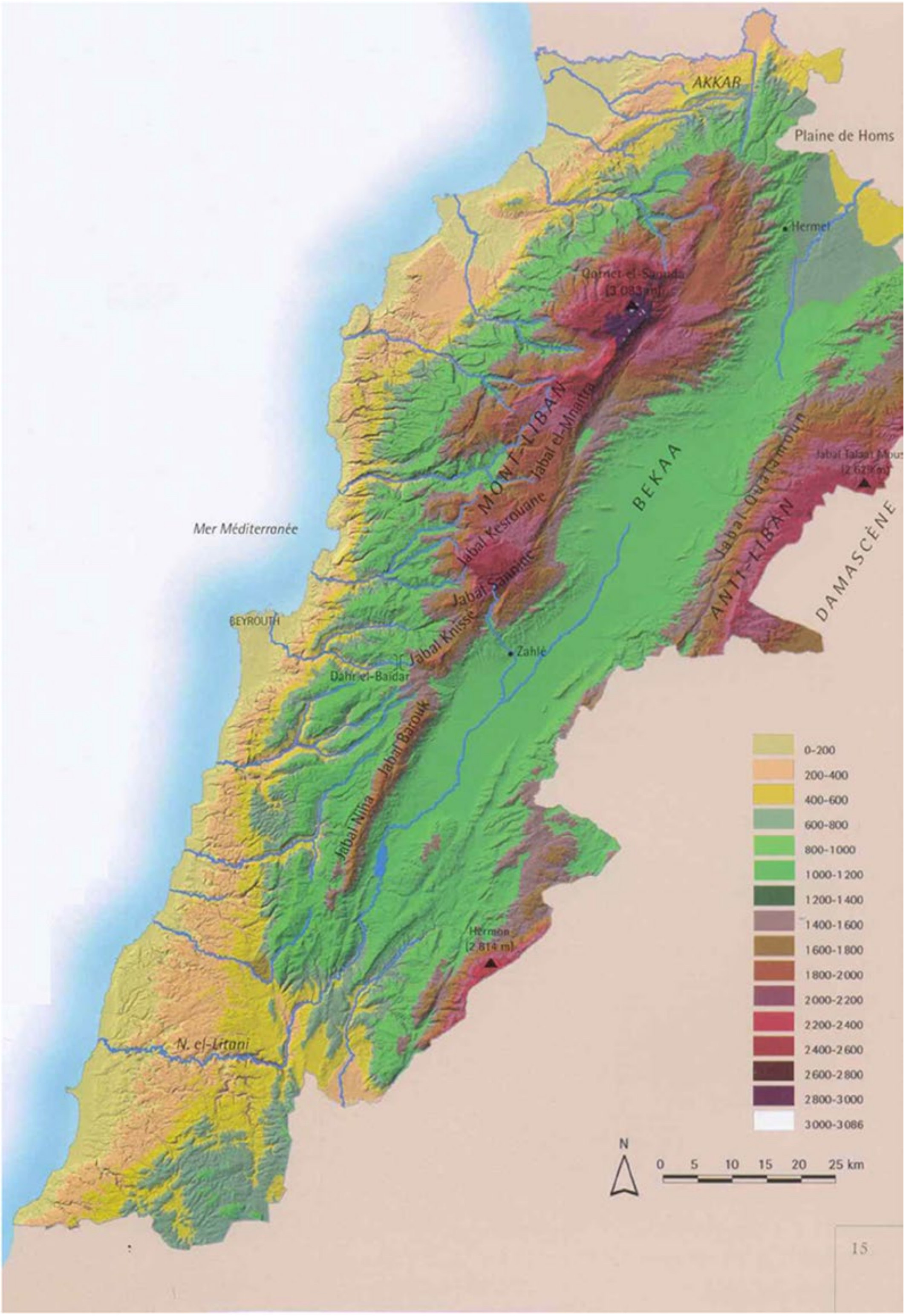

Figure 1. Lebanon's physical features (Assaf and Barakat 2006: 15).

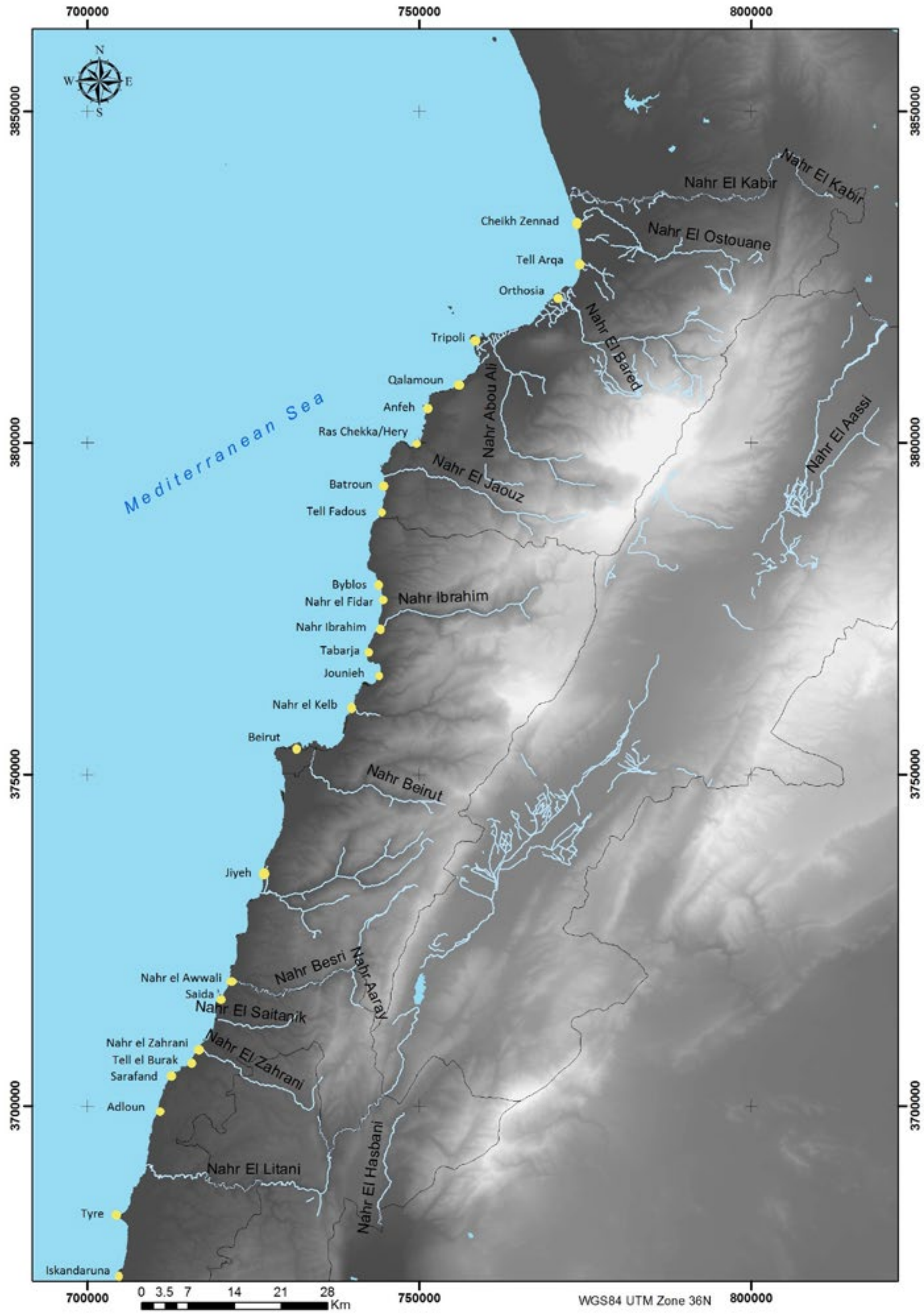

Figure 2. Lebanese rivers and sites mentioned in text (Assaf and Barakat 2006: 19).

al Jaouz, Ibrahim, al Kalb, Beirut, Damour, Awwali (Bisri in its middle section), Saitanik, Zahrani, Abu Aswad and al Litany (Qasmieh downstream), which starts in the Beqaa (Beydoun 1976: 313; De Vaumas 1954: 245; Sanlaville 1977: 89–108). All but two, Nahr al Kebir and Nahr al Litany, start near the crest of the Mount Lebanon chain and flow in deep gorges towards the sea. The rivers and their valleys constitute a network of communication between coastal sites and the hinterland (Khalil 2009; Semaan 2015: 106–16); as well as means for fluvial logging activities (Semaan 2007: 60–63, 93–100; 2015: 106–16). Finally, the few offshore islands/islets include the Zireh Islet west of the northern harbour of Sidon, and the SE-NW alignment of small islets stretching westwards from Al Mina at Tripoli. These offshore formations could have served as roadstead or outer harbours in antiquity.

It is easy to understand how this varied topography with its water supplies, arable lands, and access to marine resources encouraged human settlements on the coast of Lebanon, some of which date back to the Neolithic times (Copeland and Wescombe 1965), while others demonstrate sporadic occupation since the Palaeolithic (Copeland and Wescombe 1965; Yazbeck 2004: 2009).

Overview of maritime research in Lebanon

Evidently, the breadth and scope of maritime cultural heritage in Lebanon encompass coastal sites with unexplored maritime and underwater cultural heritage potential: coastal urban sites devoured by modern construction; coastal and submerged harbour structures; maritime quarry sites; riverbeds and mouths with archaeological potential; as well as shipwrecks.[1]

It comes as no surprise that Lebanon's maritime cultural heritage attracted the interest of travellers and scholars as early as the 17th century (Guérin 1884; Maundrell 1957; Renan 1864). However, these early scholars lacked expertise in underwater exploration and relied mainly on primary sources (Semaan 2018: 80-84). In the first half of the 20th century, the French missionary and aviator Father Antoine Poidebard (1878–1955) initiated archaeological research using aerial photography in an attempt to locate ancient submerged structures in Tyre, Sidon and Tripoli (Carayon and Viret 2004; Poidebard 1937, 1939; Poidebard and Lauffray 1951; Viret 2000; Semaan 2018: 84-87). As he was not a diver himself, he was assisted by divers on these sites and recorded their observations. His research in Tyre from 1934 to 1936 sparked the beginning of underwater archaeology in Lebanon (Poidebard 1937, 1939). His findings include a plan of the underwater remains of what he thought was the 'Egyptian harbour' south of the Tyrian peninsula, with its two moles located some 2km offshore. The hypothesis of a southern harbour was later discredited by Honor Frost (1971). Frost, who was the pioneer of maritime archaeology in Lebanon, came first to the country in 1957 and dived almost all the known underwater sites. She published her research in her monograph (Frost 1963) and several articles (e.g. Frost 1969, 1973a). Her main interests included ancient harbours, shipwrecks and a typology of anchors, focusing on Tyre, Sidon, and Byblos. Tyre was the first site Frost surveyed in Lebanon in 1956–1966. She subsequently returned there in 2002. Her primary contribution was to reassess previous assumptions and records made by Poidebard and Renan in the 19th century, as well as to investigate the submerged harbour works of Tyre and the presence of shipwrecks in its vicinity. She proposed new hypotheses of the geomorphological aspects of Tyre's peninsula and reefs, confirming the use of these latter as anchorages in antiquity. Subsequent to her surveys in the so-called 'southern harbour', she established that this area was rather submerged sections of the industrial area of the ancient city. Most remarkably, she produced a plan of an amphorae wreck by photogrammetry, then a novel technical application for site recording. Her initial research resulted in a coring project for testing the stratigraphy of the northern harbour, the tombolo, and the 'southern harbour'. But this was cancelled due to the pre-Civil War unrest in Lebanon in the late 1960s and early 1970s. It was only in 2000 and 2002 that a series of coring expeditions were undertaken with the support of UNESCO and CEDRE (Marriner, Morhange, Boudagher-Fadel, *et al.* 2005). In Sidon, Frost (1973b) investigated the Zireh Island with its natural breakwater and quarry. Her work was the first comprehensive study of the island since the times of Poidebard and Lauffray in the 1940s, who only studied the northern inner harbour. Frost surveyed the island's rock-cut installations in 1965–1968, ascertaining its use as a proto-harbour protected by a seawall. In Byblos, Frost (1998, 2000, 2001, 2002a, 2002b, 2004; Collina-Girard *et al.* 2002) centred her research on locating the Bronze Age harbour and offshore anchorages; cataloguing and studying anchors; highlighting issues of timber logging and trade; studying the proto-lighthouse on the Byblos promontory; and leading a survey of the coastal features at Ras Byblos.

Another pioneer of underwater archaeology in Lebanon is diver Zareh Amadouny (1999) who led several sporadic underwater surveys along the coast in the 1970s, 1980s and 1990s (Semaan 2018: 91-93). His investigations included the study of the submerged material culture at Tripoli, Qalamoun, Anfeh, Hery and Byblos. In 1972, French scholar Marc Chollot (1973) also undertook visual surveys at Tripoli, Anfeh, Chekka, Bouar and Batroun, Sarafand and Tyre.

Following the end of the Civil War (1975–1990), most, if not all, underwater surveys were led by Honor Frost. This period also witnessed a wave of geoarchaeological investigations at several city harbours (Carayon *et al.* 2011; Marriner 2007; Morhange and Saghieh-Beydoun 2005) such as at Byblos (Frost and Morhange 2000; Morhange 1998; Stefaniuk *et al.* 2005), Beirut (Marriner 2009; Marriner *et al.* 2008), Sidon (Marriner *et al.* 2006; Morhange 2000; Morhange *et al.* 1998; Morhange *et al.* 1999; Morhange *et al.* 2003), and Tyre (Marriner 2009; Marriner *et al.* 2005; Marriner *et al.* 2008). There were also several campaigns of underwater archaeological surveys and excavations that were meant to complement terrestrial excavations, including underwater visual surveys at the Early Bronze Age site of Tell Fadous-

[1] These sites were studied on a desk-based assessment put together by the author and funded by the Honor Frost Foundation (http://honorfrostfoundation.org/dr-lucy-semaan-desk-based-assessment-of-maritime-archaeology-in-lebanon/).

Kfarabida (Pedersen 2007, 2012), and at the Roman site of Jiyeh (Noureddine and Kotlewski 2006), and the Bronze Age site of Tell el-Burak (Pedersen 2012). Underwater recording and excavations of a Phoenician jetty at the northern harbour of Tyre (Castellvi 2012; Castellvi *et al.* 2007; Noureddine 2008, 2012) as well as the underwater excavation north-west of Tyre of a heavily looted cargo of a shipwreck from the 6th and the 4th century BC (Seco Alvarez 2012; Seco Alvarez and Noureddine 2010) also took place. More recently, projects were further encouraged and supported by the Honor Frost Foundation[2] including work at Anfeh (Panayot-Haroun and Semaan 2019; Semaan 2016; Semaan *et al.* 2016), Byblos (Francis- Allouche and Grimal 2012, 2016), Beirut (Pedersent *et al.* 2017), Sidon,[3] and Tyre (Noureddine and Mior 2013).

Such research projects with a focus on maritime archaeology demonstrate an increased academic awareness of the intrinsic connection between coastal sites, their marine environment and the underwater cultural heritage. From a long line of research centred on harbours, a few of the more recent projects such as at Anfeh (Panayot-Haroun 2015, 2016) and Byblos (Francis-Allouche and Grimal 2016) rather focus on the broader maritime cultural landscape. However, this newly acquired momentum in maritime archaeology has not come easily since the field had, and has yet, to overcome several challenges.

Challenges facing maritime archaeology in Lebanon

The effects of the Civil War on Lebanon's maritime cultural heritage are not to be underestimated. While several publications[4] portrayed the decaying state of antiquities and national heritage during and after the war that ravaged Lebanon's archaeology and material culture, specific issues pertaining to it remained unexamined, such as pillaging, illegal excavations, and trafficking targeted artefacts and remains whether these were on land or underwater, notably at Tyre in South Lebanon. There, thousands of amphorae and statuettes were illicitly retrieved from the seabed. Some are still being sold in Emirati antiquarians' boutiques (Seif 2015: 68). As Charaf (2015: iv) says: 'Much of what was destroyed or stolen during the civil war remains unaccounted for 25 years after the end of armed conflict'. Also, there are still no means to assess the damage incurred to Lebanese archaeology during the civil war, according to Sader (2013: 2). More specifically, there is not a national inventory assessing underwater cultural heritage; nor is there a dedicated management plan gauging priorities and necessary interventions (Abdul Massih 2010: 70).

The fifteen-year turmoil that the country endured resulted in successive governments being unable to completely control, mitigate, or halt the destruction and looting of coastal and underwater sites and remains. Still, the efforts of the Directorate General of Antiquities (DGA) managed to classify Byblos-Jbeil and Tyre, along with two other sites, as UNESCO World Heritage sites, in 1984 (Abdul Massih 2010: 68).

With the end of the Civil War in 1990, the focus of archaeological work in Lebanon was on its capital, Beirut. Beginning in 1992, the Beirut central district (BCD) held the largest urban excavation worldwide with more than 150 sites investigated by national and international teams under the supervision and coordination of the DGA, UNESCO, and the real estate company SOLIDERE (Abdul Massih 2010: 68; Sader 2013: 2). It was only eight years later in the summer of 1998 that Honor Frost officially revived research in maritime archaeology. She also encouraged,mentored and trained local archaeologists to assist in her many projects such as in Byblos, Sidon and Tyre.

Maritime research still faced several challenges across the country. The sites of the BCD as well as others on the coast and underwater were swept away in the rebuilding craze intended to exorcize post-war trauma. As such, remains of Iron Age, Roman and Ottoman quays and seawalls were destroyed, dumped over or dismantled for potential reconstruction that has yet to happen.[5] Several kilometres of the Beirut seafront extended westwards at the expense of the sea without any underwater survey (Marriner 2007; Marriner *et al.* 2008). Sidon's ancient waterfront itself was also buried under the newly-built concreted maritime boulevard without prior assessment of its UCH potential (Farchakh-Bajjaly 2000). Other coastal towns, such as Tripoli in the north and Tyre in the south were also hit by widespread urbanisation driven by an unregulated real-estate boom that disregarded any historical, cultural and archaeological concerns (Abdul Massih 2010: 70; Charaf 2015: iii, v).

The ongoing reconstruction generated by large real estate companies gained even more momentum in recent years. The seafront of the antique city of Byblos is threatened by yet another coastal resort that will be added to a long list of such private luxurious facilities that stretch over what is supposed to be a 'buffer area' south of the site (Battah 2016; Charaf 2016: iv). Several of these resorts block public access to the sea and are part of a large group of more than

[2] https://honorfrostfoundation.org/grants-awarded/small-grants/lebanon/lebanon-projects/
[3] https://honorfrostfoundation.org/2019/06/25/sidon-lebanon/
[4] See Hakimian 1987; Seeden 1987, 2004; Naccache 1992; Semaan 2002; Abdul Massih 2010; Hoteit and Khalifeh 2013; Sader 2013; Charaf 2015; Seif 2015.

[5] For more information on these structures see Seeden and Thorpe (1997); Elayi and Sayegh (1998; 2000); Sayegh and Elayi (2000).

one thousand violations along Lebanon's coastline that were inventoried in 2012 by the Ministry of Public Works and Transport (Zbeeb 2012). The scandal lies also in the fact that several stakeholders of these violations are either backed politically or are politicians themselves. In January 2014, the Doha-based television network Al Jazeera broadcast a fifty-minute documentary on the subject as part of its 'Black Box' [translated from Arabic by the author].[6]

Political interference in archaeological affairs draws public interest away from the 'archaeology itself' and is often more concerned with 'the political debate' around the archaeology (Sader 2013: 4). Politicians are also highly influential over the decisions, prerogatives and actions of the DGA. This governmental body has suffered substantially from this political clientelism, from outdated laws; administrative and organisational irregularities; an absence of strategic planning; a secretive diffusion of information policy; a restrictive attitude in granting permits; and a fierce monopoly over archaeological excavations despite its lack of human and financial resources (Abdul Massih 2010; Charaf 2015; Sader 2013). A positive step was undertaken in 2006 when the DGA's staff was expanded to include specialists in several fields among which was underwater archaeology. At this point, the two Lebanese maritime archaeologists in the DGA endeavoured to establish a Marine Archaeological Centre at Tyre. However, this revival was short-lived and they both resigned shortly thereafter, due mainly to administrative difficulties in undertaking research. As of 2019, the centre in Tyre still remains closed.

The culturally-driven disinterest in heritage and archaeology of the Lebanese population at large has been debated elsewhere (Abdul Massih 2010; Charaf 2015; Hakimian 1987; Sader 2013; Seeden 1987). Consequently, this apathy sustains the looting and organised theft operations that happen both on land and underwater. The UCH is mostly perceived as a trophy and its pillaging is exacerbated by socio-economic drivers. Indeed, several fisherpersons—often communities marginalised by the State—turn to treasure hunting, selling anything and everything they retrieve in their nets and/or by diving at places where submerged artefacts are known to exist.[7] Some of them are also avid collectors of these ancient 'things' and promote themselves as the protectors of the UCH in their coastal towns. Indeed, they follow the logic that if they do not take the artefact(s) they find, someone else eventually will. Some others offer complete, and what they deem 'beautiful', objects as gifts to local state employees, deputies and ministers as tokens of appreciation and gratitude in exchange for favours. Meanwhile, the growing sport diving community adds its fair share to the mix, whereby some divers prize the UCH as personal souvenirs and memorabilia.[8] Looting actions by fisherpersons and divers go frequently unregulated due to the absence of a marine patrolling force protecting UCH. Moreover, such communities are largely unaware of the legal frameworks that protect the country's maritime cultural heritage.

International and national legal frameworks

Lebanon does not suffer from the lack of a legal framework—both national and international—that theoretically protects coastal and underwater cultural heritage, but rather from shortcomings in implementing this. Hence, such important legal instruments most often fail to halt theft and trafficking.

National legislation

UCH has largely been neglected in legal texts governing archaeology in Lebanon. Meanwhile, the administration and legal framework of terrestrial archaeological sites began in the 1920s under the French Mandate (Seif 2015: 66–67). Mainstream archaeology in Lebanon is administered according to the Law of Antiquities that dates from 1933 'Arrêté Nº 166 LR du 7 Novembre 1933 portant règlement sur les Antiquités en Syrie et au Liban'. It was issued by the French Mandate authority, subsequent to several decrees of the French president starting from 23rd November 1920 (Anon 1935). This law was modified and updated in subsequent years by several ministerial decrees and decisions (Sader 2013; Seif 2015).[9] However, it did not take into account the precise nature and scope of the UCH of the country (Chacra 2015: 35).

It was not until 2006 that UCH was woven into the laws administering the archaeological and cultural heritage. Indeed, Lebanon adopted Law number 722 published on 22 May 2006 in the Official Journal (number 25). The Act is the official Arabic text of the 2001 UNESCO Convention and of the Annex 'Rules concerning activities directed at underwater cultural heritage' and was signed by former president Emile Lahoud on 15 April 2006. Lebanon then filed the instrument of acceptance with UNESCO on 8 January 2007.

A year later, Law no. 37/2008, an updated version of the 1933 Law on Antiquities was signed by former president Michel Sleiman on 16 October 2008 and published on

[6] https://www.youtube.com/watch?v=y4CfsBdjdGc.
[7] From personal encounters and discussions of the author with fishermen in Anfeh and Tyre.

[8] A detailed study of the involvement of divers with the UCH of Lebanon is found in Chakra (2015).
[9] For the latest updated regulatory decrees on the antiquities laws see http://newspaper.annahar.com/article/337892 [Accessed 21/3/2016].

20 October 2008 in the *Official Journal* (number 43). It includes criteria for identifying and defining the elements of national cultural heritage, among which it considers 'immovable remains present [...] under water in territorial waters' (Article 2a); and movable artefacts resulting from archaeological excavations [...] under water (Article 2b.1) [Translation from Arabic by the author].

Together, these international and national laws constitute strong legal tools with which the country can counter and mitigate the plundering of its maritime cultural heritage. However, implementing these especially for UCH remains a challenge due to the lack of human and financial resources in the related governmental agencies. As outlined above (see The Challenges), the general disinterest of the Lebanese population towards the significance and value of their heritage worsens the situation. As Seeden (1992: 110) argues: 'what Lebanon needs most today is not primarily a new antiquities law—even the old one dating to 1933 would do if it was applied—but the creation of a general public awareness about the real value of Lebanon's past still underground'.

International legislation

The State of Lebanon signed several international conventions warranting the protection and preservation of its national heritage. Among these, the only two conventions that specifically target underwater cultural heritage (UCH) are: The United Nations Convention on the Law of the Sea (UNCLOS, Articles 149 and 303), and the UNESCO Convention on the Protection of the Underwater Cultural Heritage (UNESCO 2001).[10]

The study by Chacra (2015: 33) discloses an additional shortcoming to the failure in implementing these conventions. She states that the UNESCO 2001 Convention 'falls short of protecting most of the contemporary wrecks of Lebanon' since these have been underwater for less than 100 years. An exception is *HMS Victoria*, a flagship of the British Mediterranean Fleet that sank in 1893 (Blanford 2004; Msallam 2013), and which is also protected by other official decisions.[11] Chacra adds: 'As time moves on, more of the contemporary wrecks of Lebanon will start to fall under the protection of the 2001 Convention. However, in the case of Lebanon, where all the contemporary shipwrecks are made out of iron or steel, they become highly prone to the natural forces of erosion [...]. Therefore, some ships that have only been underwater for more or less than half a century might become inordinately eroded before falling under the protection of the UNESCO 2001 Convention'. Added to this is that most of these wrecks are popular diving spots and are exposed to looting and scrapping.

An example of illegal trafficking of UCH: the case of Odyssey

On Christmas Eve 2015, the Cypriot authorities seized the treasure-hunting vessel *Odyssey Explorer* and confiscated a cargo of 57 crates holding about 600 artefacts dating from the 18th century AD.[11] The Bahamian-flagged ship was reportedly operating some 60km due west of Beirut in the Exclusive Economic Zone [EEZ] of Lebanon, before mooring at Limassol dock. It is owned by Odyssey Marine Exploration, a private American firm engaged in the salvage of deep-water shipwrecks, and which is often in litigation with authorities and academics in the USA and Europe. Upon seizure, Odyssey issued a statement denying the allegations.[12]

To date, this case has not been resolved. One major drawback for the Lebanese involvement is the lack of penal decrees associated with Law no. 722/2006, which corresponds to the adoption of the UNESCO 2001 Convention (see National legislation). This was not the first time Odyssey operated in Lebanon. Indeed, the Lebanese government had contacted the company in January 2010 asking it to assist in the search and recovery of the crash of Ethiopian Airlines Flight ET 409.[13] Odyssey was also rumoured to be searching for a 380kg gold cargo of a sunken Lebanese International Airways plane that went down in 1957.[14]

Shipping antiquities out of Lebanon using Cyprus as a stopover is reminiscent of illegal trade practices during the Lebanese Civil War (Fisk 1991: 243, 251–52). Back then, antiquity dealers with the blessing of militias would use uncontrolled ports to export artefacts destined for European, American and Japanese markets: ''We almost always use Cyprus' a dealer said. 'We send almost everything by sea. You can't take a marble tomb through Beirut airport. Once the stuff reaches Cyprus, the Lebanese government can't touch it' (Fisk 1991: 248).

State of academia pertaining to maritime archaeology

Maritime archaeology has never occupied the centre-stage of archaeological research in Lebanon. Most publications (see footnote 3) pertain to the threats and

[10] An analysis and comparison of these two conventions are beyond the scope of this article but can be found in Chacra (2015: 31-33).

[11] See the Facebook page dedicated to the wreck and its news https://www.facebook.com/HMS-VICTORIA-THE-VERTICAL-WRECK- 135213409838987/, and http://www.wrecksite.eu/wreck.aspx?32187.

[12] Featured in http://art-crime.blogspot.com/2015/12/ancient-artefacts-seized-from-bahamas.html [Accessed 31/1/2017].

[13] http://www.shipwreck.net/pr218.php [Accessed 31/1/2017]; also see http://www.shipwreck.net/pr198.php [Accessed 31/1/2017].

[14] http://www.nisd-online.com/Articles/et409.pdf

challenges that terrestrial archaeology faced during and after the Civil War. An exception to this is perhaps Haddad's article (2010) on the state of underwater archaeology in Lebanon. The discourse on archaeology by local academics remains anchored in land-based archaeological studies, while marginalising—albeit unwittingly—the underwater cultural heritage.

It is unfortunate that a country shaped by the sea over the centuries has no academic educational programmes in maritime archaeology. Indeed, the subjects of maritime and underwater archaeology are non-existent in the curricula at both undergraduate and postgraduate levels. Concomitantly, the number of universities[15] teaching archaeological programmes dwindled to only two in recent years due mainly to a decrease in the number of registered students (Abdul Massih 2010: 71). In the past decade, the Lebanese University updated its curricula in archaeology at the undergraduate level but failed to include a component on maritime archaeology in its courses. Meanwhile, the archaeology and history department at the American University of Beirut granted the Whittlesey Chair Visiting Assistant Professor to nautical archaeologist Ralph Pedersen who taught relevant courses for two years (2007–2008).

An absence of maritime museums

Currently, Lebanon does not possess a national maritime museum dedicated to its rich history of trade, waterborne connections and intimate relation to the sea for subsidence and transport.[16] Neither the National Archaeological Museum nor the Archaeological Museum of the American University of Beirut hold substantial collections relating to the maritime heritage of the country, only displaying a few artefacts such as anchors, vases with paintings of ships, and boat models. These, however, are not inscribed in a maritime-oriented narrative or trail, as they are exhibited alongside contemporaneous artefacts of no direct maritime significance. The same applies to the site museum of Byblos, which documents the history of the site and its excavation. Perhaps the only exhibition space that is dedicated to ancient maritime material culture is the Fondation Pépé Abed in Jbeil (modern Byblos). Here lies a collection of objects such as amphorae and figurines that Pépé Abed, a local entrepreneur in the touristic sector, retrieved from the seabed during his dives offshore of Byblos. Before his passing, he donated the collection to UNESCO. Recent foreign donations— such as from the State of Kuwait that is supporting the creation of site museums at Sidon and Beirut (Abdul Massih 2010: 70)—are generally endowed to collections from 'on-land' environments but less so from 'aquatic' contexts. It remains to be seen to what extent such new museums will include maritime histories and archaeologies in the narrative of the related sites

In contrast, education and exhibitions on local marine life are fostered by two museums, the 'Wonders of the Sea'[17] and the 'Lebanese Marine and Wildlife Museum[18] with the former holding a modest collection of traditional navigational instruments and displaying maritime equipment for early underwater diving.

The struggle of the NGOs and the civil society

Amidst the general disinterest of the Lebanese toward their own heritage, especially toward their 'invisible' UCH, there are a few nongovernmental organisations (NGOs) that attempt to promote awareness of local and national cultural heritage within their communities and the wider population. However, as Abdul Massih (2010: 71) puts it, these are 'still far too few to impact the relentless urban machine that is sweeping the rich soil of the country'.

Especially challenging is the work of NGOs and members of the civil society attempting to prevent the total defacing of the Lebanese coast (Charaf 2016: iii–iv). Recently, the Chalcolithic coastal site of Minet el-Dalieh in Beirut that was threatened by a luxury resort was classified on the 2016 Watch List of the World Monument Fund thanks to the relentless efforts of The Civil Campaign to Protect the Dalieh of Raouche (CCPDR).[19] The construction is at the moment halted but could resume at any moment (Charaf 2016: iv). The media backed the campaign with several TV reportages and written press articles[20] and members of the civil society produced short documentaries about the site.[21]

Less fortunate was the site of Adloun, thought to be a Phoenician harbour site some 17km south of Sidon. Here, the NGO, The Green Southerners,[22] was rendered powerless to counteract the destruction of the site in early 2016 by a modern marina backed by a powerful political figure.[23] This has not only constituted a great

[15] At present these are the American University of Beirut (AUB) and the Lebanese University (UL) which are offering graduate and postgraduate studies in archaeology.
[16] For a brief review of existing museums in Lebanon see Badre 1992, Seeden (2004: 144-145), and http://www.tourism.gov.lb/Content/uploads/Publication/120806053331513~Mus%C3%A9es%20english%20final.pdf.

[17] http://www.wondersofthesea.net/ [Accessed 27/1/2017].
[18] http://lmwm.org/ [Accessed 27/1/2017].
[19] See https://www.dalieh.org/ and https://www.wmf.org/project/dalieh-raouche.
[20] These are well detailed on their Facebook Page https://www.facebook.com/dalieh.org/?hc_ref=SEARCHandfref=nf.
[21] See 'Dalieh's project' video https://www.youtube.com/watch?v=EBR-83tELhU.
[22] http://greensoutherns.org/index.php/ar-aa/ and https://www.facebook.com/greensoutherners/.
[23] See http://stateofmind13.com/2016/01/21/lebanons-government

loss of coastal and underwater cultural heritage but has and will have a negative ecological impact on the marine environment and its fauna. Indeed, the government will also conduct some land reclamation, effectively killing off one of the last remaining habitats for sea turtles in Lebanon.

A few years earlier in 2012 another site in Beirut, the Venus Towers site (Plot 1398), was at the heart of a polemical debate between the academic community, the wider public, and the politics of the time.[24] To some, the site held slipways belonging to the Phoenician harbour of the city (Francis-Allouche 2012a, 2012b), to others it did not (Pedersen 2012a). Others suggested it was a quarry site in preparation of the foundation of a large building (Farrell 2012). Despite the multiple protests led by major NGOS (such as Save Beirut Heritage [SBH], and Association for the Protection of the Lebanese Heritage [APLH]) and an online petition to save the site,[25] the contractors ignored all recommendations and pleas to modify the towers' design to accommodate the remains irrespective of their actual nature.

Despite several lost battles, there are active NGOs still working to raise awareness among the Lebanese population of their historical and archaeological heritage. These groups include Biladi,[26] Archeoact,[27] and the Anfeh and Neighbourhood Heritage Committee.[28] However, none of the NGOs is specifically dedicated to the protection and conservation of the maritime and underwater cultural heritage.

Presently, only two Lebanese maritime archaeologists are members of the ICOMOS International Scientific Committee for the Protection of the Underwater Cultural Heritage (ICUCH). ICUCH was established in 1991 to promote international cooperation in the protection and management of underwater cultural heritage and to advise the International Council on Monuments and Sites (ICOMOS) on issues related to underwater cultural heritage worldwide.[29]

Suggested mitigation initiatives

Considering the above-mentioned challenges and shortage of legal tools, key strategic points for building capacity in Lebanon need to be implemented to help mitigate the current state of affairs. These points are discussed below:

While tackling corruption and corporate real estate would be a huge undertaking, that would probably be in vain; and, awaiting the implementation of relevant legal frameworks can be time-consuming with the winning war of concrete against the sea. Raising awareness from the ground up would be a more sustainable method to protect and conserve the maritime cultural heritage of Lebanon. Community engagement with heritage has been long stressed in the academic discourse in Lebanon. As Helga Seeden (1992: 118) states: 'In Lebanon [...], primary local goals must be to create awareness of the past's value by providing the public with information, in cooperation with that public'. She goes on to explain how public archaeology can foster initiatives to mitigate the losses to Lebanon's cultural heritage (Seeden 1992: 120–121). The major measures according to Seeden (1992: 120–21) entail: (1) providing Lebanese citizens with relevant information on their cultural environment through media and publications; (2) establishing informative museums at archaeological sites; (3) mitigating the 'treasure-and-cash image of antiquities' through diffusing awareness of the social value of artefacts *in situ*; (4) involving communities in local rescue work; (5) involving schools in survey archaeology; (6) organisation of low-cost pilot surveys and test soundings with local schools and universities; and, (7) regulating excavations so as to integrate results in local/regional museums/information centres for the public. Such an approach to community engagement and public archaeology would surely benefit the maritime component of Lebanon's heritage to generate not only an 'understanding of the past' but also a 'public appreciation in the present' (Firth 2015: 5, 51).

Collaboration with existing NGOs can further foster initiatives to recognize, promote and enhance the socio-economic value of maritime and UCH in the country. Currently, there is no known NGO that specifically targets such heritage; and perhaps raising the awareness of individuals and society at large would generate such interested groups. Additional public engagement initiatives could include the production of a series of short video presentations on underwater and coastal archaeology and the importance of the preservation of maritime heritage for national/ethnic history as well as for sustainable tourism. These would be freely distributed on online platforms and

-is-destroying-a-phoenician-beach-in-adloun-to-build-a-port/; http://greenarea.me/ar; http://blogbaladi.com/save-adlouns-historic-beaches/ http://www.lorientlejour.com/article/967868/le-projet-de-port-a-adloun-une-degradation-a-venir-du-littoral.html.

[24] See http://www.dailystar.com.lb/News/Local-News/2012/Jun-28/178530-construction-firm-demolishes-phoenician-port.ashx; https://hummusforthought.com/2012/06/26/2500-year-old-phoenician-shipyard-destroyed-today-in-beirut/, https://hummusforthought.com/2012/06/30/new-information-on-the-phoenician-site-destroyed-last-tuesday/ and https://hummusforthought.com/2012/06/28/%E2%80%8Esave-beirut-heritage-releases-april-icomos-report-on-the-phoenician-site-of-minet-el-hosn-freng/ for further links on the subject.

[25] See https://www.petitions24.net/le_port_phenicien_de_beyrouth.

[26] http://www.biladi.org/

[27] http://www.archeoact.com/

[28] https://anfehheritage.wordpress.com/

[29] See http://icuch.icomos.org/

at outlets such as dive shops, schools, municipalities and tourism offices. Such videos were done by the author and others with funding from the Honor Frost Foundation[30] Educating the public on the importance and value of one's heritage should also target school programmes (Hakimian 1991: 254; Salamé-Sarkis 1991). This would be done through lectures as well as site and museum visits so as to engage Lebanese youths with their history, geography, archaeology and heritage (Hakimian 1991: 256–57). Moreover, a common history book based on an all-encompassing recognition of the different communities in Lebanon would divorce students from the ongoing didactic discourse of partiality, and confessionalism (Beydoun 1984; Salamé-Sarkis 1986, 1991; Seeden 1987, 2004). Implementing such educational programmes in Lebanon has yet to be seen whereby 'a valid archaeology would reflect the varied historical traditions of all sections of Lebanese society' (Seeden 2004: 147).

Raising awareness amongst stakeholders in the fields of marine sciences, heritage management and archaeology of the importance of a maritime archaeological component would positively influence policies. Workshops and seminars targeting experts in the field as well as DGA personnel were conducted in previous years in Lebanon[31] These should be pursued in order to sustain a momentum of interest and endeavour toward the implementation of related recommendations. As Firth (2015: 51–52) recommends: 'marine and maritime cultural heritage should receive much greater attention as a facet of culture and heritage generally, and as a facet of the marine environment [...]. Its absence from debates and from policy should be remedied'. Such educational initiatives and training opportunities should be extended beyond specialists and target other governmental agencies such as municipalities, the relevant ministries (such as the Ministry of Culture, Ministry of Tourism, Ministry of Municipalities of Coastal Zones, and the Ministry of Public Works and Transport), and the Lebanese Navy. As such, specific training courses targeting Navy members and sports divers could follow the model of the Nautical Archaeological Society (NAS) training programme. Subsequently, these would be able to participate in underwater archaeology projects in Lebanon.

At the academic level, the absence of specialised courses in maritime archaeology should be remedied. As of 2019, and with the assistance of the Honor Frost Foundation, the American University of Beirut has launched a Minor in Marine Sciences and Culture which focuses on raising awareness on the maritime cultural heritage of Lebanon. The course is open for students from diverse academic background and levels of education.[32] Several lectures at other universities at undergraduate and post-graduate levels are also planned in order to gauge interest and introduce an as yet understudied field at Lebanese universities.

Recently, the establishment of a Lebanon-based maritime archaeological unit of the Honor Frost Foundation (HFF)[33] helped kick-start research and rescue projects related to maritime archaeology in Lebanon[34] (see Overview of maritime research in Lebanon). These aim to survey, record, document, investigate and inventory some of the maritime cultural heritage of Lebanon. The HFF also funded in 2015 the compilation of a desk-based assessment for maritime archaeology in the country that will be made available for interested students and researchers alike.[35] Additionally, HFF helped establish the first postdoctoral research fellowship in maritime archaeology in Lebanon at the University of Balamand, North Lebanon.[36] Such an initiative was highly encouraged and would be an asset to archaeology departments at other Lebanese universities.

These aforementioned collective efforts were greatly encouraged by the appointment in 2015 of the Director General of Antiquities, Mr Sarkis el-Khoury. This event instilled a new 'life to cultural heritage and archaeology in Lebanon' through a more open approach to bridging gaps in collaborative initiatives with national and international institutions and universities (Charaf 2015: iv). It has also resulted in the issuance of more permits allowing surveys and excavations by national universities on a wide range of sites (Charaf 2015: iv), including an emphasis on coastal research.

Finally, a significant step to develop sustainable capacity would be to promote, enhance and implement ways in which 'marine and maritime cultural heritage can create socio-economic benefits as well as environmental ones' (Firth 2015: 10). Sustainable pilot projects can include, for example, establishing underwater trails at modern wrecks with dive clubs, and at archaeological sites with local divers and fisherpersons who are familiar with the area. Such initiatives would not only contribute to

[30] https://wedigboats.wordpress.com/2017/06/04/the-ain-el-mreisseh-underwater-archaeology-project/
and https://vimeo.com/145716620

[31] For example, see: http://www.ifporient.org/node/913, http://www.ifporient.org/node/1082, and http://www.ifporient.org/node/1439.

[32] https://honorfrostfoundation.org/grants-awarded/small-grants/lebanon/hff-lebanon-team/aub-minor/

[33] https://honorfrostfoundation.org/grants-awarded/small-grants/lebanon/hff-lebanon-team/

[34] https://honorfrostfoundation.org/grants-awarded/small-grants/lebanon/

[35] See https://honorfrostfoundation.org/2020/06/08/desk-based-assessment-of-maritime-archaeology-in-lebanon/

[36] See https://honorfrostfoundation.org/2019/06/20/lucy-semaan-2015-2018/

safeguarding of sites but can also be used to evaluate and quantify the local socio-economic benefits of UCH. Indeed, they would promote diving tourism economies that ensure responsible and controlled access to sites (Rey da Silva 2014: 751–52, 755). They would also build a marine and maritime cultural heritage community that can collaborate with policy makers and heritage practitioners to enhance such benefits and enable a heritage of this nature to contribute to sustainable growth.

Conclusion

Maritime archaeology in post-civil war Lebanon has yet to gain maturity in its approaches and scope. Much has been achieved by pioneers in the field and the future looks promising with the implementation of capacity-building initiatives that ensure sustainable academic, educational and socio-economic advancement of maritime cultural heritage in thecountry.

The field is suffering from an almost non-existent national development strategy, coupled with a lack of an applicable legal framework, an absence of an academic-related education, unwarranted coastal urbanisation, and a general public indifference towards heritage. Mitigating these challenges can be achieved through a bottom-up strategy, which develops the archaeological skill base, implements public archaeology initiatives that pertain to the socio-economic development of maritime communities, and raises awareness of the significance of Lebanon's maritime cultural heritage.

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A Value-Based Model for Capability Building in Maritime Archaeology in the Developing World

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Abstract

Capability building enables people, groups, organisations and nations to achieve a greater range of activities. A programme of capability building activities in Vietnam over the past decade provides the case study for this paper. From these activities and the progress of the programme we have constructed a model of capability building that deals with maritime archaeology and underwater cultural heritage. The model is based on a value proposition that maritime archaeology is the only ethical way of dealing with underwater cultural heritage, which we believe is a world resource that belongs to current and future generations. The aim of this paper is to explain how the elements of our value-based model interact to establish and enhance capability through knowledge capital development.

Our notion of capability building is based on a process taking place over an extended period of time, which is considered necessary to achieve long term change or at least critical reflection on the part of the host organisation. In practical terms, this causes a direct exposure to the ethical and disciplinary tenets of maritime archaeology on the part of the host organisation, but some congruence of values is considered critical in order to achieve effective outcomes. The programme is based on principles of commitment to empowerment, participative learning, learning reinforcement mechanisms, and intensive communication with the stakeholders of the host organisation. We argue that training alone does not work and so the model encompasses an integrated approach by supplementing training in a variety of forms with advice, mentoring, academic research and cultural heritage management- based approaches to help answer specific problems faced by the host organisation.

Keywords

Capability building, maritime archaeology, Vietnam, value-based model

Introduction

Capability building is founded on principles of human development. Human development, however, is a complex and contested construct. How can humans be 'developed'? Does the notion of development indicate a lack of free will? Does building capability entail some degree of coercion, or a need to submit to the ideals and beliefs of the parties arranging the development activities? In this paper, we use a case study of activities undertaken by an international team in partnership with a Vietnamese national government research organisation (the Institute of Archaeology) primarily over the years 2011 to 2016. The Institute of Archaeology (IA) is part of the Vietnam Academy of Social Sciences (VASS) and currently employs more than 50 archaeological researchers who conduct survey and excavation on significant archaeological sites throughout Vietnam, working in close co-operation with the provinces. IA was established in the 1960s and was partly based on previous French archaeological research conducted in Vietnam by École Française d'Extrême-Orient (EFEO) so it has a long history of 'Western-style' archaeological approaches. Vietnam has had a legislative framework for the protection, preservation and investigation of archaeological sites on land but has struggled with underwater cultural heritage resulting in a series of treasure hunting operations being conducted in the country. As a result wrecksites at Phu Quoc, Hoi An, Vung Tau, Ca Mau and Binh Thuan have been salvaged by treasure hunters and thousands of ceramic artefacts have been sold at auction.

We use this case study to examine how capability building can occur in a way that embraces the values of collaboration, respect and learning while fulfilling the goals underlying capability building, namely to assist in creating a sustainable range of choices desirable to the host organisation.

In this paper, first, we provide a background that includes the experience of the authors, showing how that experience shaped the values that were brought to the activities outlined in the case study. We also outline the structure of activities undertaken by the international team and the host. We then define the terms 'values', and use Amartya Sen's capability approach to illustrate and unpack the model of capability building that we developed while undertaking the activities during the case study.

We use the term *capability building*, both because it is the term used by Amartya Sen (Sen 1985; Sen 1989; Sen 2003) and because it encompasses more effectively our approach than the term *capacity building*, which has been used by other authors in maritime archaeology. *Capacity building* is often used as a synonym for training activities (Eade 2010), or to provide materials that are intended to enable people to achieve certain focused goals (Grossman and Salas 2011). *Capability building* encompasses capacity building but also takes into account fostering the will in the governing bodies at a collective level to provide budget, infrastructure, planning and so on. This enables and activates the capacity building so that desirable goals in both the short-term and the long-term can be met.

We believe that for capability building to be effective, a congruence of values is necessary between the international team and the host organisation. With a congruence of values, the capability building can achieve a mutual understanding of maritime archaeology and underwater cultural heritage as long-term sustainable (and sustained) assets, rather than as short-lived non-renewable resources.

Background

Over the past decade, the lead author has conducted public awareness raising, capability building and training activities with regard to maritime archaeology and/or underwater cultural heritage in the Asia and the Pacific region. These activities have included the UNESCO Foundation course training in Thailand; Flinders University Intensive Program in Underwater Cultural Heritage Management (2009) for Asian fellows conducted at Flinders University in Australia; a UNESCO Workshop on the Protection of the Underwater Cultural Heritage in the Pacific held in the Solomon Islands; conducting a 5-day Training Workshop on Underwater Cultural Heritage Preservation with Chris Underwood at the National Taitung University in Taiwan; and teaching Maritime Archaeology for the Department of Archaeology at Gadjah Mada University in Yogyakarta, Indonesia (Favis 2011; Manders and Underwood 2015; Staniforth 2008, 2010, 2011 and 2014a). These diverse activities conducted for varying audiences in different countries of the region have shaped our approaches to capability building which, in recent years, have focussed primarily on Vietnam and provide the case study for this paper (Staniforth 2014b, 2014c). The second author is a sociologist who, within the field of training and education, has studied, taught and consulted in the fields of capability building and collective learning and memory for the past 30 years throughout Australia, Asia and the Middle East.

Since 2008 a team of international researchers and trainers mainly from the US, Canada, Japan and Australia has conducted collaborative research and training activities in Vietnam under the adopted banner of the Vietnam Maritime Archaeology Project (VMAP) including:

- 'On-the-job' training in the use of high technology field equipment on-going since 2009;
- Nautical Archaeology Society (NAS) Introduction (1 day) and Part 1 (2 day) training in Vietnam since 2011; and
- Vietnam Underwater Archaeology Training (VUAT) – a four week training programme in 2015.

In addition to these training activities, VMAP has also been involved, and participated, in joint research projects (such as projects in Bach Dang, Van Don and, more recently, Hoi An) that have allowed our Vietnamese colleagues to put some of the above training into practice in a context where learning takes place as part of 'purposeful action' (O'Toole 2011:30).

Our activities in Vietnam have been deliberately structured to provide:

- Exposure to the theory and practice of maritime archaeology;
- Exposure to international perspectives and values regarding maritime archaeology and the protection of underwater cultural heritage ;
- Encouragement to learn the skills, knowledge and values of maritime archaeology; and
- The loan or provision of equipment and the training to use it.

Our activities in Vietnam have been based on values intended to help Vietnamese capability building in the area of maritime archaeology while embracing the tenets of responsible, internationally accepted, maritime archaeology, largely as defined by ICOMOS and UNESCO (Manders and Underwood 2012; Maarleveld *et al.* 2013; Staniforth 2014a).

Most maritime archaeologists will recognise the situation where their own value set doesn't correspond with others' values. The easiest example to understand this disjunction of values is the perennial maritime archaeology/treasure hunting value divide. In a more nuanced sense, maritime archaeologists regularly find their own values are not fully shared either by their own organisation or by their government. The failure of so many governments around the world to ratify the UNESCO Convention 2001 is clear testament to this particular lack of shared values. We argue that shared values between the international team and the host organisation are a necessary component of capability building activities and that, without some shared values, attempts at capability building are likely to fail.

Values as the foundation of VMAP

The term 'value' is defined in this paper as:

> 'desirable states, objects, goals or behaviours, transcending specific situations and applied as normative standards to judge and choose among alternative modes of behaviour' (Schwartz 1992, cited in Elizur and Sagie 1999: 74).

Values can thus provide focus and determine courses of action. They are usually thought of in terms of the individual, although some organisations may develop a set of values to be applied across the organisation (Schminke *et al*. 2015). Although the terms 'values' and 'ethics' are often used interchangeably, the term 'ethics' is more precisely used to describe systems of moral principles determining right and wrong. 'Values' on the other hand, as mentioned previously, describe what is important to the individual or group, and will determine courses of action -- action that may not necessarily be ethical. The Australasian Institute of Maritime Archaeology (AIMA) *Code of Ethics*, for example, sets out principles of conduct that essentially show the moral practice that Australian maritime archaeologists are expected to endorse and follow. As noted by Coroneos (2006), however, practicing Australasian maritime archaeologists are also influenced by their own values, which may or may not be completely aligned with the AIMA *Code of Ethics*, but will be in line with what the archaeologists deem to be an important and/or desirable outcome.

In discussing values, and their effects on action, the previous discussion should indicate that we deal with subjective perceptions rather than objective truths. This paper is not a polemic on the moral worth of our values, instead we explicate our values and then explain how these values affected the decisions and activities in our dealings with Vietnamese people, organisations and government.

In planning and undertaking actions in Vietnam, as well as in other countries, the values that have guided our actions can be explicated in the following principles:

- Underwater cultural heritage is a world asset that belongs to current and future generations.
- A combination of protection for underwater cultural heritage and maritime archaeological investigation is the only ethical way of dealing with underwater cultural heritage.
- Well-managed underwater cultural heritage is an asset that improves community/national well-being.
- Activities must be carefully structured to improve community/national well-being through collaboration, mutual respect and a commitment to learning.

As mentioned previously, we use Amartya Sen's capability approach to explain how our activities contribute to Vietnam's maritime archaeology capability while being guided by our value set. Amartya Sen is a professor of economics and philosophy, who is celebrated for creating a capability approach, which is based on 'seeing life as a set of "doings and beings ... functionings"' (Sen 1989: 43), in other words, people's ability to do things (Sen 1985; Sen 1989; Sen 2003). Sen argues that the capability of a person is based on their ability to use their 'doings and beings' to achieve (1989). That being so, capability implies the ability to make choices and to achieve a positive state of being. The roots of Sen's thinking are in the writings of Marx (1844/2000) and Aristotle who both linked the ability to function - or capability - with well-being.

Sen's capability approach is a normative framework that is often used to evaluate individual well-being and social arrangements (Robeyns 2005). For this reason, Sen's framework is useful in understanding the process by which people, organisations and nations may either engage or refuse to function in ways enabled by investments of infrastructure and training.

Robeyns (2005) created a model that illustrates Sen's capability approach (see adapted version in Figure 1). We have adapted the model to enable a collective focus, to deal with the level of analysis relating to government and organisations, as well as individuals (O'Toole 1999; Weick and Roberts 1996). Hence, for example, the conversion factors, in addition to being individually focussed e.g. physical capacity and level of education, are represented on a collective level, e.g. available infrastructure and social/cultural mores, as well.

In Robeyn's model, the provision of goods and services, and the social context are factors that affect the ability to do things - functionings - rather than ends in themselves. Conversion factors relate to how the person or group can convert the goods/services into a functioning using other factors such as their ability to swim, their motivation, the support of their employer and mentors and so on. For example, the provision of SCUBA equipment to a group of people is of little value

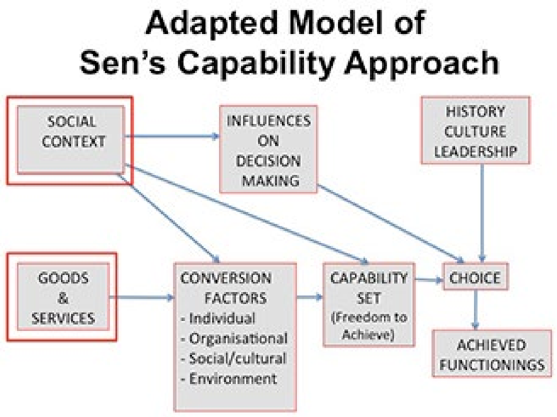

Figure 1. Adapted model of Sen's Capability Approach (Robeyns 2005).

if no-one is qualified to dive, and refuses to learn. In such a case, the social context is negating the potential opportunity to SCUBA dive, decreasing the capability of the group in terms of undertaking maritime archaeology. The reasons for such a refusal may be on the grounds of beliefs of the group regarding safety, the fact that all the group may be women, and such conduct in that society is considered unwomanly or narrow and restrictive duty statements in an organisation. In addition, personal factors in individual cases could also affect the decision to take up a given opportunity, such as age or poor health, all of which relate to the conversion factors of the group and the individuals within that group in terms of the proffered opportunity.

If the social context, conversion factors and the goods/services available enable a capability set, that is, a set of potential or achieved functions, it means that the individual or group have the ability to achieve. This ability to achieve, however, is separate from choice. A group may have been given equipment and instruction on how to use it, but simply decline to use their capability. Thus choice again depends on social context and other determinants of decision-making. Two groups with the same capability set may make different choices, based on their different cultures, history, economic circumstances and so on.

Thus the social context, such as social and legal norms, environmental factors, government priorities and so on shape decision making and therefore choices, even where the goods/services provided enable the acquisition of functionings. Figure 2 shows a simplified version of Robeyn's model to emphasise the interrelationship of social context and goods/services. Clearly, according to this model, the provision of equipment and training by itself is unlikely to lead to capability building except if by some serendipity the social context of the host organisation is already oriented towards values that are congruent with the international team.

We argue that our activities affect both the social context and the goods/services aspect of capability. Vietnamese practitioners are invited to participate in activities that broaden their awareness of maritime archaeology, learn about how the international community views maritime archaeology, and they are encouraged to question old and new ideas. The activities of the international team have emphasised learning rather than didacticism, with engagement and practice as a necessary part of building capability. While seeking to assist the host organisation enrich their capability set, we have also introduced the ideas and issues that promote reflection on issues associated with maritime archaeology and underwater cultural heritage. At the same time, we have been careful to make such activities culturally relevant, sometimes at some cost. Some of the materials provided to the Vietnamese through NAS (Nautical Archaeology Society) training, for example, have been translated into Vietnamese language thus showing a respect for their learning and their language (Figure 3).

In terms of goods and services, where possible rather than loan equipment to the Vietnamese, a great deal of effort was spent in acquiring donations of books and equipment, which were then given to the Institute of Archaeology without condition (for example, library books, SCUBA diving equipment, UHF radios, GPS units and a metal detector), and they were instructed in this equipment's correct usage. At an organisational level VMAP regularly provided advice and support for activities such as *the International Symposium on Underwater Archaeology in Vietnam and Southeast Asia: Cooperation for Development* held in Quang Ngai in 2014.

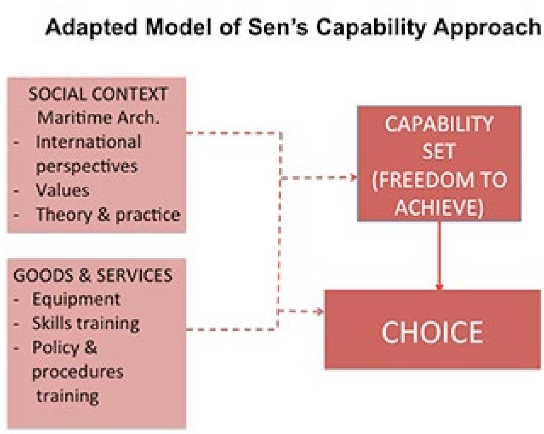

Figure 2. How activities affect capability.

Figure 3. NAS training in Vinh City, Nghe An province in 2013
(Jun Kimura; courtesy of VMAP).

In addition, where possible, opportunities for individual IA staff have been provided such as support and funding for Dr. Le Thi Lien to attend the Inaugural Asia-Pacific Regional Conference on Underwater Cultural Heritage held in Manila, Philippines in 2011. Furthermore, Dr. Le Thi Lien was nominated and elected as a member of the ICOMOS International Committee on Underwater Cultural Heritage (ICUCH) thus bringing her into direct contact with international perspectives and values regarding maritime archaeology and the protection of underwater cultural heritage. The goal of the activities in which VMAP has invested time, funding and effort is to enlarge the capability set of our Vietnamese colleagues in order to enable them to adopt maritime archaeology theory and practice to protect and investigate their underwater and maritime cultural heritage.

Our own values demand that these activities occur to enable the Vietnamese capability set without taking away their choice about whether they wish to exercise this capability set. The ability to exercise choice in the Sen capability approach is shown to be dependent on whether the individual has a capability set that gives them options to function in ways the individual believes to be beneficial. This capability set is in turn dependent on social context factors, which also influence conversion factors, and the level of goods/services available to provide benefits. Thus by affecting the goods/services available to them and their social context by helping groups learn about maritime archaeology, we are giving them the choice whether to proceed with a maritime archaeology approach, whether to adapt an 'international' maritime archaeology approach or whether to continue with their own established practices.

So in order to commence capability building activities in Vietnam, we needed to feel that there were sufficient shared values, at least at an individual and an organisational level, if not at a government level. Three shared values provided the basis for the capability building activities: first, a genuine commitment to western-style archaeology and principles of cultural heritage management, second, a willingness to conduct work in a collaborative and co-operative manner, and third, capability building needed to be seen as essential. It was these three values which partly underpinned the five-year Memorandum of Understanding (MOU) that existed between the International team (VMAP) and the Institute of Archaeology between 2011 and 2016.

If the Vietnamese choose to exercise this capability set, the result will be a paradigm and value change that will affect their legislation, policy, partnerships and practice in terms of their maritime and underwater cultural heritage. Instead of perceiving their underwater cultural heritage and maritime material culture as a non-renewable resource to be 'mined' or extracted and sold, it would become an asset to manage and to leverage while retaining the asset.

This would require a governmental change from short-term thinking to long-term thinking, creating resources and expertise to manage their assets, and national development of expertise, equipment, databases and so on. This knowledge capital creation encompasses the legislative protection of maritime and underwater cultural heritage sites, the development of tourist resources based on maritime and underwater cultural heritage, and the construction of museums with collections of maritime and underwater material culture with the funding and skilled Vietnamese staff to effectively support this infrastructure.

This long-term future is not easily won. The process underlying such capability building requires several stages:

1. Engagement occurs at several levels, that is, at the national (government) level, the organisational level and the individual level. To make such engagement effective, it is necessary to share values important to both parties. In Vietnam, the International team were fortunate in working with Dr Le Thi Lien, who proved to be an engaged and committed colleague with both influence and esteem in her profession and government circles. Engagement with Dr Lien also involved engagement with the managers of the Institute of Archaeology, a government organisation with links to Vietnamese regional and local government agencies and museums. VMAP needed the support of these organisations and individuals to undertake research and training activities, and this support was effectively brokered by Dr Lien. Dr Lien and VMAP shared a commitment to research, a belief in archaeological method, and a willingness to engage in interaction between international and Vietnamese archaeologists to conduct research and other activities in Vietnam.
2. Activities needed to be planned and undertaken that were consistent with the aims of both parties. In Vietnam, these activities revolved around the archaeological investigations, survey and excavations at two naval battlefield sites (Bach Dang and Van Don) and more recently survey and marine geophysical prospection at Cu Lao Cham. Complementary to these investigations were 'on-the-job' training in the use of high technology field equipment, NAS Introduction and Part 1 training and VUAT training. Thus as the work developed, the Vietnamese archaeologists developed competence in new techniques and technology as well. It was critical that capability building was considered important by all parties. For the leaders of the international team, the competence-building was expensive in terms of both money and time. The Vietnamese had to take such efforts seriously to encourage continued investment in these capability building activities. As part of our commitment to engaging with the Vietnamese in ways that are culturally relevant, when undertaking the formal presentations that form part of the NAS training, we ensured that the powerpoints were translated into Vietnamese, and that we had Vietnamese archaeologists to simultaneously interpret the verbal presentations. Informal feedback from participants showed that our efforts to produce materials that all the participants could fully understand were highly appreciated.
3. Activities and progress were evaluated at regular intervals to determine the ongoing viability of VMAP. Although this paper has so far concentrated on the use of the model in terms of our Vietnamese partners, the same influences are at play in terms of our own situation. Our own social context, personal factors and the availability of goods/services to use in the project shaped our ability to make choices in terms of how the project could proceed. In addition, actions taken by both parties are manifestations of the values of both parties and these needed to remain largely congruent. Changes in personnel or government policy could feasibly cause a breakdown in the relationship that could lead to significant changes about how the values that have been articulated in this paper were accepted by all participants.

Conclusion

This paper has described and explained an on-going project (VMAP) to develop maritime archaeology capability in Vietnam. Using Sen's capability approach, we have shown that it is necessary to address the host organisation's values in a shared social context rather than simply providing funding, equipment and/or training in the hope of encouraging them to embrace the values of international maritime archaeology. It is necessary that there is an understanding of some shared values that provide a basis for mutual cooperation. Even if training, shared projects and equipment are provided, the conversion factors of the host organisation may impede or prevent capability from being achieved. And, even if capability is achieved, the values, history, social context and other factors may cause the host organisation to simply choose not to exercise the functioning achieved.

The work in Vietnam has been a long-term commitment by the lead author and other VMAP members, and has been marked by respect, collaboration and mutual learning. The sustainability of this approach lies in the experience of sensitive collaboration and joint achievement that have taken place over more than a decade. This model leaves a firm foundation for future relations whether or not all the goals of the international team are met in the short or longer term. It is hoped that the Vietnamese government, in particular, and some organisations in the provinces will come to shift their paradigm and therefore their value set by understanding, acknowledging and valuing their maritime and underwater cultural heritage as an important part of Vietnam's long-term future. This, however, is a choice that cannot be made by anyone other than the Vietnamese.

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'Vive la France'—Louis de Saint Aloüarn and the French Claim to the Western Part of New Holland

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Abstract

The Age of Enlightenment marked a new phase in the history of oceanic exploration. The mystery of the uncharted region of the southern hemisphere was still to be solved. French curiosity about *Terra Australis* was upheld by French literary and scholarly writings, and the reports of discoveries by other European navigators, rather than the activities of French explorers.

In March 1772, Breton mariner Louis de Saint Aloüarn became the first French commander to order one of his officers to take possession of the western part of New Holland for France. The voyage across the southern Indian Ocean in the ship *Gros Ventre* was almost forgotten in historical annals until 1998 when French coins and a bottle confirming the act of possession were discovered on Dirk Hartog Island, in Shark Bay, Western Australia. The discovery opened up a new phase of historical investigation on the part of French historians; French descendants of de Saint Aloüarn and other personnel from the *Gros Ventre*; and, further archaeological work by the Western Australian Museum. News spread quickly across the world media, and in Australia a number of authors delayed the imminent publication of their books pending confirmation of the discoveries, wishing to be among the first to share the information in print.

This paper will outline the significance of the *Gros Ventre* voyage and the cultural evidence that now links France and Australia with a shared heritage.

Keywords

France, Australia, 18th century, Brittany, Age of Enlightenment

Introduction

The 18th century was known in Europe as the Age of Enlightenment—*Le Siècle des Lumières*. It was a time of great intellectual activity, especially among French scientists and philosophers (*philosophes*) (Stanbury 2008a). Many of the prominent writers of this period such as Charles de Brosses (1756) and George-Louis Leclerc, Comte de Buffon (1749), speculated on the existence of a *Terra Australis* and the possibility of establishing contact with its inhabitants with a view to trade or even conquest (Dunmore 1997: 36–41). Widespread belief in a vast southern land, often referred to as Gonneville Land—the mysterious continent discovered by Binot Paulmier de Gonneville of Normandy, and annexed for France in 1504 (Dunmore 1965: 4–7; Marchant 1998: 15–19; Sankey 2011; Williams and Frost 1988: 26)—remained prevalent in France and perpetuated French curiosity (Dunmore 1997: 59; Marchant 1998: 19).

Although the Dutch discoveries in the early part of the 17th century did much to dispel the notion that 'New Holland' might be the legendary southern continent, Dutch maps generally showed 'only what had been found, not what lay undiscovered' (Williams and Frost 1988: 19). The uninviting images presented by the Dutch of New Holland, and the absence of any proven discovery of *Terra Australis*, consequently failed to extinguish aspirations that had been created over centuries. Some thought it impossible that the Dutch had not discovered these lands—the *Terres Australes* or *Terres de la Concorde* as they were known in France—and were merely keeping the knowledge secret (Stanbury 2007a: 13–14).

Narratives of the Dutch and of Dampier's voyages in and about the Indian and Pacific Oceans published between 1694 and 1705 led to a revival of interest in *Terra Australis* in the first half of the 18th century resulting in a 'strange mixture of the real and the imagined' on the part of geographers (Dunmore 1965: 16 *ff.*; Williams and Frost 1988: 23). By 1749, when George-Louis Leclerc, Comte de Buffon (1707–1788), one of France's greatest naturalists and a key philosopher of the Enlightenment, published his *Histoire Naturelle* (1749), the mystery of the uncharted southern continent was still unresolved, in spite of all the knowledge that had been acquired through the mathematical sciences and the discoveries of navigators. The discovery of this new world (*Terres Australes*) would undoubtedly be '*un grand objet de curiosité*' (a great object of curiosity), and might be attended with the greatest advantages (Buffon 1749: 212–14).

Shortly after 1750, knowledge made new and very rapid strides, affirming the ascendance of Europe over the rest of the world. Its scientific advance marked the beginning of a new era in the history of oceanic exploration. French maritime interest during the 17th and early 18th centuries had mainly been directed towards establishing strategic bases in North America and the Caribbean (Stanbury 2008b). However, the Seven Years' War, which ended in 1763, brought French colonial development to an end, and saw Great Britain apparently set on world supremacy. French political strategy was thus redirected to occupying unsettled territories at key points on sea routes to counter the British expansion.

During a rare interlude of peace following the war, France and England competed vigorously to organise expeditions to seek new colonial interests and scientific knowledge. Maritime enterprises had previously held little interest for European political powers and were predominantly undertaken by private individuals—ordinary seamen or merchants. King Louis XV (1723–1774), like his successor Louis XVI (1774–1791), was greatly interested in geography and realised that if France was to equal its rival, Great Britain, as a major power the government needed to finance expeditions around the globe. By order of her maritime superiority Great Britain was the first to take action, sending James Cook on his first voyage to the Pacific. However, even after Cook returned from the Pacific in 1771, the mystery of the uncharted region of the southern hemisphere—*Terra Australis* or *Terres Australes*—was still to be solved. Cook had yet to prove that no southern continent existed between New Zealand and Cape Horn (Dunbabin 1921: 152; Stanbury 2007a).

The Kerguélen mission

In 1771 the French Government decided to support an expedition that they hoped would equal Cook's achievements, solve the mystery of the *Terres Australes* and restore its naval prestige. Yves-Josèph de Kerguélen de Trémarec, a 37-year-old ambitious naval officer and well-connected member of the Breton nobility, had finally succeeded in being entrusted with the mission he had always coveted—to explore the ocean to the south of the islands of Saint Paul and Amsterdam (Boulaire 1997; Dunmore 1965; Godard and De Kerros 2002; 2008; Stanbury 2007a; 2008b). As Leslie Marchant states in his book *France Australe* (1998: 49):

> Of all the French explorers who were sent to solve the mystery of the southern Indian Ocean and of the location of *Terra Australis*, Kerguelen Tremarec was given the best opportunity to make a most distinctive contribution and bring honour to France for being the first to make the region known.

Born in 1734, Kerguélen had been fascinated with geography, astronomy, navigation and allied subjects since his youth and both read and spoke Latin (Boulaire 1997: 16 *ff.*). He was amazed by the immense spaces of unknown territory on contemporary maps and the relative lack of knowledge that men had of the world in which they lived. Joining the navy as a student officer (*garde-marine*) at the age of sixteen, he excelled himself in many areas of marine science and naval architecture, and became trusted and highly regarded by his superiors (Boulaire 1997: 20 *ff.*; Dunmore 1965: 203).

On 10 April 1771, Kerguélen received a memorandum, signed at Versaille on 25 March 1771 by King Louis XV and Abbé Terray, Controller General and Minister for the Navy, appointing him as commander of a 'highly secret' mission (*Mémoire du Roi pour servir d'instructions particulières au sieur Kerguélen, Lieutenant de vaisseau, Commandant le vaisseaux le Berrier*, signed at Versailles on 25 Mars 1771, Marine B^4 317–Pièce n^o 63 [copy]; Kerguélen 1782: 4–6; Boulaire 1997: 73–74). No one on board his ship the *Berryer* was to know the true destination—*Terres Australes*. Firstly, he was to see whether the new route from Mauritius to the Coramandel coast proposed by Jacques Raimond Vicomte du Giron Grenier was practical (Marchant 1998: 51, fn.13) and then proceed to '*destinations ultérieures*' (further destinations) (Lettre de M. l'Abbé Terray, Contrôleur Général and Ministre de la Marine, à MM. le Chevalier des Roches and Poivre, Gouverneur and Intendant des Isles de France and de Bourbon, Versaille 25 Mars 1771, in Kerguélen 1782, MAR B/4/117, folios 168 *ff.* [copy]; Boulaire 1997: 74; Godard and De Kerros 2002: 125 *ff.*; 2008: 64–65).

The King's memorandum emphasised that this was one of the most important discoveries still to be made; and, persuaded Kerguélen not to neglect anything that might compromise the success of such a glorious enterprise with the prospect of great advantages. If *Terres Australes* was discovered, Kerguélen was to look for a harbour, establish bonds of trade and friendship with the inhabitants; examine the resources of the country, its culture, produce and advise what commerce could be derived for the French crown (Boulaire 1997: 72; Dunmore 1965: 205; Stanbury 2007a: 16). He was then to sail to New Holland and return to France via South America.

Voyage to the southern Indian Ocean

The expedition sailed from Lorient on 1 May 1771. As second-in-command Kerguélen had selected fellow Breton Louis-François-Marie Aleno de Saint Aloüarn (Godard and De Kerros 2002, 2008), one of several chosen officers who were known to Kerguélen, with whom he had grown up in Brittany, and sailed with on previous voyages. At the Île de France (Mauritius) Kerguélen exchanged the 900-ton *Berryer* for two smaller vessels—the 24-gun flute *Fortune* with a crew of 200 and the 16-gun storeship (*gabare*) *Gros Ventre* with a crew of 120, commanded by Louis de Saint Aloüarn.

Figure 1. The French 'Coin Site' overlooking Turtle Bay where the *Gros Ventre* anchored, with Cape Inscription in the background (Myra Stanbury, Western Australian Museum, 1998).

By early December 1771, Kerguélen had completed his first mission and the vessels returned to Port Louis, Mauritius, where the ships were re-provisioned and prepared for a rapid departure: the fair summer sailing weather was advancing and while completing the survey to the north, a rival private French expedition under the equally ambitious Marc Marion Joseph Dufresne had already sailed south from Mauritius on 18 October 1771 in search of *Terres Australes* (or Gonneville Land) and forestall the official expedition (Marchant 1984: 4). (Dufresne just missed discovering Kerguelen Island on 1 February 1772, twelve days before Kerguélen discovered it: see Marchant 1984: 5.)

On 16 January 1772 the *Fortune* and *Gros Ventre* headed due south from Mauritius. In the bitter cold southern Indian Ocean, on 13 February, they were the first Frenchmen to discover what Cook later named Kerguelen Island. While Kerguélen took the *Fortune* offshore and tacked back and forth in the rolling seas, Saint Aloüarn was despatched to explore the bays on the south-west coast. The plan was to survey the coast and take soundings in a bay which had been seen and which promised shelter from weather coming from the north and the west. To assist with this task Kerguélen launched a long boat under the command of Ensign Rosily to sound ahead of the *Gros Ventre*. Led by Charles Marc du Boiguéhenneuc, crew managed to get to shore and claim the desolate, inhospitable land by the placement of bottles, raising a white ensign and firing a volley of shots (Du Boisguehenneuc 1772: 6; Godard and de Kerros 2002: 125 *ff*., 2008: 79 *ff*.; Marchant 1998: 54; Stanbury 1999a, 2007: 16–19). This achieved, the *Gros Ventre* set a difficult westward course in order to rendezvous with Kerguélen but was unable to locate the *Fortune* in the thick fog. Little did they know that Kerguélen, fearing for the safety of the *Fortune*, had headed back to Mauritius, and thence to France, to advise the King that he had found a part of the *Terres Australes,* most advantageously situated for the French islands (Boulaire 1997: 86). But, the only new land Kerguélen had discovered was icy, inhospitable and offered no colonial benefit at all.

Louis de Saint Aloüarn's voyage to New Holland

Adhering to his instructions, and having searched in vain for the *Fortune*, Saint Aloüarn cleared land and sailed eastwards for New Holland in the mid and high 40 degrees south latitudes (below the old Dutch Brouwer route) searching for evidence of *Terra Australis.* They experienced a bad passage, marked by extremely cold, wild weather and towering swells. Arriving off Flinders Bay, south of Cape Leeuwin, on 17 March 1772, poor weather prevented a landing, although Rosily was able to make an accurate survey of the bay (Marchant 1998: 58–62). Desperately in need of fresh water and edible food, Saint Aloüarn decided to sail north for Shark Bay, where his charts (prepared by the French hydrographer D'Après de Manevillette) indicated known anchorages.

On the evening of 29 March 1772 the *Gros Ventre* rounded Cape Inscription at the north-west point of Dirk Hartog Island and anchored in Turtle Bay—*La Baie des Tortues* (Godard and De Kerros 2002: 251). This was the first French expedition to reach the western coast of Australia—only two years after Captain James Cook had discovered and claimed the eastern part of Australia for the British (Figure 1).

The following morning, 30 March 1772, Louis de Saint Aloüarn despatched a shore party led by Mengaud de la Hage (Mr de Mings) to explore Dirk Hartog Island and claim possession in the name of King Louis XV of France (Champvallon 1772: 38–39). The '*Prise de Possession*' (annexation), took place on the northern cliff of the island: the French flag was raised, a prepared document read aloud, followed by cries of '*Vive le Roi*—Long live the King' and a volley of rifle shots. The annexation document, written in '*les formes usitées dans pareil cas*' (the usual forms in such cases) was put into a bottle and buried at the foot of a small shrub (or tree), near which they placed '*deux écus de six francs*' (two écus of six francs). The ship's log refers to Turtle Bay as the '*Baie de Prise de Possession*' (Champvallon 1772: 41; Stanbury 1998) (Figure 2).

Although Louis de Saint Aloüarn had given Mengaud de la Hage the privilege of executing the annexation ceremony on Dirk Hartog Island, as he had bestowed on Charles Marc du Boisguéhenneuc at Kerguelen Island, as commander of the *Gros Ventre* and, thus, representative of the French Government, the accolade of being the first Frenchman to have claimed part of western Australia for France has been recognised as his achievement.

A survey of Shark Bay resulted in Rosily producing a chart of the bay which indicated more accurately than before the northern part of the bay, the outlying islands, the entrance to the bay, safe anchorages, and the dangerous currents which sweep behind Dorre and Bernier islands (Godard and De Kerros 2002: 250; 2008: pl. 41). In the shoal waters towards Carnarvon Saint Aloüarn lost two anchors, which if located will remain memorials to his visit (Stanbury 2007a: 21–22).

Leaving Shark Bay by the Naturaliste Channel, the *Gros Ventre* then made its way back to Île de France (Mauritius), following the west and north coast of western Australia, across to Timor and then Batavia (Jakarta) to obtain refreshments. It was this latter voyage that raised the interest of later French scientific explorers, such as Nicolas Baudin and Louis de Freycinet. Three weeks after arriving at Port Louis, on 27 October 1772, Louis de Saint Aloüarn died. He had celebrated his 34th birthday as he sailed through the Sunda Strait (Godard and De Kerros 2008: 200; Stanbury 2007a: 22).

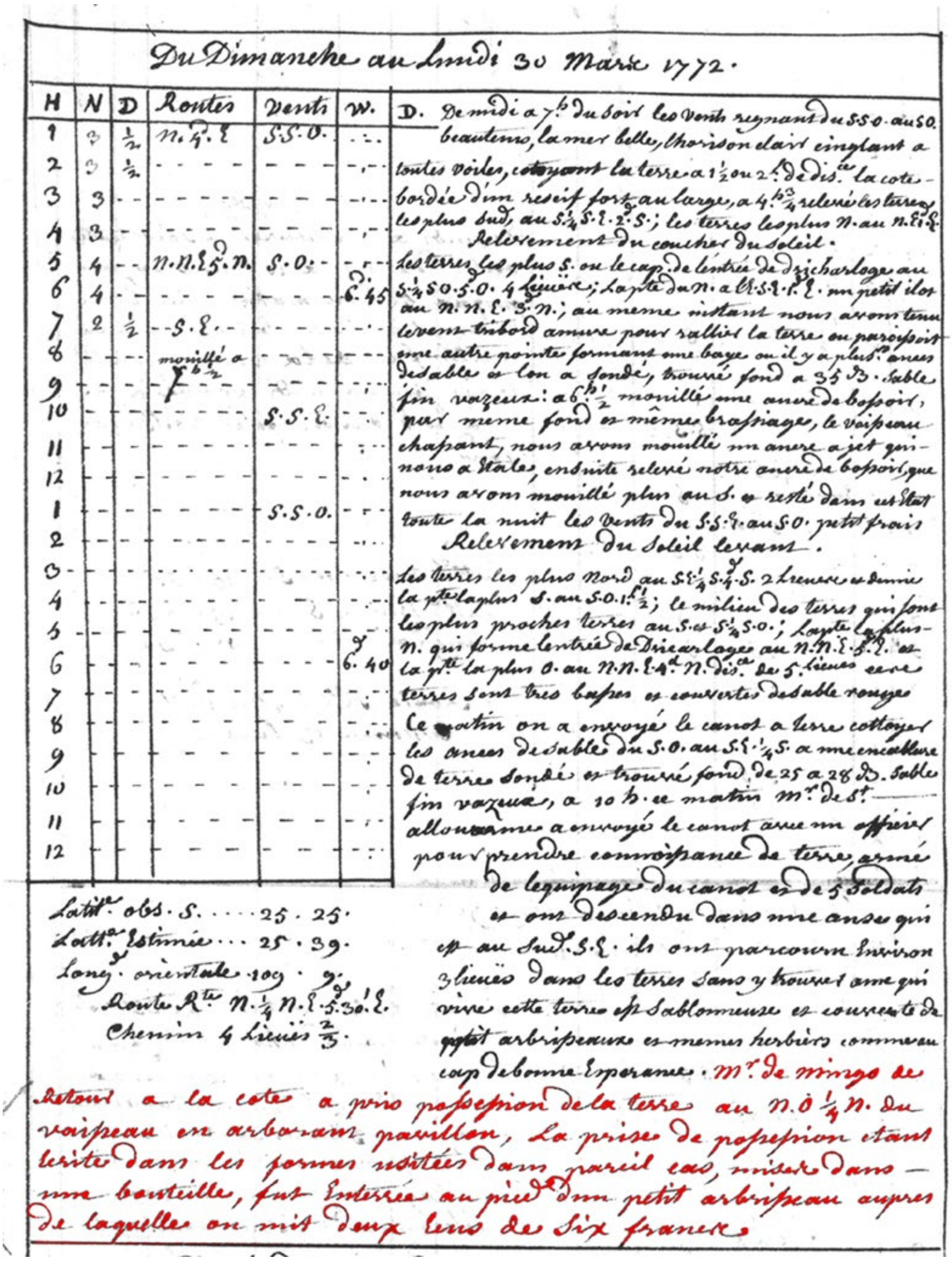
Discovery of the annexation evidence

In January 1998, Frenchman Philippe Godard, leading a team of keen amateurs from Geraldton, discovered a French écu dated 1766 encased in a lead capsule at the north end of Dirk Hartog Island (Godard and De Kerros 2002: 331–333; 2008: 214–231; McCarthy 1998a; 1998b) (Figure 3). The discovery marked many years of speculation and failed searches on behalf of many groups of Australian and French amateur and professional historians, all of whom had availed themselves of copies of original documents and charts held in the French archives (Bibliothèque Nationale de Paris); and, transcripts prepared in 1908 by Madame Robert Hélouis (housed in the National Library, Canberra and the Mitchell Library, Sydney).

Given that previous researchers had used the same documentary information, some doubts were initially raised as to the authenticity of the find. How did the Godard group succeed where others had failed? What physical evidence was there at the discovery site to associate the finds with the 1772 annexation? Were the coin and lead capsule genuine and compatible with the period in question?

In view of the fact that the discoverers had not included an historical archaeologist in their exploratory team to record cultural and physical details of the site; and, that once the location of the site became publically known, it would become potentially vulnerable to disturbance, the Western Australian Museum felt that it was imperative that the site be inspected at the earliest opportunity. Although there was some uncertainty at the time of discovery as to the legal status of the site and the recovered relics, the main concern was to accurately identify the location of the site and carry out an interim archaeological assessment on which to formulate future actions.

Based on the site inspection report and the recommendations contained therein (McCarthy 1998ab), an archaeological team from the Western Australian Museum (author participation), University of Western Australia and private consultants was dispatched in March 1998. Coincidentally, the expedition was able to take place at the same time of the year as Saint Aloüarn's visit 226 years previously. Indeed, the duration of the expedition from 25 March to 4 April 1998 included the anniversary of the French annexation ceremony. After a detailed survey of what became referred to as the French 'Coin Site', an intact glass bottle, complete with a similar lead closure containing a second écu dated 1767, was discovered on 1 April 1998 (Godard and De Kerros 2002: 335–337; 2008: plates 51–61; Harrison 1998; Souter 2000) (Figure 4). But alas, no document survived within the bottle. In


Du Dimanche au Lundi 30 Mars 1772.

Latit. obs. S. . . . . 25 . 25 .
Latt. Estimée . . . 25 . 39 .
Long. orientale 109 . 9 .
Route Rte N. ¼ N.E. 5.30. E.
Chemin 4 Lieues ⅔ .

Retour a la cote a pris possession de la terre au N.O ¼ N. du vaisseau en arborant pavillon, La prise de possession etant ecrite dans les formes usitées dans pareil cas, mise dans une bouteille, fut Enterrée au pied d'un petit arbrisseau aupres de laquelle on mit deux Ecus de Six francs

Figure 2. Page from Saint-Aloüarn's Journal dated 30 March 1772 recording the '*Prise de Possession*' by Mengaud de la Hage.

October 2006, the Western Australian Museum returned to Dirk Hartog Island and undertook a more extensive excavation of the annexation site in the hope of finding additional evidence (Ford 2007). However, no artefacts were located.

From the time of Dirk Hartog's initial landing on Dirk Hartog Island, in 1616, there is historical evidence for human visitation and activity in the region of Turtle Bay that may have disturbed the annexation site, and provided opportunities for the recovery of portable historic curios (McCarthy 2006; 2007). From the mid 1860s, a permanent human presence commenced when F.L. Von Bibra established Dirk Hartog Island Station with anecdotal evidence suggesting that at some time in the 20th century a station hand discovered a bottle containing a 'parchment' (McCarthy 2007: 28). Supposedly, this was lodged in the homestead library,

Figure 3. The first coin found was positively identified as a French écu of 1766 minted in Bayonne. The obverse legend reads: LUD.XV D.G.FR.ET NAV.REX, which translates as: Louis XV By the grace of God, King of France and Navarre. The obverse shows the bust of Louis XV facing left (Louis XV reigned from 1715 to 1774). The reverse legend reads: SIT NOMEN DOMINI BENEDICTUS 1766, which translates as: The name of the Lord be praised. The letter 'L' between DOMINI and BENEDICTUS is the mintmark for the Bayonne mint (Patrick Baker, Western Australian Museum).

Figure 4. The excavated bottle complete with lead capsule containing a second écu dated 1767 located by expedition members Bob Sheppard, Bob Creasy and Dr Michael McCarthy.
(Rodney Harrison, Western Australian Museum collection).

but later lost when fire destroyed the property soon after Sir Thomas Wardle took possession (L. Moss, 1998, pers. comm., 18 January, in McCarthy 2007: 28–29).

The only evidence for what may have been written on the parchment is from the French document enclosed in a bottle found by one of Cook's sailors during their soujourn at Christmas Harbour, Kerguelen Island, in 1776 (Cook 1776; Cook *et al.*, 1784: 32–33; Hough 1995: 353; Stanbury 1999a, 2007: 23–24; Zimmerman 1988: 42–43). Left by Lieutenant Rochegude of the ship *L'Oiseau* on the north end of Kerguelen Island during Kerguélen's return voyage in 1773, the annexation inscription read:

- *Ludovico XV Galliarum*
- *rege, et d* de Boynes*
- *regi a Secretis ad res*
- *maritimas annis 1772 et 1773.*

[During the reign of Louis XV and while d* de Boynes was Secretary for maritime affairs for the king in the years 1772 and 1773]

Cook noted that:

- From this inscription it is clear we were not the first Europeans that had been in this Harbour [Christmas Harbour], I supposed it to have been left by the ship which accompanied M. de Kerguelen when he discovered this land. After writting [*sic*] the following inscription on the back of it, I put it again into the bottle together with a silver two penny piece of 1772 [Maundy money: see Beaglehole 1967: 32 fn. 1; Stanbury 1999a] covered the mouth of the bottle with a lead cup and placed it in a pile of stones on a little eminence on the North side of the harbour and near to the place where the bottle was found.
- *Naves Resolution*
- *et Discovery*
- *de Rege Magnae Brittanniae*
- *Decembris 1776.*

[The ships *Resolution* and *Discovery* of the king of Great Britain December 1776]

- (Cook, J., Journal, 28 Dec. 1776, ADM 55/111 folio 38. The National Archives, Kew, UK).

In November 1792, the same bottle with Kerguélen's and Cook's messages was rediscovered by men from the American brig *Ino*, Captain Simon Metcalf. A third message had now been added—a letter from Captain Durgin of the brig *Phoenix* from Macau. Unfortunately bad weather prevented the sailors from the *Ino* returning the bottle to the rock where it had been found. John Bartlett, mate on the *Ino* wrote in his journal:

- Hove to off Christmas Harbour to send on shore the bottle with Captain Cook's letter, but the wind blew so fresh that it was impossible for a boat to land and we proceeded on our course [to St Paul and Amsterdam islands] (Bartlett 1925: 330).

No evidence of the bottle or document has come to light.

Significance of the cultural evidence

New avenues of historical investigation and research

The French annexation depositions associated with Louis de Saint Aloüarn discovered at Dirk Hartog Island in 1998 are deemed equally as significant as the commemorative plates left by earlier Dutch navigators—Hartog and de Vlamingh—and later French and British explorers (Bloom 1998, 2000; Godard and De Kerros 2002: 311 *ff.*, 2008: 141 *ff.*, plates 51–61; Harrison 1998; McCarthy 2007; Stanbury 1998, 1999b, 2012; Stanbury and Bloom 1998). They are tangible proof of early French interest in the vast Australian continent.

Following the press release of the discovery news spread across the world: Australian and overseas newspapers, television and radio stations carried the story; and, the French newspaper for young children *Mon Quotidien* was the first to point out that Australia could have been French! Though, they carefully added that the Aborigines were the first to people the land—'*Les Français n'ont rien découvert, on était là auvant*'—The French have not discovered anything, people were there before (Gasselin 1998).

The archaeological discoveries opened up a new phase of historical investigation on the part of French and Australian historians, several authors delaying the imminent publication of their books pending confirmation of the discoveries, wishing to be among the first to share the information in print (Bloemfield 2012; Estensen 1998; Guillou 2004; Lhuedé 2007). The news was also sufficient to encourage living descendants of Louis de Saint Aloüarn, Charles Marc du Boisguéhenneuc and Pierre de Sercy (a 16-year-old seaman who accompanied Mengaud de la Hage ashore on Dirk Hartog Island to take possession) to reconstruct the life histories of their ancestors (see Godard and De Kerros 2002; 2008: 29 *ff.*), contributing not only to Australian history but also to those episodes of French history that, in the past, have received little acknowledgement.

Many of the well-known 18th-century French navigators came from ancient noble families of Brittany (i.e. tracing their ancestry back to pre-1500). Louis de Saint Aloüarn, his commander Yves-Josèph de Kerguélen, second in command, Charles-Marc du Boisguéhenneuc and Rosily de Mesros were all cousins of the same generation, living in the same vicinity along with friends Maingaud de la Hage, Launay and others who were part of Kerguélen's choice of officers. The history of the various families, therefore, is significant in that it represents a profile of a particular class or 'estate of people in France's 'multilayered society' during the Age of Enlightenment and the years leading to the Revolution of 1789.

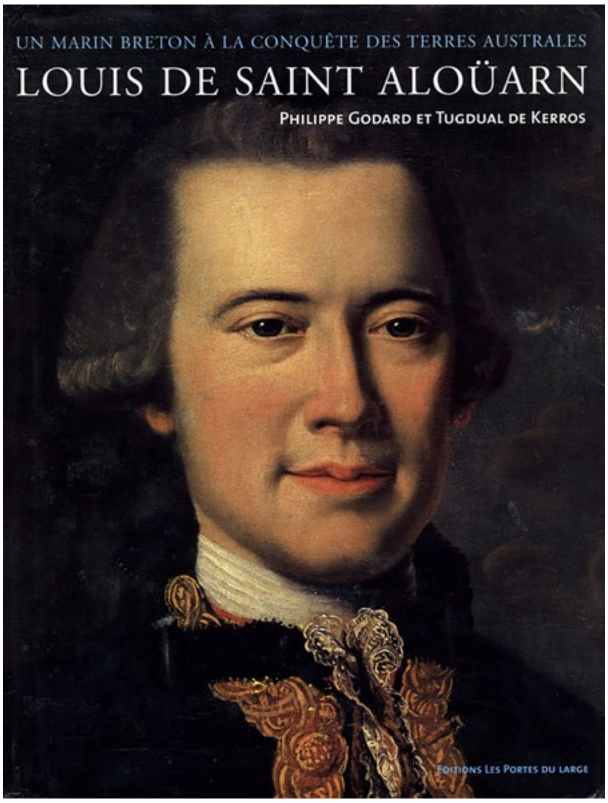


Figure 5. The first comprehensive book about Louis de Saint Aloüarn—his background and voyage to New Holland in 1772 (Authors: Philippe Godard and Tugdual de Kerros).

Piecing the story together

A keen historian and writer, Philippe Godard immediately set about drawing together anything and everything he could that related to the Kerguélen/de Saint Aloüarn voyage. His contact with Mr Tugdual de Kerros, a direct descendant of Louis de Saint Aloüarn's granddaughter, Maria Sylvie Aleno de Saint Aloüarn (1804–1873) (De Kerros 2000: 9), living at Sainte Marine, near Quimper in Brittany, was a bonus. An ardent historian of Breton history, Mr de Kerros was quick to realise the importance of the discovery for his own family history, and collaborated with Philippe Godard in the research, and the ultimate publication of the book *Louis de Saint Aloüarn: Un marin Breton à la conquête des Terres Australes* (Godard and De Kerros 2002) (Figure 5) and a subsequent English translation (Godard and De Kerros 2008).

For these two Frenchmen, access to documents in the French national and naval archives, while not without its problems, was far easier than for foreigners! Much of the language is in archaic French, the words, spellings and writing not always clearly legible or accurate. Several manuscript documents in the French national archives provided valuable information about the voyage, each in its own style. However, the identity of the writer is not always certain. In addition, several documents relating specifically to the family history of Louis de Saint Aloüarn have come to light. Most important is a moving letter that Saint Aloüarn dictated from his hospital bed in Port Louis, Île de France, to his mentor and betrayer, Kerguélen (Godard and De Kerros 2002: 347–352; 2008: 201–2013).

A particularly interesting and rare journal kept by Sergeant Lafortune who commanded the detachment from the Royal Comtois Regiment and who, in this capacity, had duties in the solemn ceremonies of taking possession of new lands was made available to Philippe Godard from a private collection (Lafortune 1772). Lafortune's spelling is totally erratic but the journal is full of interesting anecdotes from the perspective of a 'landlubber'. It was handed to the Princess de Croüy in her Castle at L'Hermitage on 25 September 1772 with the request to kindly hand it to her father, the Duc de Croüy, who had wished to have it. The Duc de Croüy was influential in the French court and had supported Kerguélen in his request to undertake the voyage.

Shared heritage—Quimper: 'City of Navigators and Explorers'

In 1989, Breton historian, Serge Duigou, wrote a booklet entitled *L'Australie oubliée de Saint-Allouarn* in which he points out that the achievement of Louis de Saint Aloüarn and his brave companions had lain forgotten both in France and Australia for more than two centuries (Duigou 1989: 32). He attributes their '*mise en lumière'* (release from oblivion), and that of other French explorers to Australia, to the work of Leslie Marchant and the publication of *France Australe* in 1982 (Marchant 1982). Duigou saw this work as a means of ending two centuries of '*profond purgatoire*' (profound purgatory). He felt that in both the antipodes and France, the time of rehabilitation had come for Louis Aleno de Saint Aloüarn and his companions. Undoubtedly, the Australian Bicentennial Celebrations of 1988, the French translation of *France Australe* and Marchant's 1998 English edition did much to draw the attention of the Australian public to the French explorations of the 18th and 19th century and share this common heritage (Marchant 1998).

Following the discovery of the annexation depositions at Shark Bay, Mr Tugdual de Kerros worked closely with the local community in Quimper to share the history of the Aleno de Saint Aloüarn family with a wider audience. Given its long maritime history, Quimper has described itself as the 'City of Navigators and Explorers'—both ancient and modern. Various properties in Geungat (9 km from Quimper) were formerly owned by the Aleno de Saint Aloüarn family and are still standing though privately owned. Two buildings, however, are now documented as part of the French community heritage programme (Patrimoine des communes) with details available on the mobile application 'Topic Topos' (www.fr.topic-topos.com). Two significant heritage sites are the following:

1. The church of Saint-Fiacre at Geungat

The resting place of Louis de Saint Aloüarn's ancestors, and several of his immediate family members. The tomb of Hervé de Saint Aloüarn and his wife Marie de Trégain dates to the 15th century, when the Aleno de Saint Aloüarn family were one of the oldest noble families of Geungat. Before the Revolution, all noble persons were entitled to be buried in a sarcophagus (*enfeu*) in the church. The frieze on either side of the chancel depicts animals that are symbols of the Aleno de Saint Aloüarn family and the region in which they resided (Figure 6).

2. Saint Aloüarn Manor, Geungat

The manor where Louis de Saint Aloüarn was born in 1738. The 16th-century tower still stands but the building is very dilapidated (Figure 7).

Shared experiences—the annexation artefacts and model of the *Gros Ventre*

The French bottle, lead capsules and silver coins are permanently displayed at the Western Australian Shipwrecks Museum, Fremantle. They were also included in two special exhibitions at the Western Australian Maritime Museum—*Voyages of Grand Discovery* in 2007 (McCarthy and Northey 2007; Stanbury 2007b: 18–19) and *Journeys of Enlightenment: French Exploration of Terres Australes* in 2008–9 (Stanbury and Northey 2008; Stanbury 2008b: 6–9). Both exhibitions were well attended by the local French community. The latter, especially, was honoured by the presence of Henry de Freycinet, a descendant of Louis de Freycinet who mapped much of the Western Australian coastline in the early 19th century.

Featuring in the *Journeys* exhibition was a beautiful model of Louis de Saint Aloüarn's gabare *Gros Ventre*, made by local model maker Dinny Cole according to the reconstructed drawings researched and produced by Gérard Delacroix (2003). A certified copy of the original construction plan of the *Gros Ventre* showed the ship to have been built in Bayonne in 1766 by Léon Michel Guignace to the design of the naval architect Jean-Joseph Ginoux (Delacroix 2003: 14–15; Godard

Figure 6. The church chancel at Geungat has a frieze where the following appear from left to right: a boar (Aléno) which is present on the Aleno shield; a fox which alludes to the surname Aloüarn (‘*louarn*’ in Breton means ‘fox’); and white hare, symbolising Geungat, *Gwenn gad* (in the Breton language *gwenn* means white and *gad* means hare. Geungat is the Parish where the Manor of Saint Aloüarn stands (Myra Stanbury).

and De Kerros 2008: 121). Persons purchasing the plans were invited to participate in ‘*Le Gros Ventre Project*’, an initiative of Gilles Korent and Gérard Delacroix (2004). Participants were able to follow the project through a periodical newsletter *The Slipway News* and communicate online with a support team and other members of the project throughout the world. The project was a valuable, shared experience that contributed to the knowledge of 18th-century ships of exploration and their construction (Figure 8).

Conclusion

The discovery of artefacts on Dirk Hartog Island, Shark Bay, Western Australia, in 1998, shown to be associated with the annexation of the western part of New Holland for France by Louis de Saint Aloüarn in 1772 led to a resurgence of interest on the part of Australian and French historians into this little known part of history. Although transcripts of some of the manuscript documents held in the French National Archives had been lodged in the National Library (Canberra) and the Mitchell Library (Sydney) as early as 1908, researchers did not appear to make use of them for almost two to three decades later. Even so, early attempts to identify the site of the annexation, or to recover associated relics were unsuccessful.

The international response to news of the discovery was quite overwhelming, so too the requests from Australian authors with publications in progress for images and information to include in their works. For the French community in Western Australia it was an exciting discovery, something they could identify with more easily than the longtime focus on the Dutch voyages of the 17th and 18th centuries. Whether Australia could almost have been French became an interesting topic of conversation, and collectors of rare French books, charts and artworks were keen to loan them for museum exhibitions. Foundations were set up by private individuals to enable collections of historic French documents, charts, maps and other items to be purchased for the benefit of the community both for research and exhibition purposes.

The Department of Maritime Archaeology of the Western Australian Museum determined to place greater emphasis on maritime projects that either directly or indirectly had French associations. These were formulated into a ‘French Connection’ Program, under the aegis of Michael McCarthy, which now covers a wide range of historical and archaeological research involving Australian and French participants, public and community programmes (see Bigourdan 2015).

Figure 7. The Manoir de Saint-Aloüarn at Geungat, Brittany, as detailed by the mobile application 'TOPIC-TOPOS', featuring the community heritage of France (fr.topic-topos.com).

Figure 8. Launch of *The Slipway News Gros Ventre* Model Project by Gerard Delacroix.

Although Louis de Saint Aloüarn's claim to the western part of Australia was not upheld by subsequent French settlement, the cultural material confirming the '*Prise de Possession*' now serves as a common link between France and Australia—from the French families who trace their ancestry to these early seafarers and their local communities, to a far wider audience.

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Sailors, Savants, Naming: France and the Knowing of Oceania, 1756–1840

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Abstract

This paper addresses the tangled interplay of mariners' experiences and prevailing theory in the French mapping, naming and classification of places and people in what is usually called Oceania (here, spanning the south Pacific Islands, Australia, New Guinea and New Zealand). Europeans have known of this this vast, mainly maritime zone, from the early 16th century as the 'fifth part of the world'. Over the next four centuries, it was mostly called the South Sea/Pacific Ocean or *Terra Australis/Océanie*. My main chronological focus is the classic era of French scientific voyaging under sail after 1750, bookended by the expeditions of Louis-Antoine de Bougainville and Jules Dumont d'Urville. I consider the creation, mutual appropriation and cross-fertilization of practical and abstract knowledges, their differential inscription in cartographic and written texts, and their uneven synthesis in 19th-century geographic and anthropological (or raciological) nomenclatures and classifications in France.

Keywords

Oceania, France, geography, anthropology, cartography, race

This paper is a history of the shifting entanglement of praxis and theory in the French mapping, naming and classification of places and people in what is usually called Oceania. It addresses varied ways in which the results of mariners' practical experience during the classic era of scientific voyaging between 1766 and 1840 were synthesized with prevailing geographic and anthropological theory and expressed differentially in French graphic and written materials. 'Oceania' here denotes the vast, mainly maritime zone encompassing the Pacific Islands, Australia, New Guinea and Aotearoa-New Zealand. From the mid-16th century, following the first Spanish trans-Pacific voyages in the 1520s, European cosmographers, geographers and cartographers imagined this space, still largely unknown to them, as the 'fifth part of the world' (e.g. Domeny de Rienzi 1836–1838; Gerritsz 1612; Mercator 1541; Plant 1793). They devised a range of oceanic, continental and insular toponyms to label it, eventually condensed as South Sea/Pacific Ocean or *Terra Australis/Océanie*.

The interplay of these practical and abstract knowledges occurred within the broad intellectual context of the late 18th-century science of man. Hardening belief in essential racial inequality challenged the ethnocentric dogma of essential human similitude that had long qualified distaste for perceived differences in religion, bodily appearance or lifestyle. In France from about 1800, the emergent discipline of anthropology, in collaboration with the spatial science of geography, was explicitly a science of race or raciology (Blanckaert 2003, 2004; Douglas 2008). This paradigmatic disciplinary movement entailed a parallel conceptual and linguistic shift whereby nominalist terminology or strategies were subsumed by categorical (Douglas 2014: 10–16). In nominalist usage, travellers attached names—local ones if known—to places and people encountered. Cartographers reinscribed such place names in their maps while natural historians such as Buffon (1749) assembled names gleaned from travel literature into fuzzy catalogues of myriad 'varieties', 'nations', or 'races' of people. In contrast, categorical terminology in anthropology encompassed actual named human groupings within rigid, a priori hierarchies of essentialised, physically-determined 'races', 'types' or 'species'. Geographically, categorical strategies imposed a regional toponymy on an entire segment of the globe. The uneven emergence of categorical thinking in the French geography, anthropology and cartography of Oceania is an integrating theme of this paper.

Before 1756: Imagined geographies

Renaissance cartographers were committed to precise representation of places and their relationships, particularly in navigational charts, but absent or limited information licensed fancy, conjecture and abstraction. From the 1520s to the mid-18th century, classical cosmographic theory about the southern Antipodes, or Antichthon, was sporadically qualified by navigators' empirical testimony (Douglas 2010: 181–196; Wroth 1944). A late 17th-century map of 'La Mer du Sud dite autrement Mer Pacifique' (The South Sea otherwise known as Pacific Sea) by the royal geographer Pierre Duval (Figure 1) provides an early instance of the

Figure 1. P. Duval, *La Mer du Sud dite autrement Mer Pacifique* (Paris: l'Auteur, 1679), National Library of Australia, Map Rm 2919, http://nla.gov.au/nla.obj-232137613.

cartographic interplay of praxis and theory in France. This map blends a multilayered record of the practical products of more than 150 years of Spanish and Dutch Pacific voyaging with coastal outlines of a vast imagined southern continent. These long hypothesised *Terres Ant-Arctiques* or *Australes* (Antarctic or Southern Lands) were allegedly discovered in 1606 by the Spaniard Pedro Fernández de Quirós (1973), who fervently endorsed their reality.

1756–1804: Classifying regions

The fifth part of the world was spatially undifferentiated in European maps and nomenclatures before 1756. Its subsequent subdivision and naming were largely French initiatives. The Burgundian littérateur Charles de Brosses (1756) proposed the first regional classification in that year, building a grand conceptual edifice on a sketchy empirical foundation drawn from the accounts of earlier voyagers. Like most French and British savants before the return of James Cook's second, myth-busting voyage in 1775, Brosses accepted the veracity of Quirós's account and its implied realisation of the ancient phantasm of *Terra Australis*—an 'immense continent of solid land south of Asia'. He did so in the face of practical demonstrations by the 16th-century Dutch navigators Willem Corneliszoon Schouten, Jacob Le Maire and Abel Janszoon Tasman of the shrinking space available to accommodate *Terra Australis* and the growing scepticism thereby fuelled in many cartographers (e.g., Goos 1668: [7], plate 1). Geographical theory and voyagers' praxis are at odds

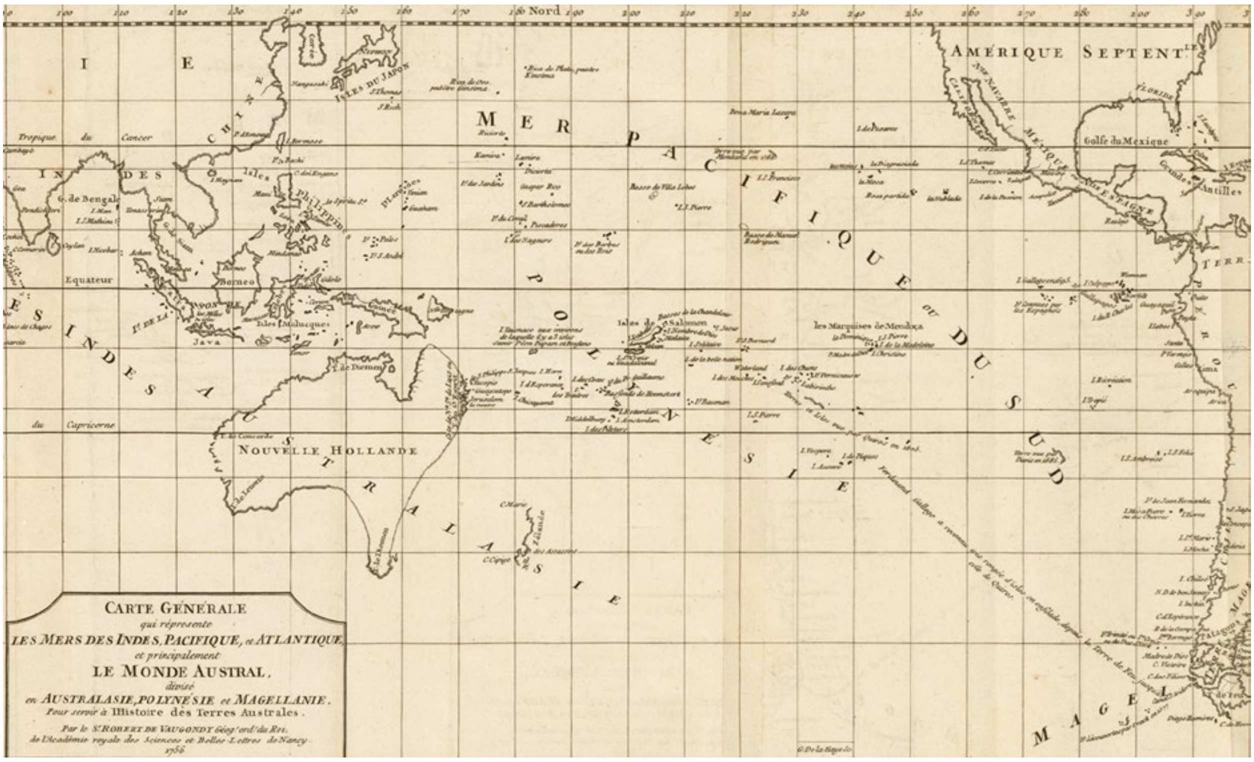

Figure 2. G. Robert de Vaugondy, Carte générale qui répresente les mers des Indes, Pacifique, et Atlantique, et principalement le monde australe, divisé en Australasie, Polynésie et Magellanie, pour servir à *l'Histoire des terres australes*, in [C. de Brosses], *Histoire des navigations aux terres australes ...*: vol. 2, plate 1 (Paris: Durand, 1756), detail, National Library of Australia, NK 6956 Map plate 1 (v. 2), http://nla.gov.au/nla.obj-601843057.

in Brosses' work since it also includes lengthy synopses of those same Dutch narratives (1756, I: 13–16, 349–420, 456–63).

Brosses (1756, I: 76–80) partitioned the 'unknown austral world' into three geographical regions and invented the enduring neologisms *Australasie* (Australasia) and *Polynésie* (Polynesia) to name two of them. However, with human taxonomy still suspect in the mid-18th century, he made no attempt to classify their 'many different peoples' and there is no racial element in his topographical terminology. Brosses' Australasia—from Latin *australis* (southern)—is a mostly conjectural land mass 'south of Asia', purportedly substantiated in scattered sightings of actual places in New Holland (Australia), New Guinea and New Britain, as well as New Zealand which was much later rezoned to Polynesia on racial grounds. Similarly, Polynesia, meaning 'multiplicity of islands'—from Greek *poly-* (many) and *nēsos* (island)—clearly differentiates space rather than people since it encompasses 'everything contained in the vast Pacific Ocean', a zone Brosses knew was 'populated by inhabitants of different colours'. A supporting map drawn by the royal geographer Gilles Robert de Vaugondy (Figure 2) is geographically more empirical and generally less fanciful than the treatise it illustrates. He barely hinted at the possibility of a southern continent and named Brosses' regions without delimiting them.

A half century later, successive scientific voyages—inaugurated by those of Louis-Antoine de Bougainville in 1766–1769 and Cook in 1768–1771—had generated profuse empirical information about the fifth part of the world, enabling the Scottish littérateur John Pinkerton (1802, II: 432–436, 464–467) to propose exact demarcations for Brosses' regions. In several English editions and a French translation (1804) of his *Modern Geography*, he computed Australasia's boundaries to incorporate the islands 'circumjacent' to New Holland, as far east as the New Hebrides and New Zealand, but assigned Fiji to Polynesia. He formalised physical criteria implicit in Brosses' nomenclature by invoking a 'characteristic feature' in each case: island 'size' in Australasia and 'innumerable small islands' in Polynesia. However, Pinkerton's written precision is not matched in Aaron Arrowsmith's (1802; 1804) illustrative maps of 'Pacific Islands' and 'Grand Océan' in which, again, the regions are named but not defined.

1804–1815: Classifying races

A stark disjunction between overly theorised writings and austerely pragmatic maps characterises the literature on Oceania produced by savants in France between 1804 and 1815. Specifically, written texts on Oceanic geography and anthropology are increasingly categorical and racialised whereas maps do not mark regional divisions and lack racial inflection (Douglas 2011: 2–10).

The disconnect between written and visual is patent in the highly influential publications of the Danish-French savant Conrad Malte-Brun, principal author of a sixteen-volume world geography purportedly grounded empirically in the 'exact and novel' information published by 'geographers, naturalists, voyagers and statisticians of the most enlightened nations' (Mentelle and Malte-Brun 1803–1805). However, Pinkerton's French publisher Jean-Gabriel Dentu (1811) accused Malte-Brun of significant plagiarism from the works of other geographers, including Pinkerton. At the end of the first volume, Malte-Brun (1803: 541–552) sketched one of the earliest global racial classifications, which he expanded in detail in subsequent volumes. His taxonomy makes skin colour, hair and bodily structure the key racial differentiae and is littered with invidious discriminations. Predictably, he located 'the most beautiful shapes and the finest blood ... of all human races' in certain European races. Within the *Grand-Océan* (Great-Ocean), he sharply distinguished the *Race Noire* (black race) from the *race basanée* (tanned race), in space as well as physically and morally. He peopled New Guinea, New Holland and the Solomon Islands with 'men as black as the negroes of Africa', negatively stereotyped with 'thick' lips, 'flat' nose and 'wool instead of hair'. In contrast, a 'very fine race of men', 'often whiter than the Spaniards', with an 'attractive face' and a 'tall, robust build', inhabited the 'most eastern part' of the Pacific Ocean, stretching from the Sandwich Islands (Hawai'i) to New Zealand.

A significant section of volume 12 of this work spans 'the fifth part of the world' (Malte-Brun 1804). Avowedly encouraged by contemporary scholarly 'interest', Malte-Brun proposed a novel 'geographical organization' based, he claimed, on his reading of nearly 80 voyage narratives. The 'ancient name *Terres-Australes*' is jettisoned in favour of the significant innovation *Océanique* (Oceanica). Brosses's dual regional geography is replaced by a nominalist table of 16 sub-groups, either archipelagos or larger lands with contiguous islands. The cardinal toponym Australasia is abandoned while the topographic toponym Polynesia is limited to the 'small islands of the South Sea', divided at the equator into 'north' and 'south' sectors 'inhabited by the same race' (Malte-Brun 1804: vii–viii, 361–3, 463, 473).

In contrast to this relatively nominalist geography, Malte-Brun's umbrella toponym Oceanica is categorically racialised from the outset. His earlier descriptors 'black race' and 'tanned race' are supplanted by the taxons *Nègres océaniques* (Oceanic Negroes) and *race polynésienne* (Polynesian race). As occupants of the Sandwich Islands and New Zealand, Malte-Brun's racial Polynesians extend far beyond his geographical north and south Polynesias (Malte-Brun 1804: 473–4). A decade later, in a 200-page section devoted to Oceanica in his magnum opus on 'universal geography', Malte-Brun (1813: 225–422) further developed his racial opposition of 'the Polynesians' and 'the Oceanic Negroes' by tracing it to two ancestral 'stocks', 'very distinct, as much by their physiognomy as by their language'. He positioned the Oceanic Negroes at 'the last degree of the savage state' and thought they might 'originate in this part of the world' (Malte-Brun 1813: 229, 244–5, 247, 253). This insinuation of autochthony gave credence to the once heterodox but now increasingly plausible idea that human diversity was primordial and organic—the racial doctrine later labelled polygenism (Douglas 2008: 47–53).

However, the maps in the atlases illustrating Malte-Brun's geographies of Oceanica are at odds with both his toponymic schema and his racial hierarchy. Neither Oceanica, nor the twin Polynesias, nor race are mentioned or insinuated in Jean-Baptiste Poirson's (1804) map of the 'Grand Océan', dated 1802, which parsimoniously differentiates only named archipelagoes. *Océanique* does not appear in a published map until 1810, in a preliminary atlas to Malte-Brun's 'universal geography'. But this map by Pierre Lapie (Figure 3) remains a utilitarian nominalist compilation of existing geographical knowledge, has no racial implications and lacks classificatory toponyms: Polynesia does not feature and *Océanique* is limited to the cartouche. Reprinting that map in an extended atlas, Lapie (1812) added maps of Oceanica's western, central, and eastern segments. Yet Polynesia is again absent while the implied regional division is entirely spatial and cardinal, with no hint of races.

1815–1832: Mapping regions

The Restoration era in France saw not only the resumption of scientific voyages to the Pacific in 1817, but also growing interest, system and exactitude in the cartography of the fifth part of the world, spearheaded by the royal geographer Adrien-Hubert Brué. As a young midshipman with Nicolas Baudin in 1801–1803, Brué was a junior contributor to the practical field of Pacific marine cartography, as celebrated in voyage atlases compiled by the hydrographer Charles-François Beautemps-Beaupré (1807) and Brué's shipmate Louis de Freycinet (1811, 1812, 1826). Thus, drilled in empirical precision and very widely read, Brué further refined the accuracy of his maps by drawing them

Figure 3. P.M. Lapie, Océanique, in C. Malte-Brun, *Précis de la géographie universelle, ou description de toutes les parties du monde, sur un plan nouveau, d'après les grandes divisions naturelles du globe ... Collection de cartes géographiques ...*: [plate 19] (Paris: F. Buisson, 1810), National Library of Australia, Map T 841, http://nla.gov.au/nla.obj-232610435.

directly on copper plates. In his *Grand atlas universel* (1816), he transformed French cartography of the fifth part of the world by amending Malte-Brun's master toponym *Océanique* to *Océanie* (Oceania) and by materialising Brosses' regional synthesis in the actual graphic structure of his maps, rather than simply in words—the first French cartographer to do so.[1] In six plates devoted to Oceania, Brué (1816: plates 36–41) used hatched lines to demarcate three great regions: the *Grand archipel d'Asie* (Great Asian Archipelago), *Australasie* and *Polynésie*. Their purely spatial parameters, devoid of any racial considerations, are underscored by the line which limits Australasia to the very large land masses of New Holland, New Guinea and New Zealand. By passing very close to the north coast of New Guinea, this line positions *all* the Pacific Islands within Polynesia (Figure 4). Brué's Polynesia, thus, encompasses several western archipelagos inhabited by Malte-Brun's Oceanic Negroes, which Pinkerton had located in Australasia on the basis of size.

The cartographic criterion of the relative magnitude of land masses or islands is strikingly denoted in two novel regional toponyms inscribed by the Florentine cartographer Bartolomeo Borghi (1826) on a map of 'Oceania' first published in 1819. Borghi relabelled Brosses' Polynesia as *Polinesia ovvero Micronesia* (Polynesia or rather Micronesia) and replaced Australasia with the explicitly topographic *Meganesia* (large islands), evidently enfolding the East Indies, New Holland, New Guinea, New Britain, New Caledonia and New Zealand. If Meganesia was an ephemeral term until reinvented by some modern scientists, Borghi's Micronesia—from Greek *mikros* (small)—was a portentous innovation, soon to be normalised in French cartography and eventually in global geopolitics.

In the second edition of his magnum opus *Atlas universel de géographie physique, politique, ancienne & moderne*, Brué

[1] The earliest graphic regionalisation of the fifth part of the world I have found is in a late eighteenth-century German map by the geographer Johann Traugott Plant (1793).

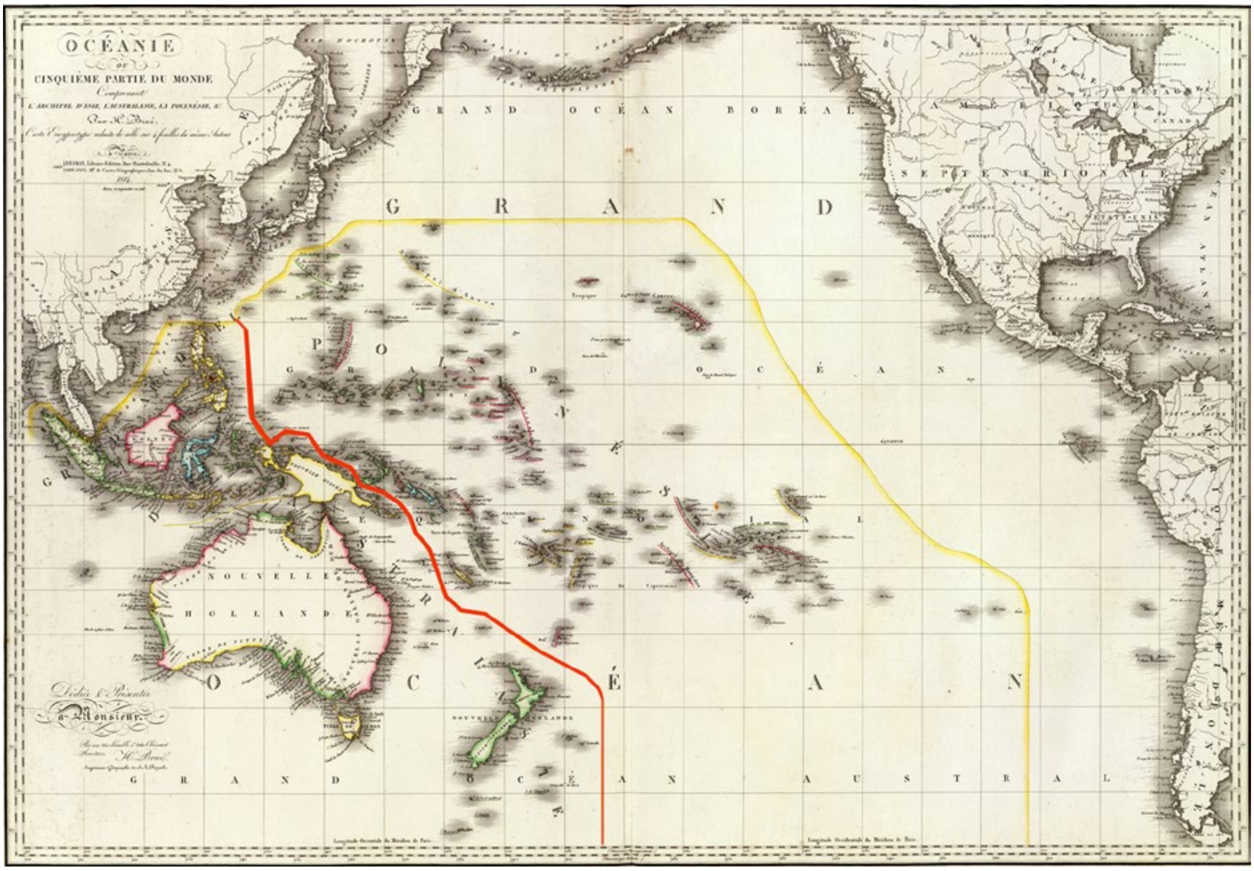

Figure 4. A.-H. Brué, Océanie ou cinquième partie du monde comprenant l'Archipel d'Asie, l'Australasie, la Polynésie, &.[a] ..., in *Grand atlas universel, ou collection de cartes encyprotypes, générales et détaillées des cinq parties du monde*: plate 36 (2nd edition, Paris: Desray, 1816) (line enhanced), David Rumsey Map Collection, 4614044, http://www.davidrumsey.com/luna/servlet/view/search?q=4614044.

(1828: plates 47–50) himself modified Brosses' schema in a new map of 'l'Océanie' condensed from three new regional maps of the *Grand Archipel d'Asie*, *Australie* (Australia)—abbreviated from *Australasie*—and *Polynésie*. Australia's boundary with Polynesia is now realigned north and east so as to group within Australia all the land masses and large islands of the western Pacific, leaving only Fiji in Polynesia (Figure 5), as Pinkerton had done verbally. In a pragmatic gesture to achieve 'the largest possible scale', Brué's *Carte particulière de la Polynésie* (1828: plate 50) splits the region at the Equator into southern and northern segments, reminiscent of Malte-Brun's twin Polynesias but without his racial connotations.

In detailed text boxes on each of these maps, Brué acknowledged the work of numerous voyagers and cartographers, but none more generously than the 'important atlas' of the Pacific Ocean published in Russian and French editions by the initial Russian circumnavigator Adam Johann von Krusenstern (1824–1826, 1824–1827a). Krusenstern's atlas, the first devoted exclusively to the Pacific, is an empirical triumph distilled from his own Oceanic experience and deep familiarity with his predecessors' work. Purely nominalist in design, content and nomenclature, and without a breath of regionalisation, the atlas is supplemented by 'hydrographic memoirs' (1824–1827b), which provide critical syntheses of island and coastal coordinates and shifting European toponymy. Krusenstern's interwoven visual and written productions served as templates for subsequent hydrographers and in wider global cartography for much of the 19th century.

Dumont d'Urville, 1832: Racial geography

The disjunction between racialised French writings on Oceania and spatialised French maps was dramatically closed in 1832 when Jules Dumont d'Urville (1832), a highly experienced navigator who had twice voyaged in Oceania and would do so again, published linked geographical and racial taxonomies, illustrated by a radically novel map of 'Océanie' (Figure 6). In the process, he synthesised elements from earlier toponymic and racial classifications with his own innovations. Dumont d'Urville formalised Malte-Brun's division of Polynesia

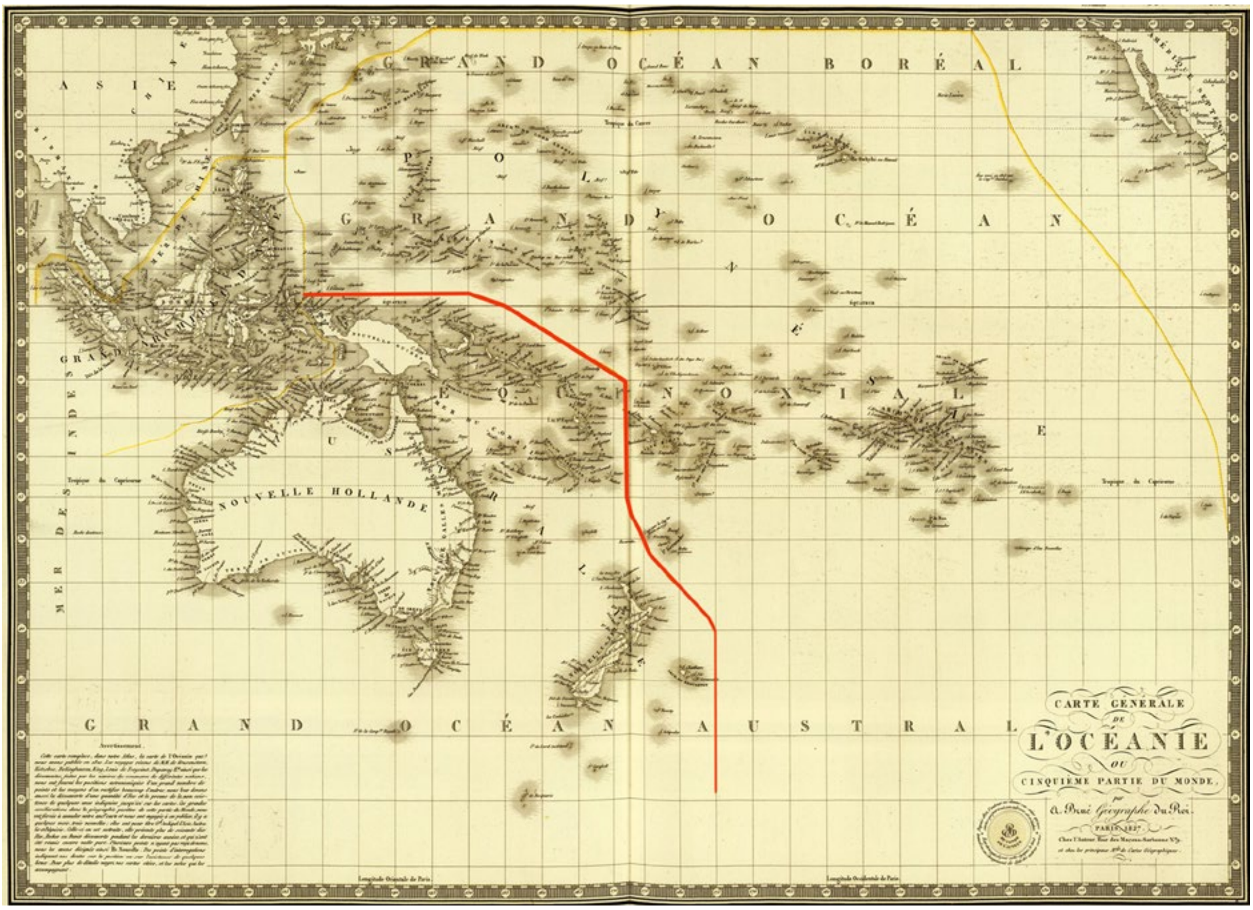

Figure 5. A.-H. Brué, Carte générale de l'Océanie ou cinquième partie du monde …, in *Atlas universel de géographie physique, politique, ancienne & moderne contenant les cartes générales et particulières de toutes les parties du monde …*: plate 47 (2nd edition, Paris: l'Auteur et Ch[les]. Piquet, 1828) (line enhanced), David Rumsey Map Collection, 0096047, http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~33948~1170101.

by applying the term *Micronésie* (Micronesia)—Borghi's Italian invention—to the northern segment and limiting *Polynésie* to the southern. Both are incorporated within a racialised regional triumvirate *Polynésie*, *Micronésie* and *Mélanésie* (Melanesia). The third term was a neologism derived from Greek *melas* (black) to label 'the homeland of the black Oceanian race', otherwise *les Mélanésiens* (the Melanesians). On explicitly racialist grounds, Dumont d'Urville drew the line between Polynesia and Melanesia to pass west of New Zealand, thereby relocated in Polynesia, and east of Fiji, thereby reassigned to Melanesia.

There was a potent experiential dimension in Dumont d'Urville's (1832: 3–4, 11–15, 19) profoundly derogatory representation of 'the Melanesians' as the 'true natives' of Oceania, lacking government, laws, or religion, the women 'still more hideous than the men', and all 'very inferior' to supposedly conquering Polynesian and Micronesian immigrants. His value-ridden dichotomy of 'the Melanesians' and 'the Polynesians' as 'two truly distinct races' was not a simple reflex of prevailing contemporary racial attitudes. It was also in part a product of his own direct encounters with Indigenous people in Oceania, particularly the very diverse relations he experienced in 1828 at the neighbouring islands of Tikopia and Vanikoro, in modern Solomon Islands. Whereas the Tikopians (classed racially as Polynesian) adopted a strategy of welcome and cooperation that enchanted Dumont d'Urville, he was intimidated and infuriated by the equally strategic aggression of the inhabitants of Vanikoro (classed racially as Melanesian). These two communities epitomise his opposed racial types (Douglas 2014: 233–51). Yet, as in most such racial systems, *all* Pacific Islanders 'naturally' ranked below the 'white' race. It was, Dumont d'Urville (1832: 19–20) reasoned, a 'law of nature' resulting from 'organic differences' in the 'intellectual faculties' of the diverse races that 'the black must obey' the 'yellow', 'or disappear', while the white 'must dominate' both the others, even when numerically inferior. This familiar formula was at once a reflex of ongoing global colonisation by Europe and a blueprint for its imminent extension across still uncolonised areas.

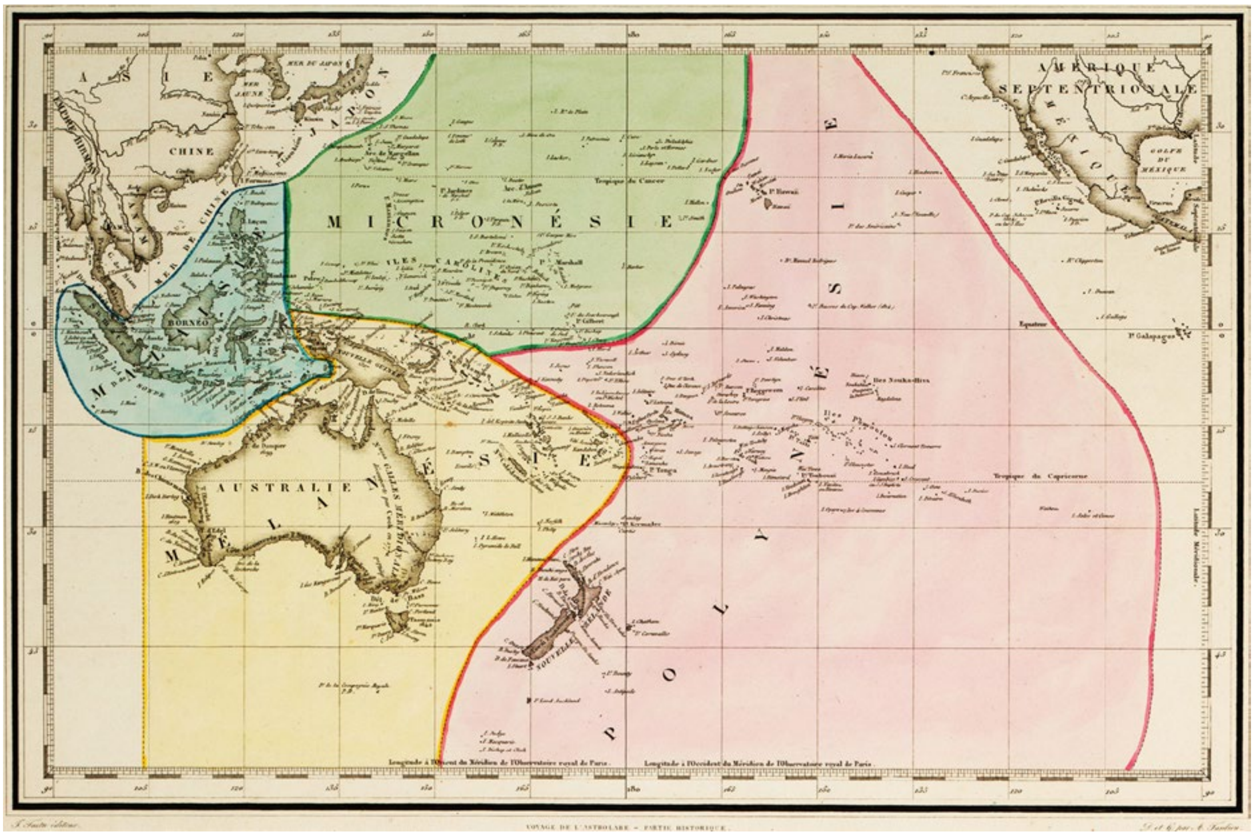

Figure 6. A. Tardieu, Carte pour l'intelligence du mémoire de M. le capitaine d'Urville sur les îles du grand océan (Océanie), in J. Dumont d'Urville, *Voyage de la corvette l'Astrolabe exécuté par ordre du Roi pendant les années 1826-1827-1828-1829 ... Atlas [historique]*: map [1] (Paris: J. Tastu, 1833 [1832]). National Library of Australia, MAP NK 2456/73, http://nla.gov.au/nla.obj-230622715.

Dumont d'Urville's seminal map, archetype for the *arrogant racialisation of Oceania in French and ultimately global cartography, also gives ironic graphic expression to a paradoxical reality—that in the mid-19th century much of Oceania remained Indigenous space where local rulers, élites and communities held sway, exercising significant control over itinerant explorers, whalers, traders and beachcombers, as well as resident Christian missionaries. Unevenly inscribed with dates and place names denoting European maritime 'discoveries', the map bears few traces of European colonialism, apart from Batavia, Manila and Port Jackson (Sydney). Dumont d'Urville's racial regions, delimited by thick hatched lines and embodied in bold slabs of colour, subtly signify the ongoing ubiquity of Indigenous presence. He must in practice have known this to be the case, from reiterated personal experience as hydrographer, naturalist and commander on naval expeditions in Oceania. There is further irony that Dumont d'Urville's lasting reputation as cartographer should be condensed into a single, atypical map that belies his major professional contribution to charting a part of the world still little surveyed in the 1820s (Dumont d'Urville 1833; Vincendon-Dumoulin 1847).*

Conclusion

This paper has probed the creation, mutual appropriation and cross-fertilisation of practical and abstract knowledges about Oceania and their varied synthesis in the nomenclatures and classifications of 19th-century geography and anthropology in France. Weaving through the discussion is the integrating theme of nominalist or categorical usages and their differential expression in cartographic and written materials. Two examples from the literature of scientific voyaging illuminate a dramatic shift in enunciatory strategies across the period considered. In 1767, Bougainville (1977: 317–18) whimsically idealised Tahiti as *la Nouvelle-Cythère* (Aphrodite's island), in categorical celebration of the inhabitants' gracious conduct, the young women's sexual complaisance and the mild climate. In his contemporary journal, he collectivised the people as *les Indiens* (the Indians), a contemporary synonym for 'native'. Instructed that *Taiti* was the island's name by the Tahitian Ahutoru, who accompanied the expedition back to France, Bougainville (1771: 209, 227) adopted that name in his published narrative and referred to the inhabitants by extension as *Taitiens*. Both words entered global cartographic and anthropological lexicons. By contrast, Dumont d'Urville's (1832) ground-breaking schema absorbs the empirical geographical entity *Taïti* within the abstract region *Polynésie*, which is in turn subsumed as an element in the quadripartite higher-level abstraction *Océanie* = {*Polynésie, Micronésie, Malaisie, Mélanésie*}; each term is equally reified. The Tahitians simply vanish from this system, collapsed as an unnamed component of *les Polynésiens*, one of two divisions of *la race cuivrée* (the copper-coloured race), which occupied the geographical abstractions *Polynésie* and *Micronésie*.

Dumont d'Urville's racialised regional toponyms Polynesia, Micronesia and Melanesia were normalised in French cartography from the year of their publication. They became the international standard in the 20th century and remain so. However, the route from French invention to global geopolitics was not straightforward. Minimalist 19th-century British mapmakers often omitted regional names or favoured Brosses' geographical terms Australasia and Polynesia, as did those in the United States. Dumont d'Urville's toponyms hardly feature in British or US maps until late in the century. In contrast, German cartographers used them regularly after 1850 while Russian atlases relied on Brosses' terminology, qualified after 1840 by Dumont d'Urville's alternative. With minor modifications, his tripartite raciology of Pacific Islanders as Polynesians, Micronesians and Melanesians permeated global racial or ethnic terminology from the late 19th century, though national trajectories were again diverse (Douglas 2011: 15–21; 2014: 7, 15–16). More recently, these categories have been naturalised in modern Indigenous usages, sparking robust academic debate on their geographic, racial or disciplinary appropriateness (e.g., Clark 2003; Douglas 1979; Green 1991; Lawson 2013; Thomas 1989, 1997: 133–155).

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Hahotrim, Israel:
A Late Second-Millennium BC Group of Metal Scrap Artefacts

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Abstract

During an inspection dive along Israel's Mediterranean coast opposite Kibbutz Hahotrim in 1980, employees of the Israel Department of Antiquities and Museums (now the Israel Antiquities Authority [IAA]) discovered artefacts on a section of hard clay seabed substrate swept clear of sand by a storm. Scattered about two large stone anchors, the finds consist primarily of small, broken or damaged metal artefacts and ingots: fragments of copper oxhide ingots, two bronze horse bits, blades, chisels and a socketed blade of a type common on the Cape Gelidonya shipwreck. The scatter also included one complete lead ingot and other ingot pieces. These items appear to be the contents of one or more containers of recycled metals, which found its/their way into the sea at the end of the Late Bronze Age or the beginning of the Iron Age. Lead Isotope Analysis (LIA), as well as chemical and metallographic analyses, confirm that the sources of the metals are consistent with other collections of metal artefacts from this period.

Keywords

Late Bronze Age, lead ingots, metals trade, nautical archaeology, oxhide ingots

The Walrus and the Carpenter
  Were walking close at hand;
They wept like anything to see
  Such quantities of sand:
'If this were only cleared away,'
  They said, 'it would be grand!'
'If seven maids with seven mops
  Swept it for half a year,
Do you suppose,' the Walrus said,
  'That they could get it clear?'
' I doubt it,' said the Carpenter,
  And shed a bitter tear.
Alice's Adventures in Wonderland
  Lewis Carroll 1866: 73-74

Introduction

The settlement of Hahotrim (Hebrew for 'The Rowers') nestles on Israel's northern Mediterranean coast, at the southern approaches to Haifa, Israel. Along these shores opposite the Carmel Mountains, the shallow, shelving coastline consists of *kurkar* (calcareous sandstone) ridges divided by depressions running parallel to them (Gabbay and Brachya 2000: 3–4). The steep decline in global sea level during the last glacial advance revealed this area to sub-aerial processes, the movement of sand dunes and to erosion. Subsequently, rising Holocene sea levels flooded the three westernmost ridges, filling the low-lying areas between them with clayey silt and sand, which today form a hard clay substrate beneath a blanket of shifting sand of constantly varying depth. During summers, short waves driven primarily by south-westerly winds, tend to drive the sand shoreward, while winter storms, waves and currents transport the sand back out to sea. Sand migrates on and offshore down to a depth of 10–15m. Due to its location near the northern extremity of the Nile littoral cell, along the Carmel Coast, this process tends periodically to sweep sections of the hard clay substrate clear of sand.

In antiquity, the coast of Israel served as a primary sailing route in the Mediterranean. Most of this activity took place during the sailing season, which ran from spring to fall (Davis 2000: 14–24; 2009; 33–43, 65–104; Wachsmann 1998: 295–301; 2013: 155–58). During this period of the year, in the eastern Mediterranean, the primary winds blow from the north-west. Thus, in addition to its importance for coastal seafaring, the route along Israel's Mediterranean coast served another crucial purpose. Due to a 'perfect storm' resulting from the seasonality of the sailing season, the summer wind regime in this region and the limitations of contemporaneous rigs to sail to windward—non-existent in the case of the boom-footed sail, which held sway in the Mediterranean until the introduction of the brailed sail in the waning decades of the Bronze Age—vessels wishing to head north from Egypt had little choice but to sail up that coast, mainly by utilising local land/sea breezes or rowing to make headway (Vinson 1993; Wachsmann 1998: 248–54). Discoveries along Israel's coast bear stark witness to the extraordinary importance of this coast as an ancient shipping lane.

Nautical archaeological research carried out over the past decades along the Carmel coast suggest that, if one could magically sweep the sea of sand as Lewis Carroll's Walrus enquired of the Carpenter, it would reveal on average evidence of *at least* one shipwreck for every 100m of shoreline (Misch-Brandl and Galili 1985: 5). And this probably represents a conservative estimate.

Relatively coherent wooden-planked hulls survive here, but generally only in proximity to geomorphological changes in the coastline. Tantura Lagoon, which lies adjacent to Tel Dor and is protected by a chain of *kurkar* islands, contains a score of articulated shipwrecks (Kahanov 2011; Wachsmann 2011): seven rest within the area of a regular sized basketball court (Wachsmann, Kahanov and Hall 1997: 5; fig. 2). In one case, two vessels (Tantura B and C) rest one upon the other, like two saucers in a cabinet (Wachsmann, Kahanov and Hall 1997: cover, 5 fig. 2: nos. 1, 6–7 fig. 3; Wachsmann and Davis 2002: cover, 512–15). To the south, two wrecks have been revealed in the region of Maagan Michael in an area protected by islands and the Athlit Ram, still attached to its internal timbers, had been protected by its eponymous promontory (Cvikel, Frøn and Boldreel 2017; Linder and Kahanov 2003–2004; Steffy 1991). I am aware of only two hulls situated away from such coastal geomorphological changes. One, unpublished, lies off Kibbutz Hahotrim, and survives due to the protection of its cargo of building stones; the other is the early 6th-century AD Dor 2006 shipwreck, discovered along an open section of beach 800m south of Tantura Lagoon (Navri 2011; Navri, Kahanov and Cvikel 2013; Pomey, Kahanov and Rieth 2013: 437).

Geomorphological variations appear rarely, however, along this shallow and predominantly linear coastline. In this environment, storms, currents and waves pummel ships that sank or stranded near shore. These processes, no doubt aided and abetted by ancient coastal wreckers and scavengers when the opportunity presented itself, resulted in the utter break-up of such vessels. In their place remain only scrambled remnants of their surviving contents and metal fitting, which over time work their way downwards as the sand cover continually shifts, eventually coming to rest on the hard clay sea bottom (Misch-Brandl and Galili 1985: 5). Add to this phenomenon the untold number of items—including, but not limited to, anchors, elements of cargoes, personal items and ships' equipment—that reached the seabed from passing vessels over the millennia due to accident or to intent, or to being washed out from shore. Today, when shifting sands reveal open tracts of the hard sea bottom containing artefacts, to the diving observer often these seem like nothing so much as jumbled smorgasbords of items from diverse periods juxtaposed on the seabed (Misch-Brandl 1985).

A corollary to this phenomenon is that with rare exceptions, such as the curious depositional situation of the Tantura B and C shipwrecks, these artefacts lack any stratigraphical context and must be dated solely based on their typology. This, then, is the geological background to the Hahotrim discoveries described below.

Discovery

In the fall of 1980 an Israeli diver, E. Adler, reported a large, well-cut three-holed stone anchor on a clay patch in the vicinity of Kibbutz Hahotrim. Nautical archaeologists of the Israel Department of Antiquities and Museum (now the IAA) searched for the anchor, but it apparently had been buried by a storm in the interim. A search dive, however, revealed an open clay patch with two additional large single-holed stone anchors, as well as a number of metal artefacts, including small fragments of copper oxhide ingots, a complete lead ingot and fragments of others, horse bits, fragments of tools and a socketed blade (Figure 1). Additionally, as might be expected given the circumstances of the location, mixed in and among these early artefacts lay a diverse collection of artefacts of varying materials and date. The discovery triggered an underwater rescue survey (Wachsmann and Raveh 1980; 1981a; 1981b; 1981c; 1984; Wachsmann 1990: 56–59; 1989: 208–09, 288, 290 fig. 12.54). Weather permitting, work continued on the site from 27 October until a two-day storm on 21–22 November buried the open patch under 1–2m of sand. Artefacts received a running record number as well as a single-letter designation indicating their type or material: A for 'Anchor;' M for 'Metal;' P for 'Pottery;' S for 'Stone' and W for 'Wood.' Here the discussion focuses solely on the stone anchors and the late second-millennium BC metal artefacts: a comprehensive final report is currently in preparation.

Artefacts

Stone Anchors

The anchors lay 13m apart. The apex of Anchor A2 faced north-northeast, while Anchor A3 faced south south-

Figure 1. The first metal artefacts found at the time of the Hahotrim site's discovery included a socketed blade, as well as fragments of oxhide ingots, chisels and horse bits (Israel Antiquity Authority).

west (Figure 2). We recorded, and left, both anchors *in situ*.

Anchor A3 has a marked asymmetrical quadrilateral shape that would make it appear to 'lean' to one side if placed on a horizontal surface. This peculiarity apparently stems from a desire that the anchor stand vertically upright on an angled bow or stern deck. The evidence supporting this hypothesis derives from a similarly shaped anchor that appears on the slanting bow of one of the seagoing ships depicted on the causeway of Unas (Vth Dynasty) at Saqqara (Wachsmann 1998: 257–58). This anchor appears to be standing vertically, but if placed on a horizontal base, it takes on the asymmetrical appearance of Anchor A3. Similar lopsided anchors have been documented along the Levantine coast and at Egyptian Red Sea sites (Wachsmann 1998: 258 fig. 12.3C, 261 fig. 12.11A).

Anchor A3 measures 80cm high, 35cm at its widest, with a consistent thickness of 35cm. The stone used for the anchor, coquina (shelly limestone), has a specific gravity of 2.71 and the anchor has a calculated volume of approximately 177 litres, for an estimated weight of 480kg, or almost half a metric ton. If this weight is even roughly correct, then this represents one of the largest stone anchors recorded in the eastern Mediterranean. Honor Frost (1963: 43 fig. 5; 1991: 370, 372, 378) describes a 540kg stone anchor from the harbour of Tabarja, in Lebanon and references other large anchors made of basalt off Tartous, Syria and Cape Greco, Cyprus.

Raising anchors this size in the manner represented on two 7th-century BC jugs would have presented significant challenges (Karageorghis and des Gagniers 1974: 122–23 nos. XI.1–2; Wachsmann 1998: 183, fig. 8.41A, C, 288). Even anchors of somewhat lesser weight must have been a challenge, particularly when raising them from the waterline to a vessel's deck.

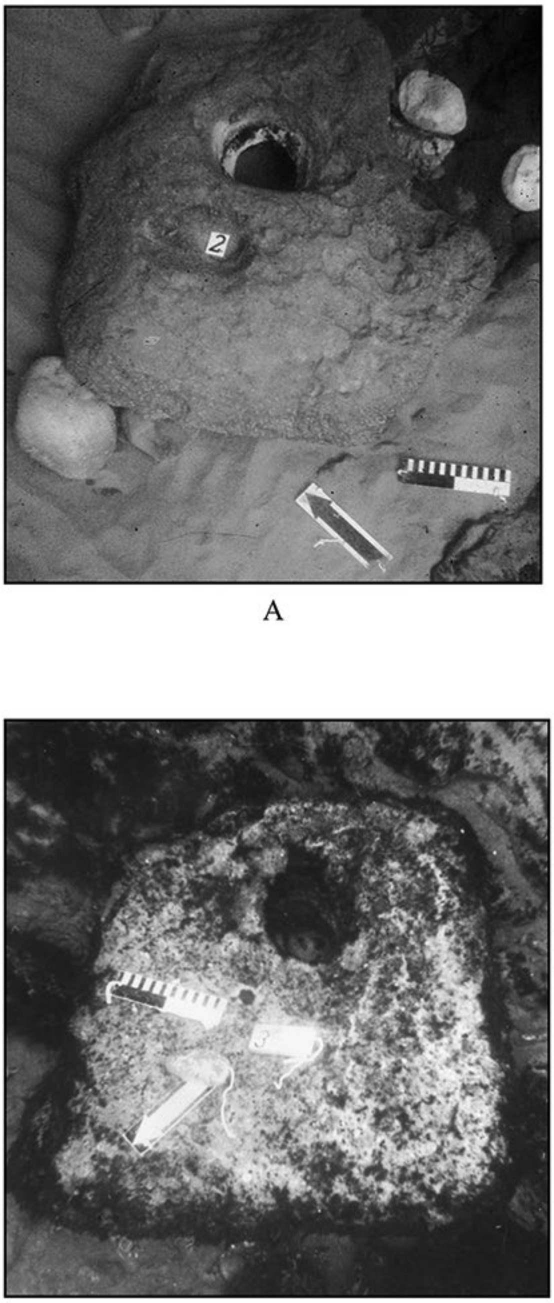
Anchor A2 impresses less. It has an irregular shape, making calculating its weight problematic. Made of limestone, A2 measures 90cm high, with a greatest width of 90cm and a varying thickness of up to 25cm.

Given the manner in which artefacts reach the hard clay substrate along this coast, no determination can be made as to whether either anchor has a relationship to the other and/or to the metal finds discussed below, beyond in situ proximity on the seafloor.

Metals

Copper

We raised ten small pieces of raw copper, apparently derived from oxhide ingots, with a total weight of 186.2gm, (Figure 1). One piece may represent part of



A

B

Figure 2. Anchors A2 (A) and A3 (B) *in situ*.
(Israel Antiquity Authority).

an oxhide ingot handle, while another appears to be casting waste. This small collection evokes the nearly 75kg of ingot fragments, recovered from the Cape Gelidonya shipwreck currently under restudy (Bass 1967: 52; Hirschfeld and Bass 2013; Van Brempt 2016: 371–402, 514–19).

Originally these were termed 'oxhide' ingots, due to the belief that their peculiar shape replicated that of an ox's hide and, thus, represented the value of an ox (Bass 1967: 69). While this interpretation has long been abandoned, the term continues in use for the sake of clarity. Based on his study of the Cape Gelidonya wreck and Egyptian iconography, G.F. Bass (1967: 52–78, 165–167) demonstrated, contra contemporary wisdom, that Syro-Canaanites played a primary role in their manufacture and their seaborne transport. This connection found further confirmation in the Uluburun shipwreck, which apparently originated from a site on Israel's Carmel coast (Pulak 2008: 300–02, 303–04). Furthermore, Ras Ibn Hani (Palais Nord), the harbour of Ugarit, revealed the only known stone oxhide ingot mould (Lagarce *et al.* 1983: 277–90).

In discussing the textual evidence of the Old Assyrian-Anatolian trade in copper J.G. Dercksen (1996: 41) notes that there might be three reasons for breaking up ingots: A) it allowed examination of the purity of an ingot's composition (Dercksen 1996: 25; Pulak 2000: 155); B) it allowed for a greater ability to weigh out accurate amounts of the commodity, and lastly, C) it simplified their transportation.

Lead

The six lead artefacts include one complete round sheet ingot, two large ingot fragments and three smaller pieces, with a total weight of 2.2kg. Neither of the ships that sank off Uluburun or Cape Gelidonya carried raw lead. The Aegean, the presumed destination of both vessels, had its own local sources for these metals at Laurion and, to a lesser degree, at Siphnos (Gale and Stos-Gale 1981a; 1981b: 192; Stos-Gale 2000: 61–68). Thus, the Bronze Age Aegean exported lead to the east, as witnessed by Egyptian lead artefacts dating to the XVIIIth Dynasty that derive from Laurion ores (Gale and Stos-Gale 1981b: 191).

At Hahotrim, lead ingot fragment M19, may be part of this story. The artefact bears remnants of a mark in the shape of a 'reversed S' (Figure 3A). In the Linear B script this symbol repeated twice connotes 1/30th of a talent (Double Mina), or 967gms (Chadwick 1976: 102–03; Petruso 1992: 18–20, 63–64; Ventris and Chadwick 1973: 57;). While M19 is fragmentary, weighing only 194g, ingot M18, which is complete (but bears a different mark), weighs 995g (Figure 4). This could suggest that these ingots may have complied with the contemporaneous Aegean weight system, even though the artefacts themselves do not derive from Aegean ores (see below).

Ingot fragment M57 is perhaps the most interesting of the lead items (Figure 5; Wachsmann and Raveh 1984). Roughly semi-circular, it had been cut straight across with sharp blows (Figure 6B). The cut side of the ingot

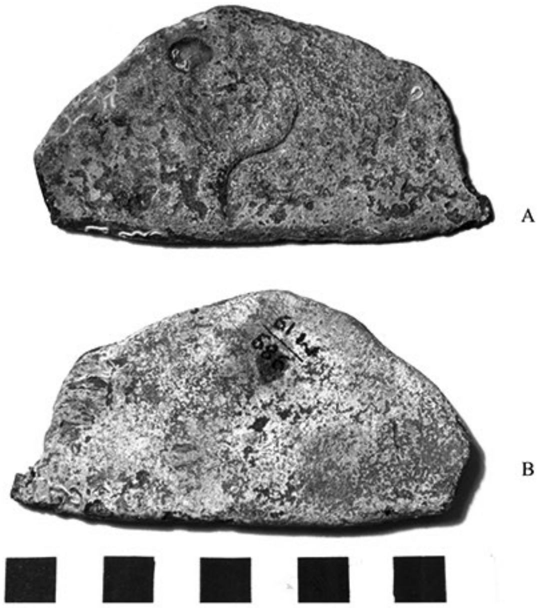


Figure 3. Lead ingot fragment M19 bears part of a single ‘reverse S’ mark (Israel Antiquity Authority).

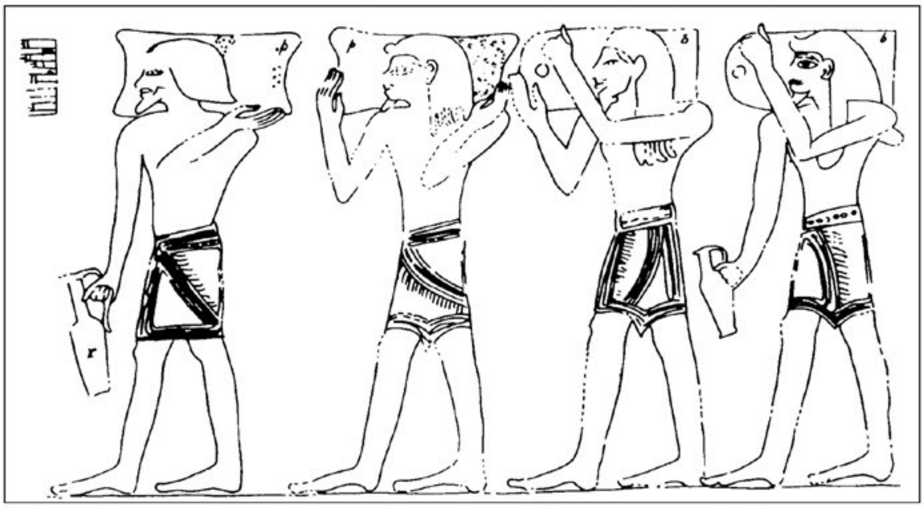
Figure 4. Lead ingot fragment M18. (Israel Antiquity Authority).

bears the remnant of a hole with a thickened rim on its bottom side, formed when the ingot had been cast (Figure 5A). Additional lead ingots bearing holes and marks have been found along the Carmel Coast (Galili, Dahari and Sharvit 1993: 65, 66 fig. 7; Galili and Rosen 2012: 3, 7 fig. 7, 8; Misch-Brandl, Galili and Wachsmann 1985: 8–9, fig. 1.3–7; Raban and Galili 1985: 327, 328 fig. 9).

Figure 5. Lead ingot fragment M57. Note the thickened rim around the partial remains of a hole on the ventral surface (A), and the evidence of hacking on its dorsal side (B). (Israel Antiquity Authority).

Egyptian scenes of foreign tribute/trade display examples of what appear to be this type of ingot. In their earliest appearance, enigmatic long-haired foreign porters, presumably Minoans based on their long hair and the red tint of their skin, carry rectangular, holed ingots in an Egyptian relief fragment believed to date to the Middle Kingdom (Figure 6A) (Evans 1928: 176 n. 4, 177 fig. 90, 178; Müller 1906: 5–8, pl. 1; Wachsmann 1987: 50, pl. LII: A). In this scene, the ingots are termed *ḏḥty,* the Egyptian term for lead (Erman and Grapow 1931: 606; Faulkner 1988: 316, 324; Wachsmann and Raveh 1984: 172, 175). In the tomb of Amenemopet (Theban Tomb [TT] 276; Thutmose IV), porters bear on their shoulders pierced, blue-coloured ingots (Figure 6B): N.d.G. Davies (1932: 62) and J. Vercoutter (1956: 365, pl. LXV: nos. 499–500) identify these as lead. The

A



B

Figure 6. A) Foreign, probably Minoan, porters carry lead ingots with holes in their apexes on a relief ascribed to the Middle Kingdom. The ingots are termed *ḏḥty*, the Egyptian term for 'lead'. B) Two hybrid porters carry on their shoulders pink-coloured oxhide ingots, followed by two others who bear lead or tin ingots painted slate blue and with holes in their apexes. Tomb of Amenemopet (TT 276). Thutmose IV. A after Müller 1906: pl. 1. B after Davies 1932: 61 fig. 13.

purpose of the holes in these ingots remains unclear: Davies, the great chronicler of Theban tombs, suggests that the piercings may have allowed porters to carry the ingots slung on poles. Similar ingots, but with oblong rather than round holes, appear in a display of foreign tribute in the tomb of Rechmire (TT 100; late Thutmose III-early Amenhotep II; Davies 1943: pl. XXI), where they, too, are termed *ḏḥty*. Note, however, that in Egyptian 'white lead' (*ḏḥty ḥd)* was a term for 'tin' (Muhly 1973: 245). Perhaps the similarities in the metal's visual appearance led to both being cast into ingot shapes with somewhat similar attributes as tin ingots with holes also have been recovered from the Carmel Coast (Galili, Gale and Rosen 2011: 67 figs 7-8 [Kfar Samir]; 2012: 6–8, 13–21 [Hishuley Carmel]).

New Kingdom texts suggest that the Syro-Canaanites played a prominent—although certainly not a unique—

role in the sea transport of lead in the Late Bronze Age. Following his fifth Syrian campaign (Year 29), Thutmose III describes the capture of two Syro-Canaanite ships noting that their cargo included lead (Breasted 1988 II: §460; Säve-Söderbergh 1946: 35). Additionally, in his seventh, ninth and 13th campaigns (Years 31, 34 and 38) he reports receiving quantities of lead as tribute from the rulers of *Retenu* (Canaan) (Breasted 1988 II: §471, 491 and 509). The availability of this metal on the Syro-Canaanite littoral is eloquently expressed by the discovery at Ras Ibn Hani (Palais Nord) of quantities of large lead plano-convex ingots/fragments weighing a total of 280kgs (Lagarce, Lagarce, Bounni and Saliby 1987: 282 fig. 6, 283 fig. 7).

Bronzes

The bronzes consist primarily of scrap tools, some of them so fragmentary as to defy identification and a worn socketed blade, of a type common at Cape Gelidonya (Figure 1 [foreground]; Bass 1967: 88–93). The nearby site of Hishuley Carmel revealed a similar specimen bearing a mark on its ventral surface (Galili, Gale and Rosen 2012: 11 fig. 18, 12 fig. 12).

This group also included parts of two bronze horse bits (Misch-Brandl, Galili and Wachsmann 1985: 10, fig. 6). Brandle (in preparation) notes that the Hahotrim bits are virtually identical to a pair from Gezer and dates them to the 13th-century BC. Furthermore, he notes that the Hahotrim bits are the first to be found in the sea and that their appearance at Hahotrim as scrap metal may explain why so few ancient bits have been found to date: when broken they were recycled. Old Assyrian merchants also dealt in scrap metal including particularly the recycling of worn implements, similar to the situation at Hahotrim (Dercksen 1996: 45–47; Singer 2015: 95). The appearance together of two bits at Hahotrim corresponds to pairs of bits found at other Bronze Age sites, which results from their original use: to control braces of horses pulling chariots. The concept of horse-mounted cavalry would be an Iron Age innovation (Yadin 1963: 220, 287, 297, 360, 382–85, 402–03, 450, 452, 456–59).

Analyses

Lead Isotope Analysis

Zofia Stos-Gale's (2015: 111-12, 118, 120 fig. 6; in preparation) Lead Isotope Analysis (LIA) study of the Hahotrim metals revealed remarkable diversity in their source ores.

The six copper-based artefacts show wide-ranging lead-isotope configurations, all of which lie within the range of Cypriot copper-bearing ores. The lead ingots fall into three distinct compositions. Two items, M18 and M19, are isotopically identical, but do not conform to any of the published samples of lead-bearing ores found in the Mediterranean region or Anatolia. These items may derive from south-eastern Turkey, however, additional ore data will be required to support this conclusion. A second group, consisting of M57 and M56—the latter may constitute a small piece cut from the former—falls within the range of lead ores from Sardinian mines in the Iglesiente district. Contacts between Cyprus and Sardinia are well documented and some lead artefacts recovered from Kition and Hala Sultan Tekke on Cyprus also derive from Sardinian lead ores (Stos-Gale and Gale 2010: 395 tab. 5). Finally, one fragment represents a third source: the lead-bearing ores from the Bolkardağ valley in the Taurus Range of southern Turkey.

The socketed blade is consistent with LIA data of ores from the Aladag region of the Taurus Mountains, while the horse bits appear to be isotopically consistent with copper associated with tin in Iran, for which LIA ore data has only recently become available (Pernicka, Kerstin, Böhme, *et al.* 2011).

Stos-Gale concludes that the LIA signatures of the analysed Hahotrim metals remain consistent with those of other groups of metal artefacts derived from Late Bronze Age eastern Mediterranean sites.

Chemical and metallographic analyses

S. Shalev (in preparation) studied the composition of the metal artifacts with chemical and metallographic analyses. The bronzes have a 6–12% tin content, consistent with typical copper/tin ratios during the Late Bronze Age in the region. The copper ingot fragments have homogenous composition, the two main impurities being arsenic and sulfur, which varies significantly from copper used in the bronzes. The lead artefacts contained impurities of small amounts of antimony and copper: their analyses failed to reveal any traces of silver.

Conclusions

The group of metal artefacts from Hahotrim appear to date to the waning years of the Late Bronze Age or the beginning of the Early Iron Age horizon, *c.* 1400–1150 BC. The latter date is defined by the reign of Ramses III, whose tomb contains images of oxhide ingots, indicating that they continued in circulation during his reign (*ESN 3394*).

An examination of the site plan indicates the majority of the metal finds lay in the vicinity of Anchor A2. Their proximity to each other, as well as their generally similar chronology, suggest that the metal artefacts reached the sea together, and scattered at that time. It seems unlikely that the three heaviest pieces of the group, M18

(995g), M57 (800g) and M6 (620g) would have moved appreciably once they reached the seabed. Perhaps the simplest explanation (Occam's Razor) for the artefacts' arrival on the seabed posits them as the contents of one or more baskets or sacks that, for a now unknowable reason, found their way into the sea. Lacking additional evidence, it would be unwise to postulate the sinking of a ship solely on the basis of these artefacts, particularly considering their questionable relationship to the stone anchors. There are numerous explanations for items reaching the seafloor, not all of which include the sinking of a vessel. An anchor or an ingot on the seabed does not necessarily require a shipwreck to explain it.

Despite the fragmentary and quantitatively limited nature of the Hahotrim metals, nevertheless, it concurs with our overall understanding of an economic 'flat world' at the end of the Bronze Age, supplying us with a vivid expression of a time when even such an insignificant collection of metal scrap can evoke a period in which trade routes stretched from Iran in the east to Sardinia in the west ... and beyond. This world of interconnectivity was about to—or perhaps already had—come crashing down when these metal artefacts reached the seabed.

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Waterlogged Ivory Conservation: Elephant Tusks at El Bajo De La Campana, San Javier, Murcia (Spain)

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Abstract

The preservation of cultural heritage encompasses a range of actions which enable us to understand, study or disseminate the assets and testimonies that make up our historical-artistic identity. The responsibility and scope inherent in these works requires the involvement of qualified professionals the use of science as the basis for our knowledge of the materials with which we work, the degree to which they have been altered, the design of conservation procedures, and their effectiveness.

The archaeological intervention at Bajo de la Campana Phoenician shipwreck, San Javier, Murcia, developed between the years 2007 and 2011 under a collaboration agreement signed by the Ministry of Culture of Spain, through the National Museum of Underwater Archaeology of Cartagena, and the Institute of Nautical Archeology of Texas A&M University. Successive campaigns of systematic excavations documented and recovered an extraordinary Phoenician cargo dating from the 7th to the 6th centuries BC. Among the raw materials it carried, stands out a magnificent set of 53 elephant tusks and tusk fragments, some of them with inscriptions. With this research, we aim to carry out a conservation procedure adapted to the special characteristics of waterlogged archaeological ivory.

Keywords

Archaeology, conservation, ivory, waterlogged

Introduction

To discuss the El Bajo de la Campana's elephant tusks we first have to refer to the Phoenician wreck from which they came. It is located on the coast of the region of Murcia, in front of the Mar Menor, on the eastern side of La Laja or Bajo de la Campana, a volcanic elevation aligned (north-east to south-west) with the Islet of Farallón and Isla Grosa (Figure 1) at its base, and close to the vertically running crack. Most of the elephant tusks were concentrated in one spot.

The uniqueness of this find is that it is one of the few documented examples of a Phoenician wreck in the Mediterranean; it is also one of the few cargos worldwide, which carried ivory as a raw material. The paucity of ivory at underwater sites is the reason why we know very little about its conservation. Finding out about its conservation is the main objective of this research work.

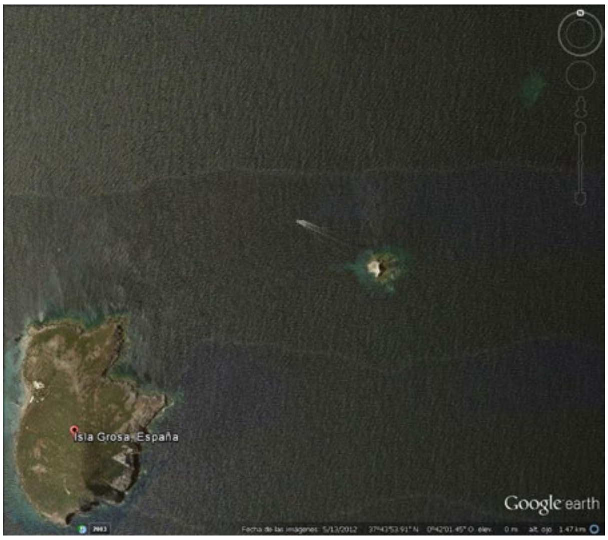

Figure 1. Orientation of El Bajo de la Campana in front of El Mar Menor, Murcia (Google Image modified by the author).

Background

At the end of the 1950s, we heard the first news of the El Bajo de la Campana site and its fortuitous discovery. In 1972, the Patronage of Submarine Archaeological Excavations of Cartagena, led by Julio Mas, planned the first intervention for this archaeological site. The pottery and tin ingots they recovered were the subject of study and publication. By the end of the decade, thirteen elephant tusks from El Bajo de la Campana had been donated to the museum. The circumstances of their extraction are unknown and the state of conservation they presented at the time of their donation to the museum was critical.

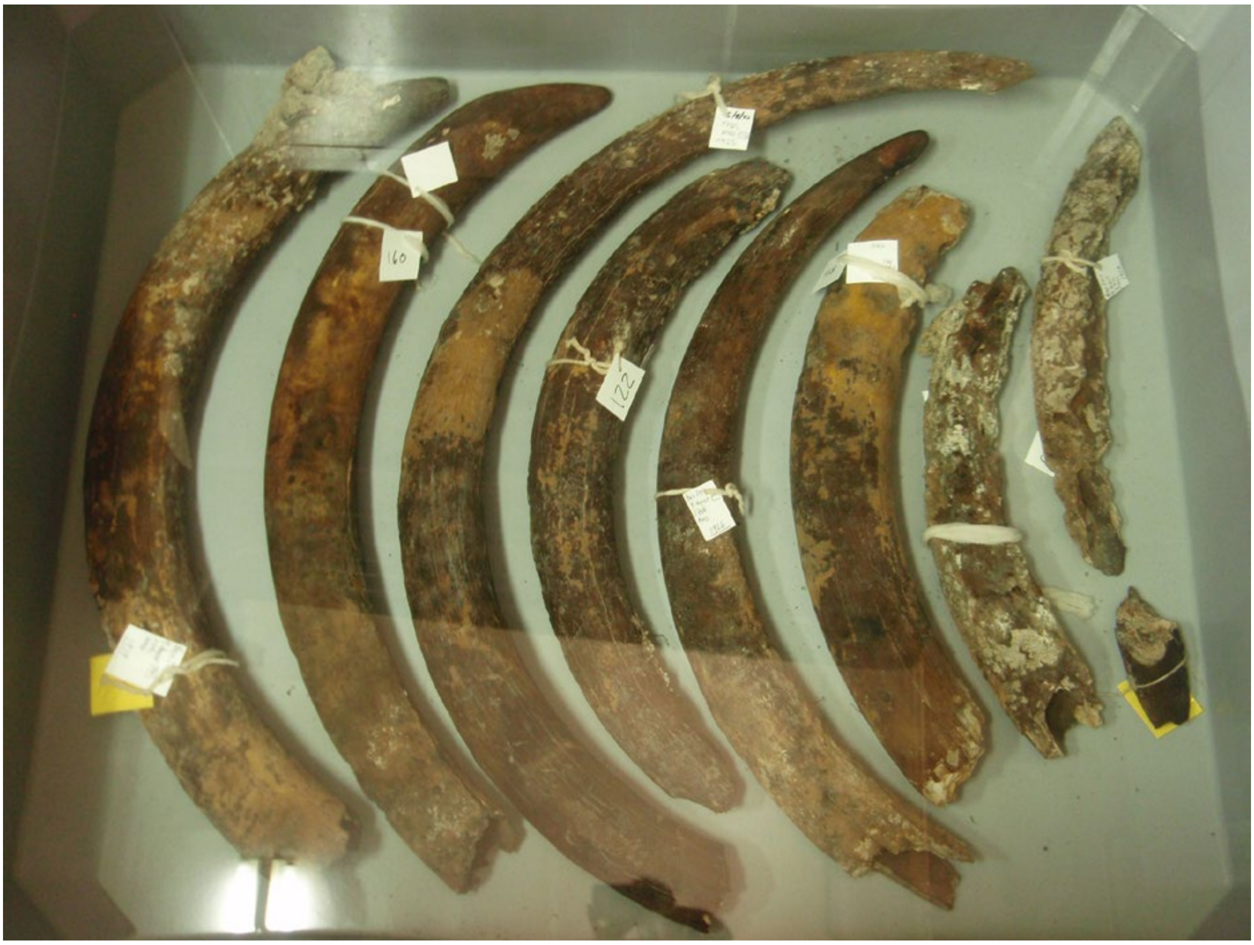

Figure 2. Some of the elephant tusks recovered in the 2010 archaeological campaign (National Museum of Underwater Archaeology of Cartagena).

During prospecting works carried out by the then-called National Museum of Maritime Archeology and National Center for Underwater Archaeological Research at the site El Bajo de la Campana in 1988, three well-defined groups of material were documented corresponding to a Phoenician, a Roman republican and a Roman imperial shipwreck.

The most recent and most important archaeological intervention at the El Bajo de la Campana site has been between 2007 and 2011, as part of a collaboration agreement between the Institute of Nautical Archaeology of Texas A&M University and the Spanish Ministry of Culture, through the National Museum of Underwater Archaeology of Cartagena. Systematic excavation has made it possible to identify and recover the extraordinary cargo of a Phoenician wreck composed of raw materials (almost two tons of galena, copper and tin ingots and elephant tusks (Figure 2), manufactured goods, mainly ceramics, and luxury objects such as a pedestal of Dolomite and exquisitely worked bronze pieces. It should be noted that of the 53 elephant tusks and tusk fragments recovered in the last excavation, some retain Phoenician inscriptions of votive character, according to the latest studies.

Conservation

The work developed by the National Museum of Underwater Archaeology of Cartagena in the archaeological campaign on the El Bajo de la Campana site from 2007 to 2011, has been focused on conservation which is one of its main functions as a museum. Conservation program was implemented, as established in the UNESCO Convention for the Protection of underwater cultural heritage 2001., in wich annex are related the most important conservation rules; when *in situ* conservation is not possible, raising archaeological materials will be carried out by qualified personnel according to current conservation criteria as well all actions carried out throughout the archaeological excavation, conservation must be applied before, during and after the arcaheological campaign and will be supported by research.

Conservation before archaeological excavation .includes assessing the possibility of *in situ* conservation or planning all conservation actions throughout the archaeological intervention. If *in situ* conservation turns out not to be possible, then we should address the recovery of artefacts only insofar as we have the capacity to carry it out, providing qualified personnel and facilities and planning all necessary actions over time. Conservation during archaeological excavation will be carried out in coordination with archaeologists on site—recovering, manipulating and transporting the most fragile materials. In the case of the elephant tusks, bandages were made and raised with rigid supports (Figure 3).

Figure 3. Gradual raising of tusks using rigid supports (Mark E. Polzer).

Once archaeological materials have been moved to an environment completely different from the one where they had laid for hundreds of years, and with which they had reached a certain equilibrium, we must provide similar conditions to those they came from and make a progressive transition to the non-marine and open air environment. For waterlogged archaeological materials, it is fundamental to transport them immobile, always wet and protected from light.

Following archaeological excavation, raised artefacts were sent to the museum's conservation laboratory. Work began with archaeological documentation and that related to conservation. In this case, DOMUS is a museographic application for management that allows compilation of all the information about the treatment. Lead Tools allow us to perform damage mapping, and define more precisely the initial conservation status.

Once the elephant tusks were initially documented, the bandages were removed and the first cleaning was performed to remove sediment and organic matter. Subsequently, they were deposited in tanks with water to initiate gradual elimination of soluble salts, first increasing the percentage of fresh water and later that of demineralised water; this avoids osmotic stress.

The cleaning of insoluble deposits is done by mechanical means, because it is more controllable and safer since it does not add products that can be incompatible with the ivory itself or with the more recently formed products that have been incorporated into the tusk (Figure 4). This operation is necessary to facilitate the removal of soluble salts and ensure the effectiveness of subsequent treatments, mainly consolidation.

Once the soluble and insoluble salts have been removed, the object proceeds to the drying phase. However, we are faced with a degraded material that has lost part of its structural components, mainly those of organic nature; others have been transformed, exogenous elements have their own reactions with the substrate and the aerial medium. Water has a clear supporting function, so if the tusks are dried without a conservation procedure, the result is the collapse of the whole object.

Methodology/analysis

Conservation of ivory from underwater sites is based on our knowledge of the materials with which we work, their composition and structure, environmental degradation factors, and the processes of deterioration that have been generated. All these factors determine the state of conservation of the materials at the time of recovery.

Ivory is composed of a combination of two closely related organic and inorganic components, 2/3 parts of HAPCa and 1/3 part of type I collagen, mainly highly hierarchical from the nanoscale, which are secreted by odontoblasts through the dentin tubules. These components and their organisation give ivory its extraordinary physical-mechanical characteristics. Among the factors which have contributed to the alteration of the ivory in the underwater environment of El Bajo de la

Figure 4. Mechanical cleaning of deposits of biological origin (National Museum of Underwater Archaeology of Cartagena).

Campana we highlight the following: waterlogging, the dissolving power of water, salinity, shallow and sedimentary background, water temperature, biota, pH and redox potential, hydrodynamics and the anthropic factor. Their interaction with the elephant tusks has triggered a series of deterioration processes that include physical (fracture, loss of matter, cracks, etc.), chemical (dissolution of structural components, surface stains of pollutants such as tar and also stains that are intimately incorporated into the surface, mainly iron oxides, metallic elements in the deposit, infiltration of exogenous and newly formed components in fissures and between growth rings, and sedimentation, especially in the pulp cavity), and finally biological (damage caused by lithophytes and annelids).

To understand the state of conservation of the elephant tusks, it was necessary to carry out a chemical-analytical study with a multi-technique analytical strategy for the micro-morphological characterisation and determination of the elemental composition. In order to accurately evaluate any changes which had taken place as a consequence of the diagenetic processes during the burial phase, a non-degraded elephant tusk has been studied in parallel (Figure 5).

As a result of our analysis of the archaeological tusk sample, we can establish a series of diagenetic trajectories that have determined the state of conservation in which it is currently found. The immersion period has caused the hydrolysis and dissolution by gelatinisation of the protein material, which has increased the sample's porosity. This process has led to the development of other parallel secondary processes such as ion exchange, colonisation by invasive species of the marine environment, which in some cases have contributed to the formation of new products, the infiltration of autogenic minerals, the disintegration of bioapatite in the surfaces in contact with water, partial dissolution of bioapatite crystals and subsequent recrystallisation with a consequent increase in crystallinity (Doménech-Carbó *et al.* 2016).

The tusks of El Bajo de la Campana are therefore materials of mixed nature with a very important degree of alteration, which causes the water to become part of their structure and its loss would lead to serious tensions that would cause irreversible structural collapse. As pointed out at the outset, the paucity of documented cases of ivory from underwater sites means that we know little about its conservation—fewer than twenty wrecks of diverse chronology throughout the world, among which El Bajo de la Campana is one of the oldest.

A review of archaeological ivory conservation reveals the few treatments applied so far. We know of some cases of natural or induced drying and impregnation with acrylic resins with unpredictable and unequal results. Recently the work of Dr Ian Godfrey of the Western Australian Museum is a qualitative leap in the status of the issue. It started with studies on the impact of the underwater environment on the elephant tusks of the *Vergulde Draeck*, a Dutch merchant from the 18th century, and worked for the first time with the procedure of plastination developed by Von Hagens in the late 1970s for the preservation of organic specimens in medical and veterinary education. The Biodur © S10 and S15 procedures basically consist of solvent dehydration (ethanol and acetone), impregnation of the polymer with catalyst and, finally, cured by exposure to crosslinker vapours.

There is a variant of the procedure developed by Dr Wayne Smith of the Archaeological Preservation Research Laboratory, Texas A&M University (Smith 2003). In Dr Godfrey's work both procedures are applied. The effectiveness of the treatment is documented ten years after the application and the results in all cases have been satisfactory (Godfrey *et al.* 2012).

Once these procedures of plastination were known and the state of preservation of the elephant tusks of El Bajo de la Campana were defined, we wanted to test it, in particular the technique Biodur © S15 at room temperature. For this, we were able to draw on the extensive experience of professors Dr Rafael Latorre and Dr Octavio Albors, in charge of the Plastination Laboratory of the Faculty of Veterinary Medicine, University of Murcia, who share our interest in documenting and understanding the possibilities and suitability of the Plastination procedure on waterlogged ivory conservation.

We proposed the application of the procedure in successive phases, first with a tusk section

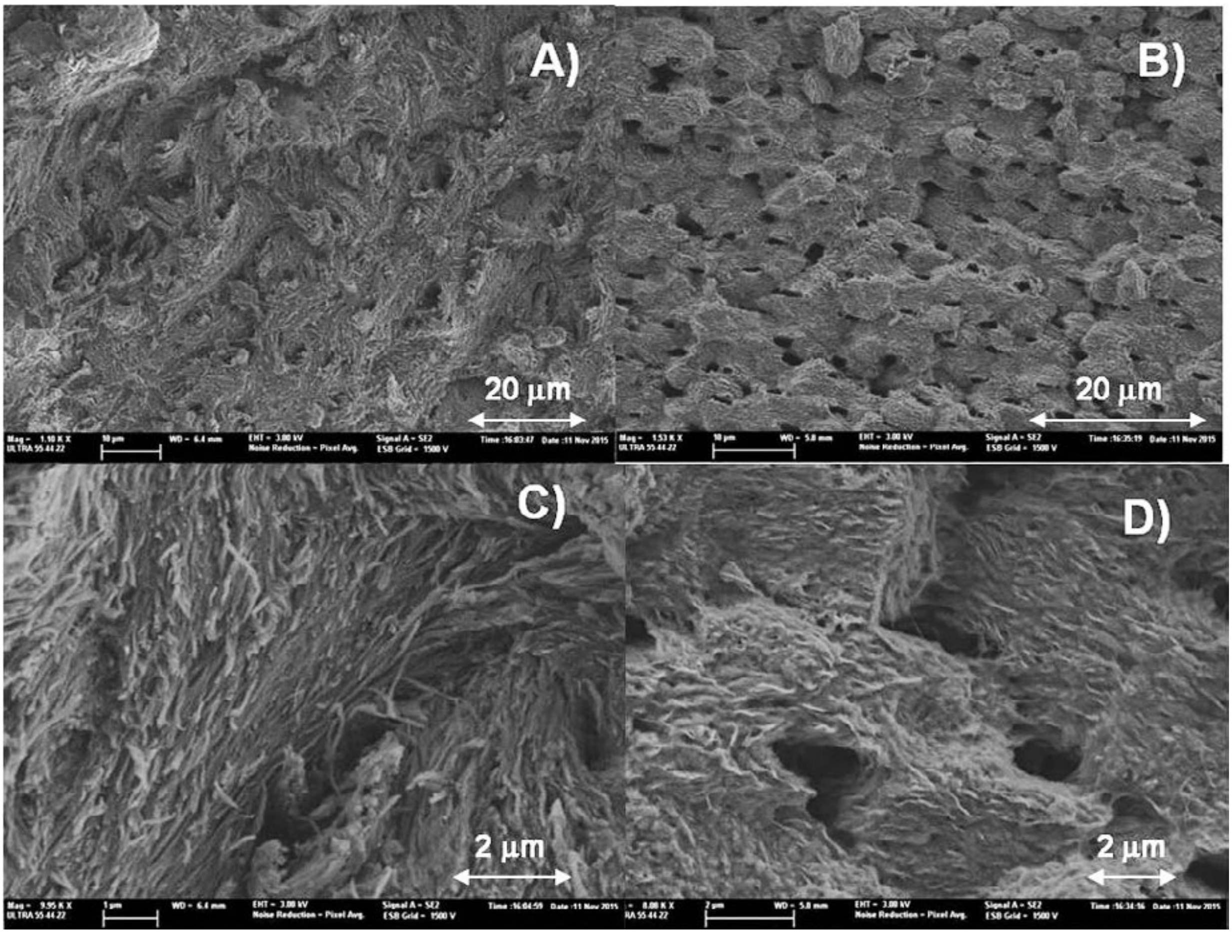

Figure 5. Secondary electron image from: A) ivory from the modern tusk; B) ivory from the archaeological tusk; C) detail of ivory from the modern tusk; and D) detail of ivory from the archaeological tusk.

(SJBC_11_2471_4), then, depending on the results obtained, proceed to a tusk fragment (SJBC_11_2980) and finally, to a complete tusk (SJBC_10_1926). In all three cases, the results were satisfactory and the recording of parameters such as weight, density or volume, has demonstrated the dimensional stability of the procedure.

As already noted above, the steps of the Biodur © S15 plastination procedure at room temperature in all three cases have been dehydration, vacuum impregnation and curing. Acetone has been used for dehydration and the baths have been kept at a temperature of 4° C, to prevent the exchange from occurring rapidly. The time to complete the water / acetone exchange depends on the size and volume of the pieces.

Dehydration is the stage where we noticed some change; in section SJBC_11_2471_4 the appearance of a crack seems to be related to the substitution of acetone for water. However, neither in the tusk fragment nor in the complete tusk have we observed the appearance of cracks, or cracks which did not originally exist, as is the case of the micro fissure already present in SJBC_10_1926, which has not evolved with treatment.

The impregnation phase with vacuum aid has been carried out without problems; the mixture of polymer and catalyst has been perfectly incorporated in each case. Bubbling indicated the incorporation of the mixture of the polymer and catalyst and the exit of the acetone. When the bubbling ceases we know that we have reached the end of the process. In our case, waterlogged ivory, reaching pressure values of 5 mm Hg - 2 mm Hg has not had any negative impact on the material and the time used for impregnation has been proportional to the size and volume of the pieces. After impregnation, the pieces have been introduced into a curing chamber where they have been exposed to the crosslinker vapours, Biodur © S6.

Results/interpretation

The application of the Biodur © S15 plastination procedure on waterlogged archaeological ivory of El Bajo de la Campana has given us satisfactory results.

Figure 6. Task with inventory number SJBC_10_1926 plastinated (Archive image from MNAS).

The complete tusk and tusk fragment have a smaller retraction during the curing phase than the section, so the size and surfaces exposed by the cut seem to be related to this fact.

The 3D documentation and the register of magnitudes such as weight, density and volume, before and after the plastination procedure complement the data obtained in the characterisation on the degree of alteration of the waterlogged archaeological ivory. The dimensional stability that we have achieved with this treatment was one of the most important objectives for the conservation of underwater heritage that we tried to achieved with this work. As for the final aspect that we obtain after curing, the result is optimal. Incorporation of the silicone polymer has slightly enhanced the colour. The parts acquire, after treatment, the sufficient mechanical resistance for their handling to be safe and without fear of new losses or detachments (Figure 6). Tests for understanding the efficiency of the plastination procedure have consisted of morphological examination, structural analysis and mechanical tests. The results have shown that the consolidating product is chemically stable; it highlights its high diffusion power and introduces a slight change in the chromaticism of the tusk.

Discussion and conclusion

The evaluation of the procedure is positive; we not only manage to eliminate water, but we gain also a dimensional stability that is essential for the preservation and study of the pieces. The polymer becomes the supporting element of a damaged structure, such as the ivory of El Bajo de la Campana. Its chemical stability makes it suitable for ivory, as well as for the exogenous elements incorporated, especially the most unstable, such as pyrite, and we can achieve a natural visual appearance.

The tests of stability with exposure to light, thermal changes and contaminated media carried out on the silicon compound used in plastination and on the tusk fragment subjected to plastination have revealed the high resistance of the silicon compound to environmental degrading agents. As in the work of Dr Godfrey *et al.* (2010), we must document the effectiveness of the treatment over time so the next stage of our work will be the best testimony to its success.

The results obtained are a stimulus to continue research, deepen the study of the ivory at El Bajo de la Campana and to explore conservation procedures based on the methodology we have presented. Interdisciplinary work and collaboration between institutions have proven necessary and fruitful—with the combining of resources and effort as well as the benefit of broadening knowledge on the subject and being able to disseminate it.

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Shipwrecks and Cargoes.
Trade Routes of the Mediterranean Sea as Seen Through the Finds of Hellenistic Moldmade Relief Bowls

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Abstract

Investigation of specific categories of objects from cargoes offers new possibilities in reconstructing the trends of trade and routes across the Mediterranean Sea. This paper deals with one such category of object: Hellenistic moldmade relief bowls from the period corresponding to the Late Roman Republic.

The research has focused on the interpretation of groups of bowls recovered exclusively from shipwrecks—though not only as part of cargoes—or from submerged sites. Finds of this type are known from several shipwrecks: Antikythera, Apollonia B (Cyrenaica, Libya), Grand Congloué B (Marseille, France), Spargi (Sardinia, Italy), Čiovo and Šćedro B (Dalmatia, Croatia).

Comparison of these finds with the bowls recovered from the wreck TSS4 at Torre Santa Sabina, located along the Adriatic coast 30km north of Brindisi (Italy), is particularly fruitful. This is the most important group of finds of this type to have been discovered in submerged contexts, both because of its volume (*c.* 600 fragments belonging to at least 280 cups) and its origin (cargo of a ship). Furthermore, many dozens of Hellenistic moldmade relief bowls also come from the submerged site of Resnik, near Kaštel Novi (Croatia)—this group, probably produced locally, suggests the existence of workshops in Resnik.

Keywords

Hellenistic moldmade relief bowls, shipwrecks and cargoes, submerged sites, Mediterranean Sea, trades and routes

Introduction

Reconstruction of trading relations and sailing routes in the ancient Mediterranean Sea has usually relied on archaeological data from shipwreck cargoes of which the study of amphorae has always been the main and fundamental source. Amphorae have traditionally played a key role in our understanding of commercial relations between the cities of the Mediterranean Basin, in particular where they occur in association with equally important classes of fine wares (e.g. black-gloss, red-gloss or red-slip ware, etc.) or common wares and cooking vessels.

Yet the study of other specific—but less conventional—categories of objects, possibly coming from shipwreck cargoes, may offer different possibilities for collecting new archaeological data sets. It also contributes to a more precise definition of the pattern of sailing routes and trends in the trades in the ancient Mediterranean.

The main aim of this research is to provide a new point of view for understanding the role of some important trading hubs within the Mediterranean Basin and for defining their manufacturing and commercial relations during the Hellenistic and Late Roman Republican periods. Following the methodology adopted in Antonazzo (2015–2016), the research has been carried out through the investigation of a specific class of artefact, generally defined as 'Hellenistic moldmade relief bowls'. This paper focuses on finds discovered at submerged sites, with special attention to bowls of this kind recovered from shipwrecks as part of cargoes. Indeed, they may offer new archaeological data about the origins of the ships and contribute to the definition of the nature of commercial relations between the different areas of the Mediterranean Basin. All the data and final results of this paper are updated to 2017

Hellenistic moldmade relief bowls

Bowls defined as 'Hellenistic moldmade relief bowls' belong to a very broad group of Hellenistic ceramic vessels produced from about the last quarter of the 3rd century BC to the first half of the 1st century BC. Production started in Athens at the end of the 3rd century BC. Clay bowls decorated with motifs in relief suddenly appeared, an innovation aiming to imitate the luxurious and more expensive metal vessels. Athenian strata have yielded the oldest finds of this class of object, but bowls of the same type have been discovered frequently across the ancient Mediterranean area.

The moldmade relief decoration technique was an instant success and these products became immediately fashionable. Local workshops were established first in Corinth and then in numerous other cities especially in Greece (Argos, Ephestia, Elis, Gortys of Arcadia, etc.) and Asia Minor (particularly Ephesos, Knidos, Hierapolis of Phrygia, Kyme, Miletus, Pergamon, Samos, Sardis, etc.), and also in the Adriatic (Dyrrachium, Pharos, Resnik, Vis/Issa, Zadar/Iader, etc.) and Tyrrhenian (Cosa, Mevania and Ocriculum, Nora, etc.) areas and in the Black Sea region (Pontic Olbia, Pantikapaion, Tomis, etc.). At the same time the exports spread throughout the entire Mediterranean Basin (Antonazzo 2015–2016; Babin 2004; Bouzek 1985, 1990; Brusić 1990, 1999; Courby 1922; Dereboylu 2001; Edwards 1981, 1986; Edwards 1956, 1965, 1975; Guldager Bilde 1993, 2010; Kögler 2000, 2014; Ladstätter 2005; Laumonier 1977; Massa 1992; Puppo 1995; Rogl 2001, 2014; Rotroff 1982, 1997; Rotroff and Oliver 2003; Semeraro 2003, 2005; Šešelj 2008; Siebert 1977, 1978).

All the bowls were characterised mainly by a hemispherical shape with relief decorations and produced using a unique though common technique of manufacture: their standard manufacturing process used moulds to define shape (modelling it also on the potter wheel) and relief motifs. According to Rotroff (1982: 2–3), we should define these products as 'Hellenistic hemispherical moldmade ceramic relief bowls' to encapsulate all their peculiarities, but this definition, although appropriate, seems too complex a periphrasis.

The class is also known by the conventional term 'Megarian bowls' coined by Benndorf (1868) and still used for its univocal and synthetic value; this term is however incorrect, as it is the result of an archaeological misunderstanding. During his research Benndorf wrongly thought that Megara had been the first production centre, but we now know that this type of bowls was never produced there.

Many definitions ('Hemispherical moldmade relief bowls', 'Hellenistic relief bowls', 'Moulded relief ware', 'Moldmade bowls', etc.) created by several authors (Brusić 1999: 4; Edwards 1956: 83–84; Edwards 1975: 151; Günay Tuluk 2001: 51; Massa 1992: 32; Rotroff 1982: 2–3; Rotroff 1997: 3; Rotroff and Oliver 2003: 91) represent other attempts—more or less successful—to simplify the nomenclature, however, none of them use unequivocal terms. More recently, the acronym MMBs for 'MoldMade Bowls' has also been proposed (Gudalger Bilde 2010: 269; Rosenthal-Heginbottom 2016: 113). In the following text, we introduce the acronym HMR (Hellenistic Moldmade Relief) bowls to indicate this class of wares.

Hellenistic moldmade relief bowls from shipwrecks and submerged sites

Although many publications include studies of HMR bowls, in many cases this class of objects is not completely understood and its significance is underestimated. This kind of pottery can offer a new perspective for the study of commercial relationships between the cities of the Mediterranean Basin during the Late Roman Republican period. Through the identification of production workshops and the study of specimens and fragments found in stratified contexts in settlements, necropoleis and tombs, on sites for votive offerings as well as underwater sites, it is possible to plot the distribution of the HMR bowls across the Mediterranean. These geographical data may contribute to our understanding of the relations and connections between different areas in the Mediterranean and may also support hypotheses about ancient trades and routes.

In this paper, our investigation is focused exclusively on the interpretation of significant HMR bowls recovered during underwater archaeological research and brought to light from shipwrecks or other submerged sites. Special attention is focused on those particularly significant assemblages of bowls that can be identified as parts of cargoes.

Torre Santa Sabina 4 shipwreck

Torre Santa Sabina is a small natural landing place located along the Adriatic coast of southern Apulia, about 30km north of Brindisi, Italy (Figure 1: n. 1). The importance of the bay is revealed by the exceptional underwater evidence discovered on the seabed, including the remains of cargoes and wooden hulls related to at least five ships (Antonazzo 2004–2005; Antonazzo 2014; Antonazzo and Nuovo 2018; Auriemma 2014). In particular, a significant volume of Hellenistic Moldmade Relief ware has been recovered from the submerged context related to the shipwreck named Torre Santa Sabina 4 (TSS4).

This archaeological evidence consists of *c.* 600 fragments belonging to at least 280 bowls; they surely represent the most important group of finds of this type discovered in Italy due both to the noteworthy quantity and to find context (Figure 2). The majority of these finds can be identified as imports from Asia Minor, especially from the workshops of Ephesos, Miletus and Knidos that were already known for their exports to Italy, Spain, southern Gaul and even southern Russia. Among those produced at Ephesos, the bowls related to the workshop of Menemachos (mid-2nd century BC) and the so-called workshop of the Monogram [ΠΑΡ] are particularly significant; the latter was the most

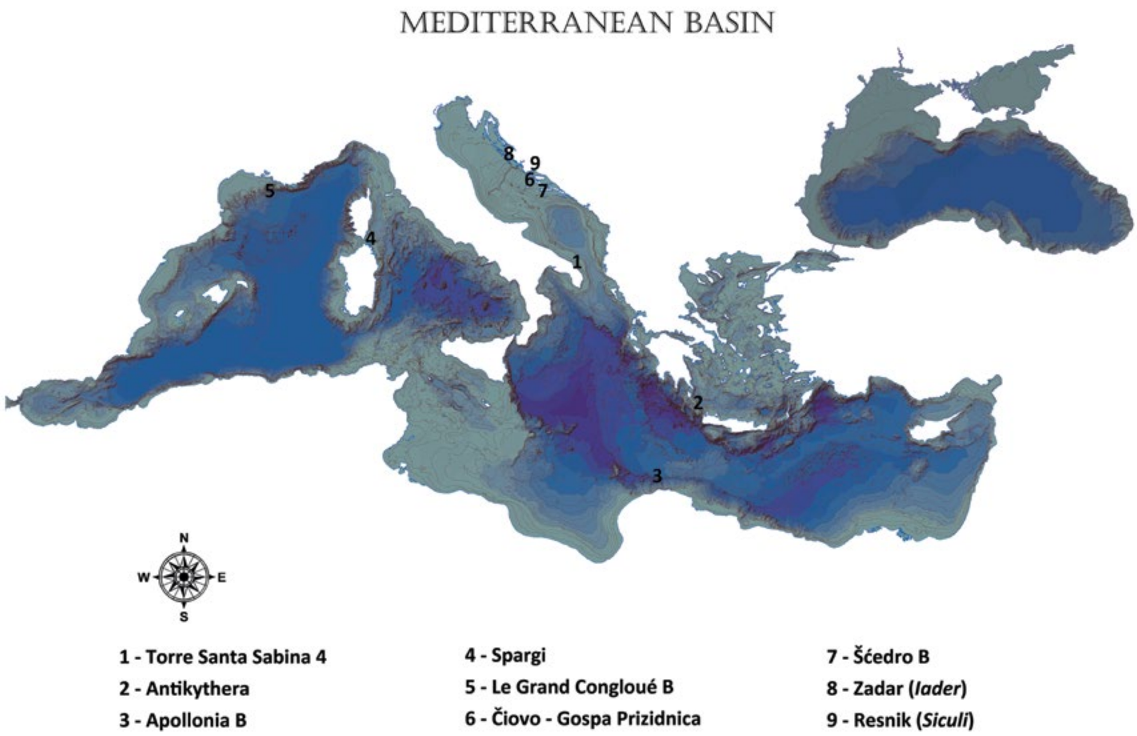

Figure 1. Hellenistic moldmade relief bowls from shipwrecks and submerged sites in the Mediterranean Basin.

Figure 2. Torre Santa Sabina 4 shipwreck: some HMR bowls (A. Antonazzo; University of Salento).

important Aegean production centre in the second and third quarters of the 2nd century BC.

Other Ionian workshops can be identified in this group of finds, such as the Beautiful Medusas (dated to the first half of the 2nd century BC), the Comedian with the Stick and Philon (dated to the end of the 2nd–1st century BC), yet these are less represented. A smaller number of specimens correspond to Attic production (or show some Attic influence) and Peloponnesian workshops (Argos, Corinth, Sparta, Elis).

The presence of a specimen from the workshop of the Argive-Corinthian Monogram is noteworthy as the only one from the eastern Peloponnese that we know travelled beyond its regional boundaries between the end of the 3rd and the middle of the 2nd century BC (Antonazzo 2014; Antonazzo 2015-2016; Siebert 1977).

In contrast, it seems that the so-called 'Tarantine' production identified by G. Siebert (1977) can almost certainly be discounted. The author assigned only five fragmentary examples to this group, and these are considered dubious for various reasons: uncertain identification due to alterations of the clay, the oddity of their presence—limited to only a few fragments—in a cargo of cups exclusively imported from Greece and finally the lack of conspicuous finds of the same ware in Taranto itself. All these factors could instead point to an origin in the eastern Adriatic.

A very small number of bowls (including several decorated with accurate vegetal motifs accompanied by masks on the bottom) can be compared to examples found in many eastern Adriatic sites, like Palagruža, Resnik, Vis and Cape Ploča, among which several fragments of relief kraters are comparable to the corresponding pieces from Torre Santa Sabina. Even examples of the Ionic type, characterised by the so-called 'Delian' profile, find numerous parallels with other finds from central Dalmatia and the *ateliers* of Dyrrachium (Antonazzo 2014; Antonazzo 2015–2016).

The main cargo of the ship TSS4 consisted of a significant number of Late Republican amphorae of Salentine production (Apani and Giancola types, for both wine and oil, that are a transitional type between the late Greco-Italic and the Lamboglia 2), Dressel 2–4 (probably produced in Kos together with Chian, Knidian and Thasian types) and Rhodian amphorae (some of which are stamped with the eponym *Aristodamos* II), several 'early' Tripolitanian productions and one nearly complete Punic amphora. The rest of the cargo included fine wares, storage and cooking wares produced in Puglia, in the Aegean Basin, and, to a lesser extent, in the Tyrrhenian Basin: black-gloss ware; Campana A ware; Eastern Sigillata A ware; Knidian-type cups; 'colour-coated ware'; thin-walled pottery; lamps; plain and cooking wares (Antonazzo 2014; Auriemma 2014). The amphorae and other items of the cargo suggest that the wreck should be dated to the second half of the 2nd century BC.

The ship's hull was not identified; only a few small fragments of wood were recovered during the 1970s and 1980s research. Some of them seemed burnt, suggesting that the ship sank because of fire on board and broke against the cliff. Another wooden boat fragment, perhaps part of the keel, was recovered during the excavations carried out between 2007 and 2012 by the Underwater Archaeology team of the University of Salento. The ^{14}C analysis, carried out by the CEDAD - CEnter of Applied Physics, DAting e Diagnostics (see http://www.cedad.unisalento.it/en/how-to-find-us-and-contact.php) of the University of Salento dated the wood fragment to 125 BC (Antonazzo and Nuovo 2018).

Antikythera shipwreck

A few HMR bowls, some inscribed with Greek characters, are associated with the cargo of the Antikythera A ship (Figure 1: n. 2). They seem to have mainly related to daily life on board. Several cooking vessels, various types of fragmentary black-glazed plates, lekythoi, lamps (in metal or in clay with traces of use), a manual rotary grinder, a grindstone and many pieces for the crew's games have been interpreted in the same way (Bouya 2012b: 30–31; Gadolou 2012a: 51; Gadolou 2012b: 84; Kavvadias 2012: 183).

This wreck is dated to the second quarter of the 1st century BC (*c.* 75–50 BC) by 29 commercial amphorae from Rhodes, Kos, Ephesos (Nikandros Group) and the Adriatic coast (Lamboglia 2). The other finds, in addition to the important Antikythera Mechanism, consist of original bronze statues and statuettes, 36 marble statues, three bronze *klinai*, vessels of copper, lead and tin, silver bowls, gold jewellery and precious stones, coins, 20 glass vessels, fine red slipped tableware and Eastern Sigillata A hemispherical cups and 47 lagynoi (mostly for wine transportation). Many more amphorae and goods may still be on the seabed (Bouya 2012a: 26; Bouya 2012b: 29–31; Christopoulou, Gadolou and Bouyia 2012; Gadolou 2012b: 82; Parker 1992: 55–56). A. Laumonier (1977: 7, 275) attributed one of the HMR fragments (Edwards 1965: 18–19, 26) to the Ionian workshop of Hèra(ios) and dated it to *c.* 80 BC (Figure 3).

Apollonia B shipwreck

The wrecked cargo of the Apollonia B ship was found off the coast of Cyrenaica, in Libya (Figure 1: n. 3), at a depth of 8m and near wreck A, apparently without any surviving hull remains.

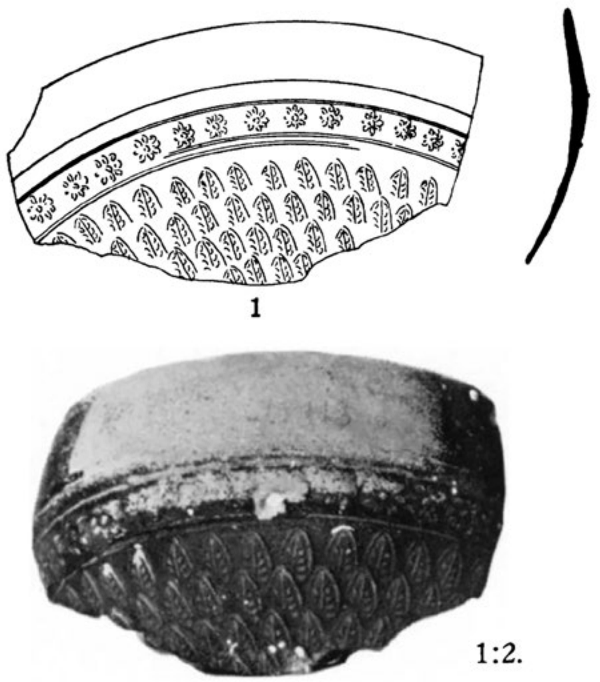

Figure 3. Antikythera A shipwreck: fragment of HMR bowl attributed to the Workshop of Hera[ios] (Edwards 1965, edited).

The main cargo was comprised HMR bowls (still defined as 'Megarian bowls') found in association with Rhodian amphorae. Some of the bowls have the stamps of the potter *Menemachos* and for this reason they have been attributed to the Ephesian workshop (Laronde 1987; Parker 1992: 57).

The Rhodian amphorae have stamps of *Drakontidas* and *Aristonos* that allow the cargo to be dated. In the past, it was dated to 180–150 BC but the new low chronology proposed by G. Finkielsztejn dates *Drakontidas* stamps to 167–165 BC, and *Aristonos II* stamps to 150–147 BC (Finkielsztejn 2001: 131, 135–36; Lawall 2005: 36; Parker 1992: 57).

Spargi shipwreck

This wreck and its rich cargo were found at a depth of about 17–18m near the Island of Spargi (Figure 1: n. 4), not far from La Maddalena in Sardinia, Italy, and are dated to 120–100 BC.

The cargo comprised a very large number of amphorae especially Dressel 1A and Dressel 1B, as well as some ovoid amphorae and several small Rhodian amphorae (Pallarés 1979; Pallarés 2004; Parker 1992: 409–11).

The rest of the cargo consisted of large quantities of black-gloss pottery (thousands of pieces with fabric related to Campana B, from northern Campania or southern Latium), several moulded glass alabastra, 'presigillata' ware in several different fabric varieties, thin-walled pottery, lamps, red-and-black bowls, unguentaria, lagynoi and coarseware.

Other finds included worked or half-worked stones, beads of glass and lapis lazuli, glass and bone pendants, amulets, buttons and pins, a ring and a bone box that belonged to the crew; about 100 fragments of Campana A pottery belonged to shipboard supplies and many marble and bronze objects were assigned to the shrine of the ship (Pallarés 1979; Pallarés 2004; Parker 1992: 409–11).

Hellenistic relief pottery from Pergamon was associated with the amphorae of the cargo and, also in this case, a few fragments of HMR bowls were found, which likely belonged to the crew. The fragments were very small and poorly preserved (Figure 4), nevertheless their profile could be identified as typically Ionian (wrongly defined as 'Delian') of Eastern production (Figure 4).

This feature probably confirms their origin from the eastern Aegean, possibly by way of the free port of Delos or maybe of Pergamon (Cucuzza and Falezza 2009: 617; Pallarés 1979: 154–55, 173–74 and figures 32–33; Parker 1992: 410).

Le Grand Congloué B shipwreck

About a dozen fragments reveal the presence of a few HMR bowls in the cargo. These specimens were recovered from the seabed near the islet of Le Grand Congloué, south of Marseille, France (Figure 1: n. 5), during research in the years 1952-1955 (Benoit 1961: 72, 99). The bowls were found beside parts of the cargo of the B wreck, corresponding to the second wreck of Le Grand Congloué that was overlying wreck A (Bass 1963: 156; Benoit 1954: 47; Parker 1992: 200–01). The fragments showed decorations made of vegetal motifs or imbricate leaves and the characteristic Ionian profile; they had no inscriptions or signatures (Figure 5).

Fernand Benoit (1961: 72, 99–100) dated the wreck to 110-80 BC and defined the Hellenistic pottery finds as '*bols à relief hellénistiques*' imported from Delos. However, A. Laumonier (1977: 7, 21, 313) attributed some of the bowls more precisely to the Ephesian workshops of Menemachos and of the 'Plagiaire / C-I'. The bowls were part of a cargo which mostly consisted of a large number of Dressel 1A amphorae, probably made in Etruria. The other finds were represented by two Punic amphorae, Campana B (20 pieces) and Campana C pottery, thin-

Figure 4. Spargi shipwreck: fragments of HMR bowls (Pallarés 1979, edited).

Figure 5. Le Grand Congloué B shipwreck: fragments of HMR bowls
(Benoit 1961, edited).

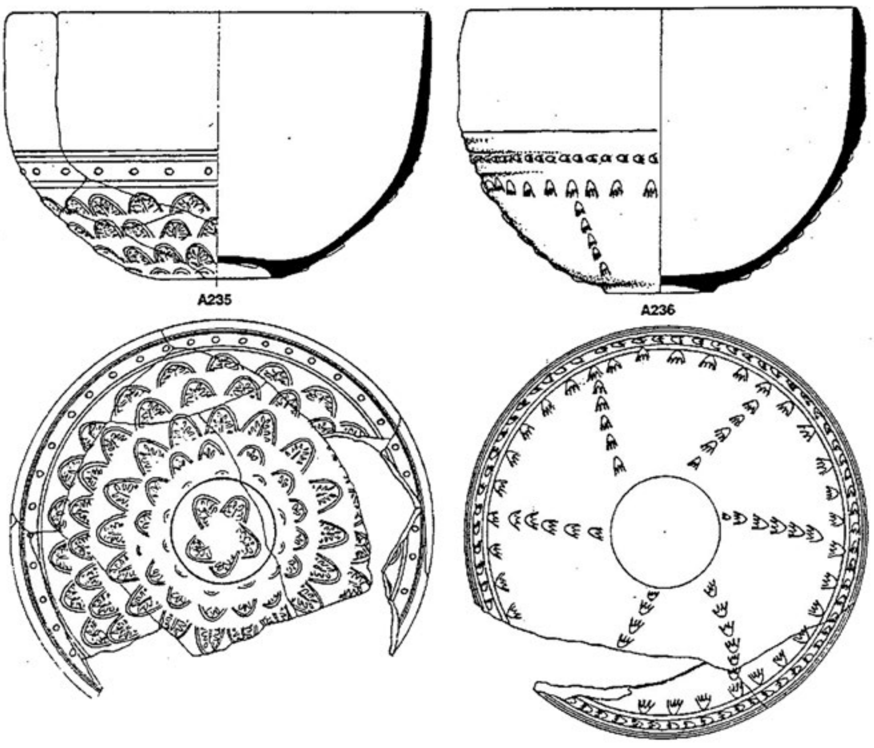

Figure 6. Čiovo shipwreck: HMR bowls of eastern Adriatic production (Brusić 1999, edited).

walled pottery and various coarseware vessels (Bass 1963: 156; Benoit 1961: 72; Parker 1992: 201).

Čiovo-Gospa Prizidnica shipwreck

Three specimens of HMR ware were brought to light from a shipwreck discovered near Čiovo Island, Gospa Prizidnica, in Dalmatia, not far from Resnik (Figure 1: n. 6). The bowls were found in association with black-gloss ware and a main cargo of Lamboglia 2 amphorae. The small number of HMR bowls, however, does not suggest the existence of a related cargo. The decorations show vegetal relief motifs, in two cases with little imbricate leaves (Figure 6).

On the basis of their shapes and decorations the bowls have been attributed to the Eastern Adriatic workshops; the influence of the manufacture of Dyrrachium has been noted in particular (Brusić 1999: 10, 15, 95, 171, n. A235–A237; Kirigin, Katunarić and Šešelj 2005: 16, 24, figure 15; Parker 1992: 146; Šešelj 2008: 105).

Šćedro B shipwreck

A single HMR bowl comes from the site of the Šćedro B shipwreck near the small Island of Šćedro, (ancient Tauris) in Dalmatia (Figure 1: n. 7). The relief bowl was found beside parts of the cargo and ship equipment, together with black-gloss ware and a main cargo of Lamboglia 2 amphorae (Brusić 1999; Kirigin, Katunarić and Šešelj 2005; Kirigin, Katunarić and Šešelj 2006; Parker 1992: 388–89).

Zadar (Iader)—submerged site

Some important finds of HMR ware come from urban contexts and especially from the ancient port of nearby Zadar, ancient Iader (Figure 1: n. 8). The most important specimen for our research is a mould recovered from the seabed at a 1.8m depth. The mould was used to make relief kraters rather than hemispherical bowls. This find is unique for the city but its presence suggests the existence of a local workshop for the production of HMR ware. Moreover, the same relief decorative motif has been discovered on a fragment of a bowl found in Resnik (Brusić 1999: 9, 14, 76 n. 119, 153 and Figure 21).

Resnik—submerged site

An important assemblage of HMR ware comes from the submerged site of the Hellenistic port of the city of Resnik, situated near Kaštel Novi in southern Dalmatia (Figure 1: n. 9). Resnik has been identified with the ancient Roman city of Siculi, and the remains of the Hellenistic port have been discovered about 50m from the coast at a depth of 2–6m. These remains consist of heaps of stones and a layer rich in artefacts such as pottery, metal objects, silver and bronze coins, wooden objects etc.; they allow us to date the port as being in existence prior to the 1st century BC (Brusić 1999: 9–10; Kirigin, Katunarić and Šešelj 2005: 16, 24).

The Resnik assemblage of HMR ware comprises about 104 fragments of bowls and moulds—they belong to the same class as the other finds in the Mediterranean Basin, yet they show peculiar features of local manufacture (colours and characteristics of clay and slip). These peculiarities and the discovery of moulds and stamps have suggested that Resnik had its own local workshop for the production of this kind of pottery. At the same time, the large number of fragments suggests that Resnik was the main production centre on the eastern Adriatic coast (Brusić 1990: 117–19; Brusić 1999: 9–10, 77). The discovery of local workshops both in Resnik and in Vis (ancient Issa) and Pharos confirms the existence of a Hellenistic manufacturing centre in Dalmatia (Mise and Šeselj 2008: 118), probably influenced by the Dyrrachium workshops of Aristen and of Sopatros (Šeselj 2008: 105–07).

New data and future perspectives

The investigation of HMR bowls from shipwreck contexts offers specific possibilities for research. By comparing cargoes and contexts in detail we may have a key to interpreting many archaeological data sets which have as yet not been fully understood. Furthermore, a different point of view can contribute to the formulating of new questions and to increasing knowledge of contacts, exchanges and networks of commercial relations that were active in the Hellenistic world.

The research highlighted some features that link several shipwreck and raised some doubts. A significant element of interest is the association of the HMR bowls with specific kinds of goods in different cargoes:

- Campana A and B pottery: found on Torre Santa Sabina 4, Le Grand Congloué B and Spargi;
- Thin-walled pottery: found on Torre Santa Sabina 4, Le Grand Congloué B and Spargi;
- Rhodian amphorae: found on Torre Santa Sabina 4, Spargi, Apollonia B and Antikythera;
- Lamboglia 2 amphorae: found on Torre Santa Sabina 4, Antikythera , Čiovo-Gospa Prizidnica and Šćedro B;
- Black-gloss ware: found on Torre Santa Sabina 4, Čiovo - Gospa Prizidnica and Šćedro B; and
- Dressel 1A amphorae: found on Le Grand Congloué B and Spargi.

The coexistence with Rhodian amphorae may be highly significant—it is possible, in fact, that HMR bowls imported via maritime trade have travelled along the same routes as Rhodian amphorae. Southern Italian merchants surely had a key role in the trade of those items. Apulian ports were probably a crucial staging point for the commercial exchange of Rhodian products (mostly wine, but also the purchase and reselling of grain), particularly in the 2nd century BC. Rhodian commerce seems to have followed two routes from Apulia: one towards the Ionian Sea and terminating at Taranto; and, one or more towards the Adriatic Sea, along the eastern coast (Auriemma and Silvestrelli 2013: 445–46; Benoit 1961).

In this context, and despite the natural size of its bay, Torre Santa Sabina's little harbour certainly had an enduring and increasing key-role along the trade routes of the Adriatic Sea during the Late Roman Republican period. Its proximity to Brundisium (Brindisi), to the amphorae production sites of Apani and Giancola, as well as to quarries and to the considerable road networks related to the Via Traiana, made the harbour one of the most important in cabotage routes.

Cargoes of oriental amphorae and fine wares sailed on Aegean and Greek ships towards the harbours of the Adriatic coast. Then the ships departed towards the north-eastern Adriatic Sea, sailing from harbours like Torre Santa Sabina and exporting Salentine oil and wine in amphorae of local production. The Late Republican cargo of TSS4 is a 'cargo of secondary formation', according to this 'redistributive' model of trade—amphorae both of local and Aegean production travelled to Brundisium together with eastern fine and cooking wares. From here, eastern imports were shipped to other destinations along with local products, probably following vertical routes along the Adriatic coast and with a final destination along the western Adriatic route (Antonazzo 2014; Antonazzo and Nuovo 2018; Auriemma 2014).

The archaeological evidence along the coast and the large number of amphorae and fine wares from TSS4 wreck had already revealed that during the Late Roman Republican period, Torre Santa Sabina became a flourishing hub, subsidiary to Brindisi, in the trades from the East and Greece towards the eastern Adriatic coast and Brindisi. It continued to play a key role along the trade routes of the Adriatic Sea over the centuries. The comparison with the other shipwrecks considered in this paper seems to extend its importance. In particular we have to highlight the great value of Torre Santa Sabina's HMR bowls. Now it is possible to confirm that the discovery of a cargo of bowls of this class from a shipwreck is exceptional not only in the region of Italy, but also in the whole Mediterranean Basin, where no similar context has been found (Antonazzo 2015-2016).

The context of Torre Santa Sabina, with the wreck TSS4 and its cargo of HMR bowls, is still unique especially when contrasted with the exiguous quantity of fragments recovered from the other wrecks. This feature raises questions about why TSS4 is unique. The cargo of Apollonia B should be studied more precisely and also the bowls associated with the crew; yet the main question is to try to identify the place (or places) of origin and destination for the great number of HMR bowls on TSS4 wreck discussed above.

Many of these objects can be identified as imports from several workshops in Greece or Asia Minor, especially from the workshops of Menemachos and Monogram [ΠAP]. The products of these workshops were initially attributed to Delos. However, archaeological data clearly suggest that local production in Delos was unlikely to have existed, and allow us to locate the workshops in the Ionian area, especially in the sites of Ephesos and Miletos or Knidos.

The workshop of the so-called Monogram [ΠAP] has been firmly identified in Ephesos and represents the most important Aegean production centre in the second and third quarters of the 2nd century BC; it had branch facilities as far away as Samos. Its exports reached Italy, Spain, southern Gaul and southern Russia (Gudalger Bilde 2010: 276; Rogl 2001: 100-105; Rogl 2014: 132-133 and 136; Rosenthal-Heginbottom 2016: 117-118). Also, the workshop of Menemachos, in the past considered one of the most important Delian potters for this type of bowls, should probably be located in the area of Ephesos (Dereboylu 2001: 30, 36–37). Consequently, we can consider Ephesos the most important place of production for the Hellenistic Moldmade Relief bowls (Gudalger Bilde 2010: 271; Laumonier 1977; Rogl 2001: 103; Rosenthal-Heginbottom 2016: 117). Yet, the role of the free port of Delos should not be underestimated. In fact, its market was the main centre of redistribution of products and goods between East and West. Delos was a tax-free port where Roman merchants and bankers predominantly operated during the first half of the 1st century.

Thousands of fragments and bowls of HMR ware have been found in Delos, many of which can be attributed to the Ephesian workshops of the Monogram [ΠAP], of Menemachos and of Hera[ios]. For these reasons we may suggest a common origin for the Hellenistic moldmade relief bowls found on the shipwrecks of the Grand Congloué B, Apollonia B, Torre Santa Sabina 4 and Spargi. It is possible, for example, that the ship of Spargi loaded its goods at the market of Delos.

A similar, although not exclusive, hypothesis could be proposed for the Antikythera shipwreck. The cargo of this big commercial ship provides important trading information not only on wine and foodstuffs but also on fine wares and luxury items such as sculptures, jewellery, utensils made of glass or precious metals, coins etc. during the late Hellenistic period. The sinking near the east coast of Antikythera suggests that the ship came from the eastern Aegean; at the same time, the inscriptions discovered on several fragments of pottery confirm that some men on board were Greek-speakers. Moreover, on the basis of the items of the cargo it has been suggested that the final destination may have been the Bay of Naples and the Roman port of Puteoli (Bouya 2012b: 29, 31; Gadolou 2012b: 83) whereas there are three different hypotheses for the places of origin. The first is Delos, market for the redistribution of luxury and exotic goods. The other two, Pergamon and Ephesos, have also been suggested mainly due to the presence of certain amphorae, lamps and coins (Bouya 2012a: 26; Bouya 2012b: 29–30; Gadolou 2012b: 83).

The latter place seems coherent with the identification of a fragment of bowl associated with the Ephesian production of Hera[ios] (Laumonier 1977: 7, 275). Yet the presence of the Lamboglia 2 amphorae does not exclude different contents, usage by the crew, secondary usage or redistributed trade (Bouya 2012a: 26; Bouya 2012b: 29–30; Gadolou 2012b: 83). Moreover, interesting information could come from the discoveries of HMR bowls in the cargoes of shipwrecks off the eastern Adriatic coast such as the Čiovo—Gospa Prizidnica and Šćedro B wrecks. In these cases, the bowls could be compared with those produced locally in the Dalmatian region.

Indeed, in addition to all these findings, the large number of HMR bowls from the submerged site of Resnik, near Kaštel Novi (Croatia), is of great relevance. About 104 pieces were found in this underwater archaeological site. They were probably produced locally and suggest the presence of at least one workshop for the production of the Hellenistic pottery in Resnik.

The finds of HMR bowls along the eastern coast of the Adriatic Sea seem to show a slightly different system of trade. Shipwrecks and submerged sites, in fact, seem to be less involved in the import/export of HMR products of Ionian origin. In this area, according to the current state of research, products associated with the local manufacture referred to Dalmatian area are predominant.

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It’s Not About a Ship: Presenting the *Mary Rose* in a New Museum

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Abstract

The *Mary Rose* was raised in October 1982 after what is still the largest ever archaeological excavation underwater (Figure 1). Although the ship and a selection of artefacts from within were displayed in two museums in Portsmouth over the following 34 years, it was not until July 2016 that the permanent museum housing both the ship and the collection in one location was opened to the public in its final form. The *Mary Rose* was excavated in the 20th century but now needed a museum fit for the 21st century.

One of the important concepts of the new Mary Rose Museum was to present the results of this major underwater excavation in a way that would be relevant to a 21st century audience. Although not overstated, archaeology is at the heart of the interpretation: the context of the artefacts is the key to the museum. But how do we ensure that our displays do not turn out to be worthy but dull? How do we make them both authentic *and* interesting? One method we used was to emphasise the intensely personal nature of the objects—to ensure that the artefacts, and more particularly the people who owned and used them on board, were as evident to visitors as the ship herself. This and other concepts used in the displays will be presented.

Keywords

Interpretation, relevance, context, access, authenticity

Introduction

The discovery, excavation and raising of the *Mary Rose* during the 1970s and 1980s has been well documented, from McKee’s accounts of the early years (McKee 1982), Rule’s account of the excavations (Rule 1982), details of the salvage operation (Dobbs 1995) and the five volume publication outlining five major areas of the project: the loss and recovery (Marsden 2003), the ship (Marsden 2009), the armaments (Hildred 2011), the artefacts and human remains (Gardiner 2005) and the conservation (Jones 2003). However this paper will concentrate on the details behind how the results of that seminal excavation are now presented to the public in the Mary Rose museum (Figure 2).

The new museum welcomed one million visitors in the two years after opening but most of the museum was again closed from December 2015 to June 2016 to allow the final building phase to be completed before fully revealing the hull in July 2016. At last it can now be viewed without the previous obstacles of the piping systems and mist from the 30-year spraying phase of the conservation programme or the large air ducts from the intensive drying programme. This paper will summarise the current methods we are using to help the objects, the people and the ship come to life. This illustrates how we approach that final, essential part of the archaeological process: disseminating the results of the work by displaying the ship and her contents to the widest possible audience. This echoes statements of Edson and Dean (1994: 182) and others that it is the museum professional’s responsibility to seek out and try new ways to make the museum experience one that is worthwhile and valuable to the greatest number of people.

Relevance

So how can we make the results of our maritime excavations relevant to the public today? How can museums attract new visitors who might be put off by words such as archaeology, history, ship, navy, maritime or even museum? Over the last 30 years as we teach museum studies courses, we have gone through many catch phrases such as ‘bringing the past to life’, ‘telling stories’, ‘making it personal’, ‘conveying a spirit of place’, and ‘creating a narrative’. One example of current thinking is that people are seeking experiences rather than products. So how can we lure them into our museums using that enticement? The Mary Rose museum has either consciously or subconsciously incorporated all of these concepts in some way. We have drawn on ideas and displays seen in visits to other museums and visitor attractions over the last 40 years, and indeed from so many places that it would be impossible now to acknowledge them all.

People are interested in people. Understanding this is a key to making the museum people-oriented. We use

Figure 1. The raising of the *Mary Rose* in October 1982 (Christopher Dobbs).

Figure 2. Concept photo-montage of the new museum, situated next to HMS *Victory* (© Wilkinson Eyre).

the personal possessions of the crew to get insights into their lives. How important were they or how rich? How religious were they and what did they do in any spare time? What was their profession or how learned were they? In eight showcases in the museum we display objects that were found together or where the archaeology suggests that they belonged to one particular individual. Perhaps they were found in a chest or in a corner of a deck next to some human remains. These can be used to explore those questions and, hence, tell individual stories about specific members of the crew. We relate the objects to everyday life.

As well as including the obvious objects like guns or ship's equipment, or unique objects such as a Tudor shawm (a woodwind instrument), a backgammon set or a pocket sundial, the collection includes everyday objects as well such as a wooden shovel, a simple three-legged stool, a carpenter's trestle, and a bread trough. It also includes objects that almost any society in the world could identify with, yet they come from a world away—from 16th-century Tudor England. It is the *extraordinarily ordinary* objects that contribute to making the experience special—not just the spectacular, the unique or the valuable.

The approach to the museum has not just been about displaying the ship and the objects to tell the stories of the people but trying to get that holistic approach as summarised by Black (2005: 269) in his essay about 'The Engaging Museum'. Incorporating intangible elements into the philosophy and the visitor experience was a core part of the vision for the interpretation but also the hardest to describe to stakeholders and potential funding sources simply because it was intangible.

Spirit of Place

Making the museum relevant is not just about selecting the right objects and telling the right stories, it is about creating the right atmosphere so that visitors are receptive to new ideas and information or get some feeling of being transported back in time [apologies, another catch phrase]. As a variant to the concept of 'conveying a spirit of place' we hope we have provided the closest practical experience to feeling that you are walking down the decks of the *Mary Rose* or meeting the crew. Both experiences are impossible to achieve, but that does not mean we should not try to get close to those ideals. Lighting, ambient sounds, the use of space (or rather restricted space making it feel more enclosed) all contribute to helping visitors feel, perhaps sub-consciously, that they are in a different place.

But how can we create these narratives, atmospheres and stories without just creating 'make-believe'—a Disney World or Hollywood version of the truth? A key is to always ensure that authenticity and integrity are uppermost in the mind when conceiving the displays and experiences.

Authenticity and integrity

Central to our museum philosophy is the need for authenticity and integrity. In a world where virtual reality is the must have new thing, at the museum we are more keen on displaying and getting the most out of the real thing. That is central to what museums are for. You can visit virtual museums or see things in 3-D using Oculus Rift headsets anywhere, but we display the *real* 3-D item. We have the 'power of the real thing' as Susan Pearce (1994: 20) and others call it. Many visitors just cannot believe that the astonishingly well-preserved objects in our museum are nearly 500 years old. They can accept that a bronze cannon is Tudor but not the wooden carriage it is displayed on or the leather bucket beside it, and 'surely the anchor cable on the upper deck display must be a stage set'. No, all the objects behind glass are real and from the *Mary Rose* excavations. One exception we make is that where, for example, the blade of a tool or a knife has not survived and it is essential for the understanding of the item to see what it was, we have mounted it with a blade of frosted acrylic so that the visitor can plainly see the difference between real and replica. In this way, the objects are more understandable, yet their authenticity is not compromised.

A similar philosophy was used during the reconstruction of the hull. Only the original timbers, such as the decks that were removed from the ship shortly before salvage, have been replaced into the hull. Unlike many ancient ships on show, we have not reconstructed missing parts with replacement timbers. Where structural strengthening has been required, totally different material has been used, namely titanium, so that there should be no confusion for visitors as to what is real and what is replica. In recent years some temporary additional scaffold supports have been inserted to stabilise the ship during the air-drying programme, but it is intended that a permanent solution to the hull supports will be designed soon.

Context

Archaeology is about context. Part of the philosophy of authenticity involves using the context in which the artefacts were found. This is already evident from the example above where the context of the personal objects—such as those found in chests—is used to inform the stories. Another way in which we apply context is to use the three largest galleries in the museum to display objects opposite where they were found. This was one of

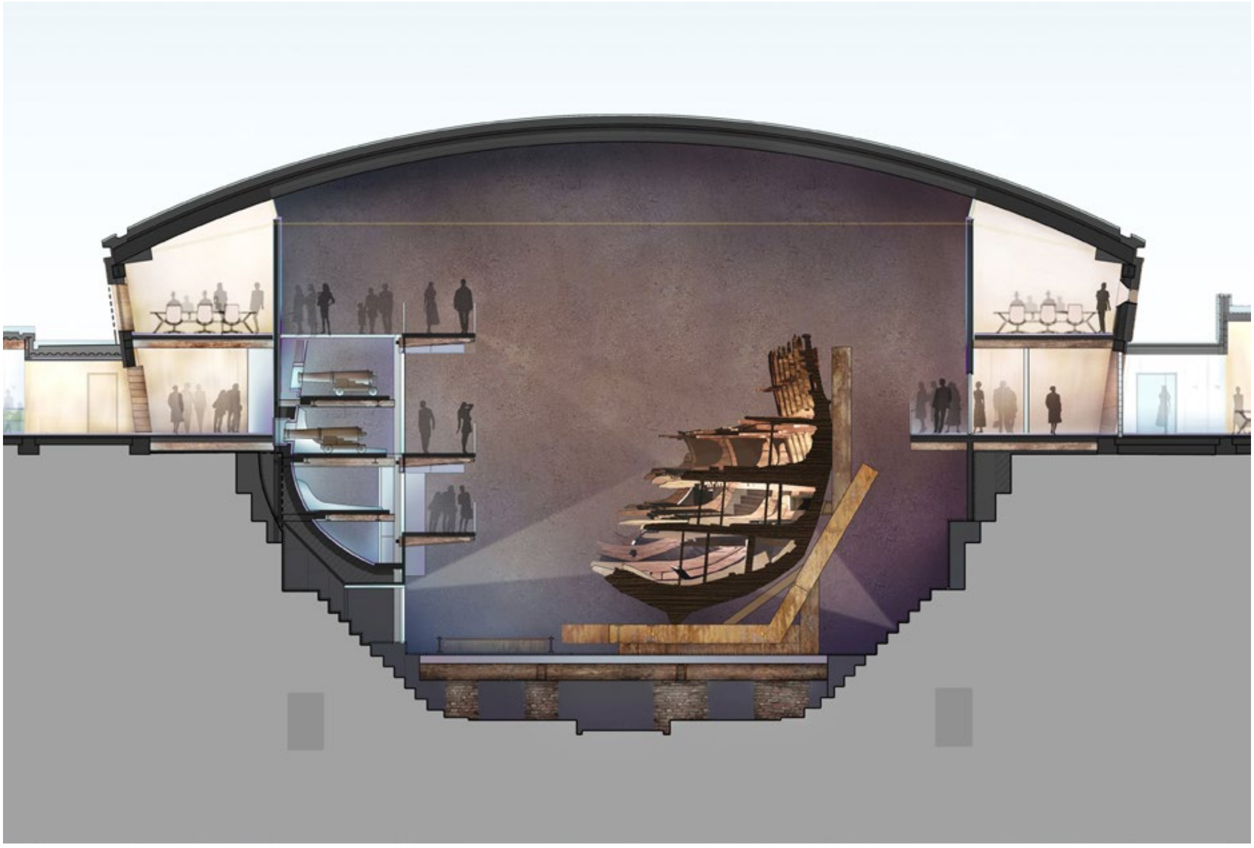

Figure 3. Concept drawing of the museum interior (© Perkins+Will).

the main concepts for the museum (Figure 3) whereby the hull is displayed on one side of the museum, whilst galleries on three levels display thousands of objects opposite the area where they were located on board. These displays are only possible because the locations of all the objects were well recorded by the divers and archaeologists underwater. It is an example of how the archaeology is at the core of the museum but without being over-explained or over-stated.

Another example is in the relationships between the objects displayed on each level of the museum in the end galleries. Those on the lowest floor represent the people and functions of the lower deck: the cook and the purser, storage, provisioning and cooking. Those on the ground floor represent the people and functions of the main deck: the guns and gun furniture on board and also displays about the Surgeon, the Master Carpenter and the Master Gunner as they either had cabins on that deck or chests containing their possessions. Finally, on the top floor there is the 'Men of the Upper Decks' gallery, reflecting the gentlemen and officers of higher status whose accommodation would have been high up on the castle decks of the ship. The archers and their longbows and arrows, and hand-weapons used by soldiers at their action stations are also displayed here. The fine pewter garnish (dining set) of Sir George Carew the vice admiral who died on board and the high status musical instruments of his musicians are also displayed at the top level. This reflects both the geographical distribution of the artefacts as well as the level in society of their owners.

Finally, the floor-to-ceiling glass allows visitors to look back at the ship from all nine of the major galleries (Figure 4) so that there is a constant reminder of the context in which all these objects were found and from which they were carefully excavated and recovered.

Access

Giving access to the results of excavations is a core part of what we do as archaeologists. Much has been said in the past about the importance of archaeological publication and that duty is drilled into us during our academic or avocational training. But how wide an audience does traditional publication reach? Our duty should also be to make the results of our work accessible to the widest possible audience, and museums should play a key role in this dissemination. Access policies in museums used to concentrate on the needs of those with more obvious physical disabilities and, yes, our museum keeps to the best practice of displaying both objects and text within that zone between 700mm and

Figure 4. View of the hold and orlop deck galleries opposite the hull (Hufton+Crow).

1700mm high that allows the best views for both tall and short, seated and standing, young and old. Font shape and size, readability and a 70% contrast between text and background are all well specified in modern museum briefs. But access policies in the 21st century should encompass a whole spectrum of special needs and not just those caused by barriers of mobility, sight, hearing, and language. They should broaden out to be more inclusive towards the wide varieties of intellectual ranges and learning styles.

Four accepted learning styles are Visual, Auditory, Reading/Writing preference and Kinaesthetic. Whilst 20th century museums traditionally coped with the Read / Write and Visual learners, for a 21st century museum to be relevant it has to cater for all learning styles if it is attempting to reach a wide audience. So, yes, we use the objects themselves with text captions and panels, but also audio and video, games, interactives, workstations, and hands-on activities and demonstrations. Targeting different senses is another way of broadening access by using different learning styles and, hence, appeal to new audiences. Sight, hearing and touch are obvious senses to reach but smell is also a very powerful sense for evoking memories and experiences. I would like to do more with taste, but food safety standards would really make this difficult in a museum that does not specialise in food or food products so we have not yet been able to incorporate that sense or experience. But an unusual sense to target is balance. A great deal of effort was taken to replicate the sheer (slope) of the Main Deck in the flooring opposite that level in the ship. This was to ensure that visitors were level with the deck and able to receive an experience close to walking on the deck of the Tudor warship, however, it also affects visitors subconsciously so they feel they are in a different environment. The difficulty was partly in the need to comply with the requirements of the maximum slope angle recommended by best practice or legislation (in the UK this is the DDA or Disability Discrimination Act 1995). Indeed, many visitors will not notice the slope at all, but a few visitors have asked how we get the floor to move beneath them? The answer is that we do not—but, if that is their perception, then the whole concept is no doubt working, i.e. the atmosphere of low light, combined with subtle background ambient sounds of what might be heard on a sailing warship, as well as using space to hint at claustrophobia and a gradient that adjusts awareness. Two people out of almost two million visitors since opening have reported feeling seasick in the Main Deck gallery. Whilst that is not a condition that you would wish on any visitor, perhaps if one-in-a-million visitors feel seasick, then the targeting of different senses at a subtle level is indeed working on many other visitors.

As well as visitors with limiting physical abilities we have also tried to cater for those with limiting mental abilities. An outreach programme enabled visits to many different groups with special needs including those affected by strokes or Alzheimer's. At a different level, the texts in the museum have kept to plain English and appropriate readability without 'dumbing down'. Although the curators were aware of the Ekarv

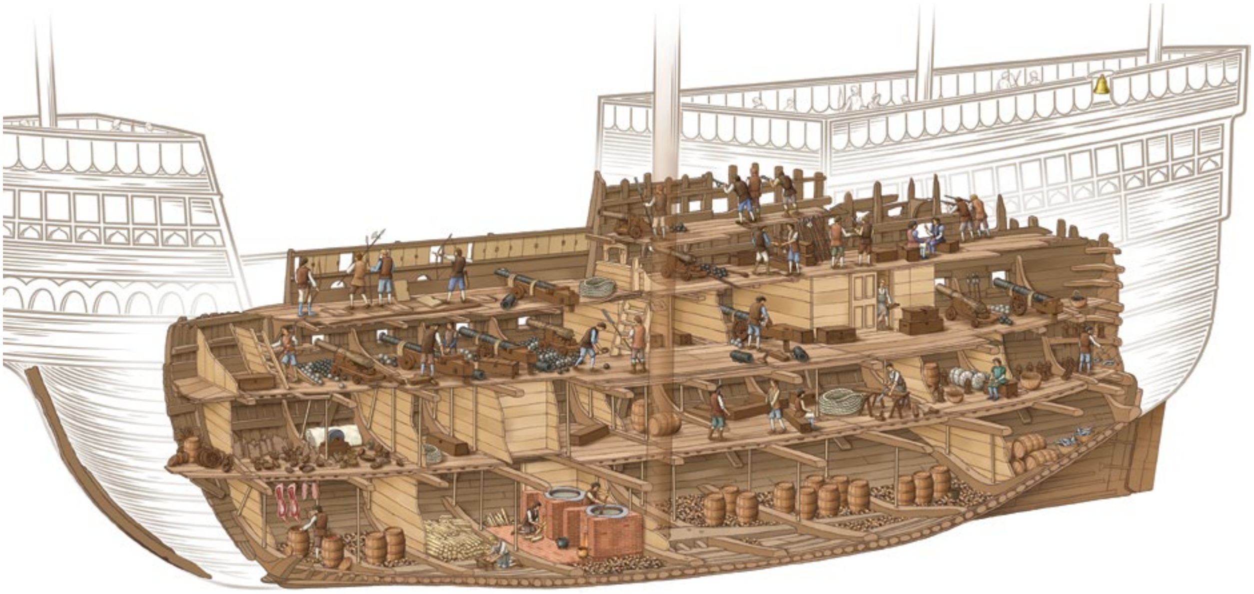

Figure 5. Isometric drawing of the hull with an interpretation of the men and objects (© Mary Rose Trust).

style for captions, they were not written with the strict Ekarv layout but hope to subscribe to the important guidelines of the method proposed by Ekarv (1999: 207). These include using simple language to express complex ideas, avoiding subordinate clauses and complicated construction; and, continually revising and refining the wording.

Sometimes very simple graphics have been used to make a point. An advantage of this is that they are understood by everyone, very quickly, but those who do not think they need such simplicity often think they are for the benefit of children when actually they can help all visitors. Our isometric drawing of the hull with reconstructions of the crew added to give life to the ship in two dimensions looks cartoon-like (Figure 5) but it helps visitors of all ages and a wide range of cognitive abilities, not just the young.

The most rewarding access initiatives are those that are originally designed for one group but which we then find are used by a variety of audiences who had not been predicted in advance. An example is our large print texts. In each gallery there is a complete written set of the text and illustrations for that gallery, situated at a bench in a better-lit area with a magazine rack that holds the simple A4 booklets. The large texts were originally designed for those who find that the size of text that can be used in the captions and panels is too uncomfortable to read. However, visitors who simply get tired use these booklets even more frequently and, as they find rest on the convenient benches, come across the texts and realise they can read the information sitting down. But this is not the same as sitting at home and reading it as they still have the museum atmosphere and they can go over to a display that intrigues them.

The captions in the museum are written in sentences rather than as a simple title so that the stories can be told, and they often encourage visitors to look again at the object to notice a particularly interesting feature. Reading the text in the same galleries allows visitors to go back and do just that, but whilst they read or relax, their hyperactive grandchild or super-interested spouse can continue their overlong inspection of every object and text panel. A third category of users are those who simply cannot be bothered to queue to read the texts as they have visited at the busiest period of the day in the busiest month when, sadly, the museum does get crowded at two particular pinch-points near the most popular exhibits [a problem we still need to solve in other ways].

One final aspect of access worth considering is to recognise that visits for those with limiting abilities should not necessarily be identical to those who do not have special needs. But the visit should be comparable in terms of having experienced or felt something special. We have mentioned above that there are a number of learning styles. Visitors also come with different prior knowledge, different pre-conceptions and different interests. As long as it is possible for all the different visitor types to leave having *felt* something rather than just having learnt something; having empathised with a Tudor sailor from 500 years ago rather than just having looked at some objects, then our vision will have been fulfilled.

Figure 6. Images are projected onto the ship that show the sailors at work in that area. Immediately opposite are the artefacts excavated from the same area (Hufton+Crow).

Conclusions / summary

In the first ever PowerPoint presentation made to stakeholders and then to the Heritage Lottery Fund, a graphic of the themes that we wanted to cover centred on three links. These represented the ship, the objects and the men on board. But, how could we present all three items together in one place when the ship is too fragile to support heavy objects on the decks and the objects have to be housed in different environmentally-controlled conditions and the men tragically perished during the sinking?

When the spraying phase finished in 2016, it became possible to achieve the effect of this by projecting two-minute films onto the hull structure combining these three elements (Figure 6). Volunteers and staff re-enacted short vignettes of life on board. One film reflects more peaceable times whilst a second film shows the men at war. One advantage of using film projected onto the structure is that for five minutes out of seven, the films are turned off and visitors can just view the authentic and original hull—whilst for the two minutes when the films are projected visitors can see the hull and the crew come to life. The people provide scale and movement to an otherwise static ship. But again, the initiative needed to have integrity and authenticity. All the activities that are illustrated could have happened in that part of the ship—and indeed the real objects that are replicated in the films are on display in the mirror image opposite the hull. Men load guns in the gun bays, the cook stirs a broth in the enormous brass cauldron, men sharpen knives on a grindstone that is displayed right opposite. The result is to combine those three elements: the hull, the objects and the men. It is another illustration of how the museum is not just about a ship.

Whilst the museum is not about a ship, the ship provides the context for the museum. As the architects, Chris Wilkinson and Chris Brandon stressed in their initial presentations, the ship is the jewel within the jewel box—the pearl within the oyster. We are so fortunate that we have both the ship and the extraordinary collection of personal and professional objects from 500 years ago. But these items give us insights into the people whose remains we also found and who lived, worked and died aboard that ship in 1545. The museum is not about a ship, it is about people, real people—the men on board, and it is dedicated to their memory.

Acknowledgements

Just like the raising of the *Mary Rose*, the building of the new museum was also a tremendous team effort from many varied disciplines. There were architects and engineers, builders and project managers, fundraisers and administrators, designers and AV specialists, lighting experts and sound engineers: certainly too many people to list in an archaeological publication but whose work ensured the completion of our long-held dreams and visions. The generous grant from the Heritage Lottery Fund was the catalyst without which the new museum would not have been possible. However, I particularly need to single out the tremendous contribution of Dr Eric Kentley, our external adviser whose wise counsel, independent views and constant help as a sounding board ensured the museum content achieved the vision.

Amongst the staff, again, a myriad of people contributed to the whole, but three people cannot be left un-named. Dr Alexzandra Hildred co-authored half of the museum panels as well as the texts for the videos and drill-downs. The late Andrew Elkerton, who also started on the project with us in 1979, was an essential part of the curatorial team as the Registrar in the Collections Department and contributed text and ideas and could always locate details forgotten by others. Rose Smith, our in-house designer contributed more than anyone will ever know and her physical models of each showcase were perfect for allowing curators, brought up in a pre-digital age, to effectively visualise and therefore interpret the displays for future visitors. Indeed, all members of staff and volunteers from the day that the Mary Rose Trust was formed in 1979 (and others before that) are due credit for this latest phase of the Mary Rose Project.

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Underwater Cultural Heritage and Maritime Museums—the Past and the Future

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Abstract

Underwater cultural heritage (UCH) has both an historical and archaeological value. It can reveal a new side to human nature and open up windows to the past. This unique heritage asset includes the remains of ships and shipwrecks, their cargoes, harbours, shipyards, quays, jetties, lighthouses, wharves, fish-traps and the now-submerged ruins of ancient cities and buildings.

Underwater cultural heritage can be presented to the general public in attractive ways and the easiest is via museums. Some museums are still following traditional and outdated methods, which confine artefacts and site information to glass showcases with written labels, which is no longer consistent with modern-day exhibition practices. Without an exciting and engaging approach to the presentation of underwater cultural heritage, museum visits often result in a lack of enthusiasm for this heritage asset. Creative ideas and methods in presenting underwater cultural heritage, i.e. effective in attracting audience, include the reconstruction of underwater archaeological sites or entire ships that visitors can enter and explore. More recently, the use of technology for exhibitions has taken on a new dimension with the use of advanced multimedia, three-dimensional modelling and virtual reality.

This paper will discuss the dilemma of presenting underwater cultural heritage by highlighting some of the creative display methods and ideas, and outline what can be done to encourage audiences to visit museums. Furthermore, this paper will provide a brief overview of some maritime museums around the world and their strategies in presenting and displaying their collections.

Keywords

Presenting heritage, recovery, conservation, maritime museums, 21st century

Introduction

The cultural heritage that lies beneath the sea is part of the universal heritage of humanity and differs in many respects from archaeological sites on land (Grenier 2006: 10; Smith and Couper 2003: 30).

Underwater Cultural Heritage means all traces of human existence having a cultural, historical or archaeological character which have been partially or totally under water, periodically or continuously, for at least 100 years.

Article one of the UNESCO 2001 Convention on the Protection of Underwater Cultural Heritage (Paris 2001)

Thus UCH includes both underwater and terrestrial sites, consisting of the remains of ships and shipwrecks, their cargoes, harbours, ship yards, quays, jetties, lighthouses, wharves, fish-traps and the ruins of ancient cities or villages, that for reasons such as sea level changes or catastrophes, have ended up beneath the surface of the water. UCH also includes aircraft, sea-walls, breakwaters and coastal building defences such as castles (Linder and Raban 1976: 12–13; Martin 1981: 17; Staniforth 1993: 216; UNESCO Convention 2001: 3–4).

Underwater archaeological remains are irreplaceable cultural resources that form part of our national and international heritage, and have a significant role to play in the intricate jigsaw puzzle of the past. They have a historical and archaeological value, as they allow discourse and reflection upon the past and can reveal a new side to human nature, opening up windows to history. If destroyed or disturbed, these archaeological remains are lost forever (Robinson 1998: 3; Vadi 2009: 856–57; Wijkander 2007: 66).

The question now is how we should present this unique heritage in 21st-century museums? How we can deliver this heritage to the public? Should we recover to display?

The dilemma over presenting UCH

UCH can be presented to the general public in attractive ways in museums. However, before displaying, this unique heritage passes through two main stages, recovery and conservation, which are costly, risky and time consuming. Conservation in particular has the highest cost rate; it could exceed the whole project budget (Muckelroy 1980: 180; Pearson 1977: 37). After conservation, the default stage is display, which presents its own dilemmas as archaeologists face the problem of space limitation. The capacity of museums to house excavated shipwrecks or large collections of artefacts is generally limited. In addition, such finds need special display requirements including air-conditioned rooms and controlled humidity, as well as temperature and light control.

The dilemma over presenting UCH lies in the high rate of recovering artefacts and the low rate of displaying them. Whilst there is no reason for recovering any archaeological artefact, plenty of information can be gained from surveying, mapping, photographing and recording alone, without recovering or even disturbing the site by conducting excavation (Hutchinson 1996: 289; Nash 2001: 3; Robinson 1998: 7, 11, 85; Zamora 2008: 21). At the same time, plenty of display methods could be implemented to deliver these underwater artefacts to the public without recovery. If the underwater site or artefact is threatened in some way by natural or human factors, then recovery may be necessary, but only the most threatened underwater artefacts should be recovered.

A considerable number of countries around the world are suffering from this dilemma, and Egypt is one of them. Over the last twenty years, the Egyptian department of Underwater Antiquities, in collaboration with various foreign underwater archaeological expeditions, recovered vast number of artefacts including huge statues, parts of submerged buildings, anchors, coins, pottery, and porcelain, golden and wooden pieces. These ended up in stores and only the archaeologists, specialists and researchers know about them and have the ability to access them. This results in a lack of general public awareness, appreciation and knowledge. Approximately 95% of these artefacts are in storage after years of conservation processes, while 5% are displayed using classical and traditional methods such as glass showcases with information labels or open air displays in a number of places and museums in Egypt (Figure 1).

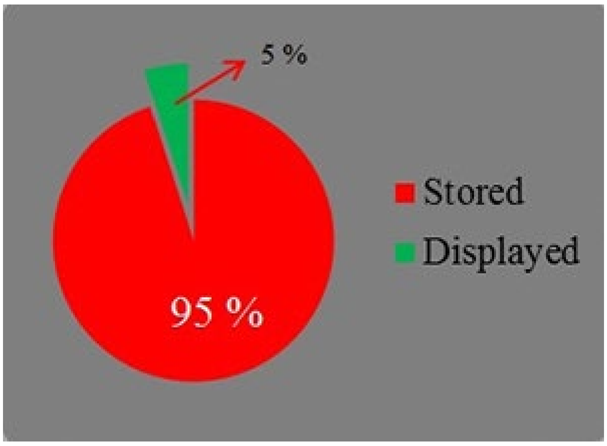

Figure 1. Percentage of displayed verses stored artefacts in Egypt (Chart by the author).

Some museums around the world still follow traditional methods that confine artefacts to glass showcases with written information labels, but this is no longer consistent with modern-day exhibition practices. Without an exciting and engaging approach to the presentation of UCH, museum visits often result in a lack of enthusiasm for this heritage asset. Glass showcases and information labels are a classic approach to museum displays. But we should not stop there.

Obviously, recovering the remains of ancient archaeological artefacts or shipwrecks from the sea depths for exhibition makes it accessible to a much wider audience, leading to a rapid and significant development in the value of UCH in the eyes of the public. For example, the raising of the *Vasa* shipwreck succeeded in attracting the public and the Vasa museum is still one of the most appealing attractions for the general public. Other examples include the raising and displaying of the *Mary Rose* shipwreck (England) and the Bremen Cog shipwreck in the German Maritime Museum in Bremerhaven (Alves 2008: 82).

The following table (Table 1) highlights a number of facts about the recovery and conservation process for the *Vasa*, *Mary Rose* and Bremen Cog shipwrecks (Bjordal and Nilsson 2008: 862; Chippindale 1983: 281–84; Davidde 2002: 83; Delgado 2001: 454; Koschtial 2008: 67–8; Maarleveld, Guérin and Egger 2011: 91–5; Martin and Flemming 1977: 214; Mary Rose Trust 2016; Ortmann, McKinnon and Richards 2010: 39; Schofield *et al.* 2011: 354; Vasa Museet 2016).

While these shipwrecks succeeded in attracting the general public, the recovery and conservation operations were exceedingly costly, risky and time consuming, and are exacerbated by the potential hazards of losing and damaging the artefacts. At the same time, this heritage could be made much more accessible and attractive to the public, while avoiding the recovery of every discovered artefact, by expanding the range of display techniques. And the relevant word is ‘explore’.

Ideas and methods in presenting UCH

Most maritime museums around the world do not depend on their display of real artefacts—it is the ideas that are enough to create an attractive and innovative maritime museum.

Table 1. Facts about the recovery and conservation process for the Vasa, Mary Rose and Bremen Cog shipwrecks.

	Recovery Process	Under Conservation	Costs	Hazards
Vasa Shipwreck	More than a year (lifted as a whole).	17 years	Over £5 million	Risk during recovery (potential of collapsing) + Risk during conservation (potential of losing)
Mary Rose Shipwreck	More than a year (lifted as a whole but this is only about 1/3 of the ship). In addition to the recovery of the contents.	34 years	Over £5 million	
Bremen Cog Shipwreck	(Lifted dismantled and reconstructed after complete recovery).	18–20 years	Over £4 million	

Figure 2. Hatshepsut replica boat Min of the Desert, Suez Museum, Suez- Egypt (Mona Mokhtar).

Replicas

Building a replica is a creative method for presenting the UCH to the public, as it can narrow the gap between the artefact itself and the visitor. It gives the visitor a chance to touch, feel and explore the object, specifically in the case of a replica vessel. Replicas can be made of the whole ship, artefacts, or the underwater archaeological site scene itself, as in the following examples:

- Hatshepsut replica boat which is called *Min of the Desert*; it is now on display in Suez Museum, Suez- Egypt (Figure 2) (Ward 2012: 217–32).
- The Ulburun life-sized replica from the late Roman period at Bodrum Museum of Underwater Archaeology, Turkey.
- A replica of an American whaleboat known as *Beetle* at Western Australia Maritime Museum, Fremantle, WA, which is, in the author's opinion,

Figure 3. Replica of an American whaleboat, known as *Beetle* at Western Australia Maritime Museum, Fremantle, WA. (© The author).

Figure 4. Replica of Tenix AE2 submarine conning tower at Western Australia Maritime Museum, Fremantle, WA. (© The author).

a masterpiece. It is stunning; an amazing and attractive replica that reifies an historical story (Figure 3). Additionally, the WA Maritime Museum houses a beautiful submarine replica called Tenix AE2 submarine conning tower, distinguished with seashells and seawater effects like rust, corrosion and concretions, in a marvellous scene that catches the eye. This submarine is the best example of the ability to make a replica close enough to appear to be a real artefact, and how to deliver it to the public in an attractive and innovative way (Figure 4).

Visualisation

Visualisation is another method in reifying history, and is considered a successful way to deliver information to the public. For example, the visualisation made for boat and shipbuilding at Odisha State Maritime Museum, India.

Models

Making models of different sizes for the most important artefacts (vessels, amphorae, coins, anchors, parts of ancient buildings) is the easiest and most creative method not only for displaying, but also for increasing the museum income, by encouraging the public to buy models and keep a piece of history. The British Museum produces incredible and stunning small souvenirs and models of iconic artefacts that are eye-catching.

As for display, models of ancient tools such as the ancient navigation tools housed at the South Australian

Maritime Museum in Adelaide can be produced in order to let visitors handle them (Figure 5). Moreover, models are not only appropriate just for small sized artefacts, but also models for entire underwater archaeological sites, like the *Xantho* shipwreck site reconstruction in the Shipwreck Galleries, Western Australia Maritime Museum, Fremantle.

Figure 5. Model of sextant at South Australia Maritime Museum, Adelaide (© The author).

Cinematic exhibitions

Producing a short movie that narrates the story of the destruction of an ancient vessel, or any type of historical story or information about sailors, traders, shipboard society, trade routes, and shipbuilding techniques, could be more engaging for visitors than reading information labels and posters containing long texts. These movies would be more attractive, providing exhilarating sound effects and displayed via large room-sized screens. Short movies like these are already in use at the Netherlands Maritime Past exhibit at the National Maritime Museum, Amsterdam, and in the Australian National Maritime Museum, Sydney.

Hands-on exhibitions

This type of display attracts both children and adults. Hands-on displays are tools to deliver complicated information, like the boat balance, in an easy and entertaining way for children. At the Australian National Maritime Museum, Sydney, this information is delivered through making a plastic boat model. The child must find the correct way to make the boat balance by moving a certain number of blocks.

Virtual reality

Virtual reality and technology are the keywords of the 21st century. Virtual reality is the term used to describe a three-dimensional, computer-generated environment that can be explored and interacted with by a person immersed within this virtual environment. A person can control what he or she wants to see or focus on, by using a mouse/remote control, or performing gestures while wearing a head-mounted display (HMD) or 3D glasses (McCarthy 2011: 1041).

Virtual reality can be used in displaying artefacts and information that the museum cannot present either due to lack of space or fragility and need for special handling. It can also help in reconstructing artefacts that cannot be easily viewed or that no longer exist (Flyg 2011: 289; McCarthy 2011: 1041; Weirich 2007: 79).

Cave and Cave two are alternative tools in using virtual reality. A cave is an immersive virtual reality system inside a cube room with four screens (three walls and a floor), and is used to display different types of visualised information from many disciplines while the user wears 3D glasses. Cave two is considered the next generation of Cave, which is a display system with a curved video wall of 3D LCD screens (Manjrekar *et al.* 2014: 130–35; Scott *et al.* 1997: 1–14).

Computer vision photogrammetry—3D modelling

Photogrammetry is one of the alternative tools in using virtual reality in archaeology, and has become one of the most essential recording and documentation tools in any maritime archaeology project. Photogrammetry is a method to produce a 3D model using computer software such as Agisoft Photoscan and Autodesk's 3D Studio Max for producing an animated video, which reconstructs the artefact.

Agisoft Photoscan works by uploading a number of high-quality overlapping 2D pictures into the software, which

Figure 6. 3D printed models produced by John McCarthy and displayed at the 3D modelling and interpretation for underwater archaeology workshop, Flinders University, Adelaide (© The author).

is easy to use, and which generates accurate 3D models (Damme 2015: 231–38). The generated models can be manipulated by the user to view details from all angles. As well as using the Computer Vision Photogrammetry as a recording and documentation tool, it can also be used as an educational tool. The Alexandria Centre for Maritime Archaeology in Alexandria, Egypt, produces 3D models for a number of underwater and terrestrial sites for educational purposes. However, this facility could make a difference if used to display UCH in Egypt and other countries around the world. This technology could be used to display the most fragile artefacts, which are not easy to display to the public due to protection and conservation requirements. Furthermore, it could be extremely useful in bringing the underwater archaeological sites to visitors through the use of sound effects. Certainly, this technology requires a significant budget, however, satisfying results can also be achieved by using low cost devices. In other words, for display purposes we do not need complicated and expensive devices and machines, which are only required for interpretation purposes.

3D printing

3D printing is a flashlight of 21st century technology. As with printing papers and posters on different types of materials, it offers the ability to print reified objects made of coloured plastic. Computer software programs like Agisoft Photoscan and 3D Max produce the required 3D designs and then send the design to the machine, without using any prepared moulds. The user can print any shape or size, be it a complicated or simple design, in a matter of hours (Zhang 2013: 1383–84). Furthermore, 3D printing facilities are available in a number of countries around the world, such as England and Australia.

3D printed models could not only be used in displays, but also in increasing museum income, through the same process of making ordinary models, as mentioned above. 3D printed models would be an effective tool in generating enthusiasm among the public for visiting the museum frequently and raising awareness about UCH by giving them a chance to keep a small plastic model of an artefact, or an entire site (Figure 6).

Conclusion

These innovative ideas and technology would make a difference displaying the UCH of Egypt and other countries around the world. These concepts avoid the need to recover every discovered artefact, especially large ones and, consequently:

- Avoid the risk of artefacts collapsing during the recovery process if they are not effectively and efficiently supported;
- Avoid the risk of losing artefacts during the conservation process or in the period prior to conservation (hours after recovery). This period is crucial because it can cause irreversible damage if artefacts are allowed to dry without following the right procedures, such as cracking. This is especially true of organic materials, which can be reduced to nothing in a matter of hours after recovery. That is to say, the conservation of underwater archaeological materials has always posed difficulties for archaeologists and conservators as it requires extensive, expensive and time-consuming treatment to remain stable in air. Archaeologists have long been aware of the innate natural ability of water, and sediments, to preserve a wide range of cultural materials (Bjordal and Nilsson 2008: 862; Davidde 2002:

83; Koschtial 2008: 67–8; Maarleveld, Guérin and Egger 2011: 91–5; Ortmann, McKinnon and Richards 2010: 39); and,
- Provide an alternative to museum space limitations, and avoid accumulation of artefacts in stores.

These ideas and technology could help in:

- Visualising sites that may have been destroyed or cannot be visited;
- Interacting with displays;
- Attracting visitors; and,
- Increasing museum visitation and public enthusiasm.

Finally, this is how we should display UCH in the 21st century. So, we should not recover to display. Although some of these ideas could also prove costly, and may not attract all of the general public, it is safe to suggest that some will be amused by this technology, while others will prefer traditional methods of displaying artefacts. Perhaps the ideal solution would be to find a balance between traditional and innovative methods for museum displays and exhibitions.

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Making a Lot with Very Little: the Western Australian Museum's 'steamship to Suffragettes' Exhibit

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Abstract

In Western societies, the 21st century appears to have ushered in an era where funding for many enterprises, including the arts, is rapidly dwindling. With a few exceptions, less staff, less funds, less resources, alongside increasing demands for exciting content, appears the norm in any Western nation's galleries and museums. This includes the products of maritime and underwater archaeology, which, given the time taken for conservation, is perhaps the most expensive of all museological endeavours. The 'Steamships to Suffragettes' exhibit, centering on the SS *Xantho* and its owners, the Broadhurst family, has been one of the 'key' exhibits at the Western Australian Museum's Shipwreck galleries for decades, and has found itself largely immune from this trend. Constantly changing, entering yet another iteration in 2016, it is a possible pointer for those now seeking to present their work in an increasingly difficult environment. This paper will describe the continually evolving link between archaeological fieldwork, conservation, exhibition, and public engagement characterising what is in effect a 'living exhibit' involving professional and amateur (avocational) practitioners, often at work in the gallery itself and regularly interacting with the visiting public.

Keywords

19th-century, engine, living museum, volunteers, 3D printing

Introduction

The SS *Xantho* project and its permanent gallery at the Western Australian Museum's Shipwreck Galleries in Fremantle (which is now in its 7th iteration) has been developed utilising both professional and avocational input and involvement, the vast majority of it at no cost. This strategy was a necessity, owing to the project's low profile when it was initiated in the early 1980s. At this time, the study of iron and steel shipwreck sites was in its nascency and not widely considered as an appropriate field of research within maritime archaeological studies (Lyons 1974). The subsequent raising for the first time of a complex seven-ton maritime archaeological object (i.e. the engine) from a saline environment, challenged both archaeological and conservation expectations (as well as acknowledged the project as an important example [Harvey 2009]), and allowed to combine historical, technical and economic research into what was at the time a forgotten and once much-derided shipwreck site.

Furthermore, while understanding that museums represent one of the main outlets for maritime, underwater and nautical archaeological material (Catsambis *et al.* 2014), the Western Australian Museum's multifaceted *Xantho*-Broadhurst exhibition at the Shipwreck Galleries in Fremantle represents also a showcase for one of Western Australia's most influential colonial families on a number of social and economic levels. Additionally, in espousing 'new museology and its concern to establish more meaningful relations between museums and communities', Andrea Whitcomb (2003: 69–70) observed that this exhibit presents an 'opportunity to address Western Australia's colonial maritime history through maritime archaeological remains'.

Insights

The *Xantho*-Broadhurst programme provides some useful examples into surmounting the problems caused by the often-difficult process and the often-alarming costs of mounting a maritime archaeological exhibition. With reducing budgets and diminishing staff numbers across museums and maritime archaeological departments, the *Xantho*-Broadhurst experience may prove of value to others, being one of the first and prime example of what can, and still is being achieved through the application of ongoing creative responses to a low-budget situation.

As part of the approval process necessitated to raise the *Xantho* engine, a 'vision statement' was prepared which was proposing a unique opportunity to research and bring to the public a unique artefact for a total operation budget of AUD $7,200. Against most expectations, the engine was successfully raised, transported to Fremantle and housed in a specially made treatment tank utilising sponsorship and in-kind support.

One core element in the success of the SS *Xantho* in-water and in-museum project has been the ability to respond opportunistically to the myriad of opportunities presented by academic, institutional, and avocational (volunteer) expressions of interest. The exhibit for example was progressed by the acquisition of surplus materials and was then brought to life by the willingness of staff, volunteers and tertiary students to 'work' in the gallery and be prepared to engage with the public.

The first, most important and perhaps the most daunting requirement for maritime archaeologists contemplating such an endeavour is the need to acquire and secure a dedicated 'public' space in which to exhibit the archaeological materials. For this project, that process led to the realisation that to open the doors when staff were present would cater for a classic 'behind the scenes', 'storage on exhibition' situation and would pose no threat to the *Xantho* engine parts. In being opened only when staff were present, this became an *'in vivo'*, 'living museum' situation where the public could follow the rebuilding of the engine and informally interact with the archaeologists and conservation staff. There, they could also learn of associated research and exhibition developments such as the global importance of the unique engine and listen as staff explained their growing understanding that Charles Broadhurst should not have been summarily dismissed as a failed entrepreneur, for the strange engine that was powering his steamer may not have been a mistake as first thought. That initiative proved very popular and was quickly recognised as an almost unique opportunity for both the public and fellow heritage practitioners to view 'the museum at work' in its Fremantle context. This 'museum at work' mantra became the facilitating banner that allowed many challenges to be overcome.

As a corollary, because the objects were constantly changing and the research was exponentially growing, the presentation also set the scene for repeat visits i.e. the living, ever-changing multi-faceted exhibit in the tradition of the museum administrator George Brown Goode (once of the Smithsonian) who advised around at the end of the 19th century that 'a finished museum is a dead museum, and a dead museum is a useless museum' (quoted in Kavanagh 1994: 45). This philosophy continues to underpin and permeate what (for reasons that will now become apparent) is now entitled the 'Steamships to Suffragettes' exhibit.

Background

When a Scottish scrap metal dealer purchased a 23-year-old paddle steamer named *Xantho*, and re-engined it in 1871 with a ten-year-old former Royal Navy gunboat engine, he could not have envisaged it would travel half way across the world to one of Western Australian's most remote and desolate coasts. In purchasing it for use as a 'mother ship' carrying labourers, pearling equipment, stores and shells, Charles Edward Broadhurst introduced steam to the north-west pearling industry and to the Western Australian coast in general. He also used *Xantho* as a 'tramp steamer' for goods, passengers (including Aboriginal convicts from the Cossack region who had been incarcerated at Rottnest Island near Fremantle), and livestock. After attempting to augment the seriously depleted Indigenous labour pool, Broadhurst sourced a new labour force in the form of divers from the islands off north-west Australia, generally but incorrectly called 'Malays'. These men and boys (aged 12–14) were used as indentured labour. However, in November 1872 the ship sank at Port Gregory (just north of Geraldton) on the mid-west coast. After being ruined by this loss and abandoning his crew in the north-west, Broadhurst then transferred his labour force to Shark Bay, where they proved a great success in the pearling industry until the 1874 downturn (McCarthy 2000).

Though Broadhust kept no images of his ill-fated steamship, a number of rock engravings of what is believed to be the SS *Xantho* appear at an Indigenous rock art gallery at Inthanoona Station (Paterson and Wilson 2009). This possible identification is based on the link between the depiction of livestock being loaded onto a vessel in this gallery and the knowledge that the *Xantho* was the first steamer into the region, carrying rams. Another depiction which can also be seen at Walga Rock (an Indigenous gallery hundreds of kilometers inland along the Murchison River), is believed to be of the *Xantho*. This depiction can be most parsimoniously attributed to a former pearling worker (Sammy Malay), who left the Shark Bay pearl fields for the Murchison district sometime around 1917 (McCarthy 2000).

In order to better contextualise Charles Broadhusrt's milieu, research emphasis turned to other members of his family. His wife, Eliza, a talented musician, teacher, headmistress and actor was a mentor for the colony's young women and became involved in the nascent feminist movement. Their son, Florance Constantine, used his mercantile expertise to completely turn

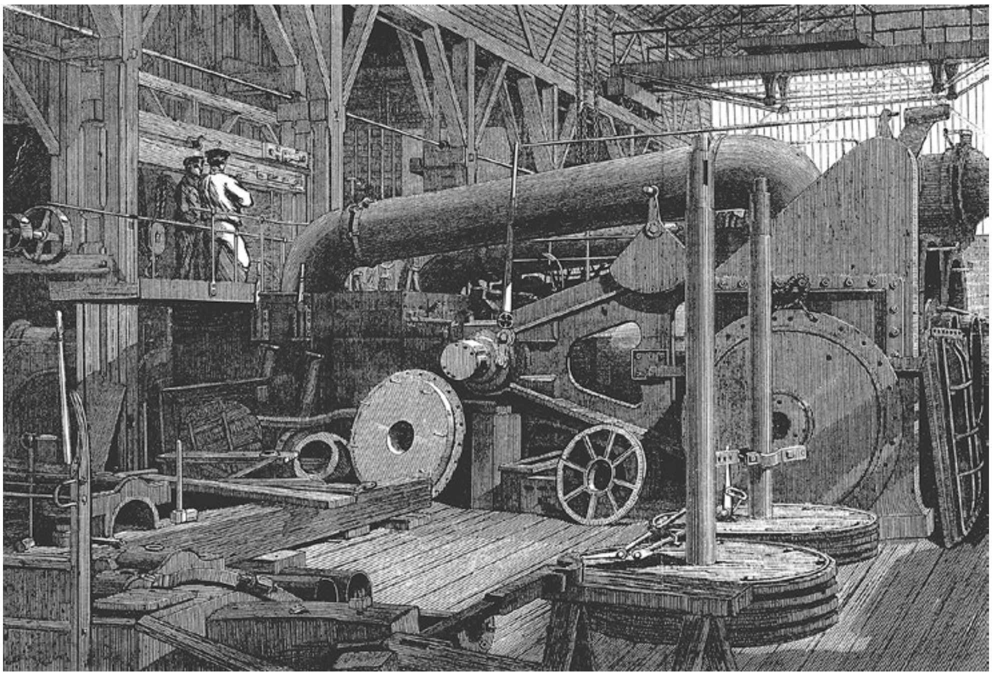

Figure 1. John Penn's workshop in the era he received the order to build the RN Gunboat engines (Illustrated London News, 7/10/1865).

around the fortunes of his father's guano business. And finally their daughter Katharine helped Western Australian women to obtain the right to vote in 1899, before becoming a suffragette in England and being subsequently imprisoned for her stance.

The shipwreck site

The wreck of the *Xantho* was formally identified by WA Museum staff in 1979 (with support from the Maritime Archaeology Association of WA). A pre-disturbance survey showed that the vessel was powered by a Crimean War–type gunboat engine, the only-known representative of a seminal era in marine engineering, being the first mass-produced, high-revolution and high-pressure marine engines ever made (McCarthy 2000). Preserved in excellent condition beneath a layer of concretion, the engine was soon deemed to be at risk from looting. Consequently in 1985 approval was granted (by the Maritime Archaeology Advisory Committee or MAAC, and the Directorate of the WA Museum) to raise and conserve the engine. This marked the beginning of an important change in attitudes to iron and steamships, the impact of which continues to be felt today.

After recovery, the engine was transported to the WA Museum in Fremantle, where it was housed in a specially built treatment tank at the Museum's conservation laboratory. Here the engine was de-concreted, and desalinated over seven years. In 1992, the engine was totally disassembled and each component part was returned to the tank for further treatment. From here each part was progressively moved into a climate controlled exhibition space. Additionally, the recovery of *Xantho*'s truck engine served as a catalyst for two pivotal seminars on iron and steamships archaeology held in 1985 and 2006.

The *Xantho* in a 'living museum'

The first iteration of the *Xantho* display presented essentially bronze and brass fittings from the engine, together with simple photocopied text panels, the ship's engine bed (which was being progressively rebuilt), and black-and-white photographs with the main attraction being the opportunity to interact with staff. This rather bland presentation changed when Technical and Further Education (TAFE) students undertaking an undergraduate exhibition and design course under former WA Museum exhibition and design staff Darryl Hick joined the project. The display was subsequently redesigned, utilising the 19th-century (storage part of the 1850's original Commissariat building) structure of the exhibition space, with its timber beam and rolling gantries. Consequently, the *Xantho* gallery was redesigned into a mirror image of John Penn's workshop on the eve of receiving the contract to build the gunboat engines in the 1860s (Figure 1).

Over the years visitors have also been able to fully interact with what is presented as a 'living' exhibit. Tools, hoists and cranes, grubby laboratory coats and the other paraphernalia of a workshop have added a

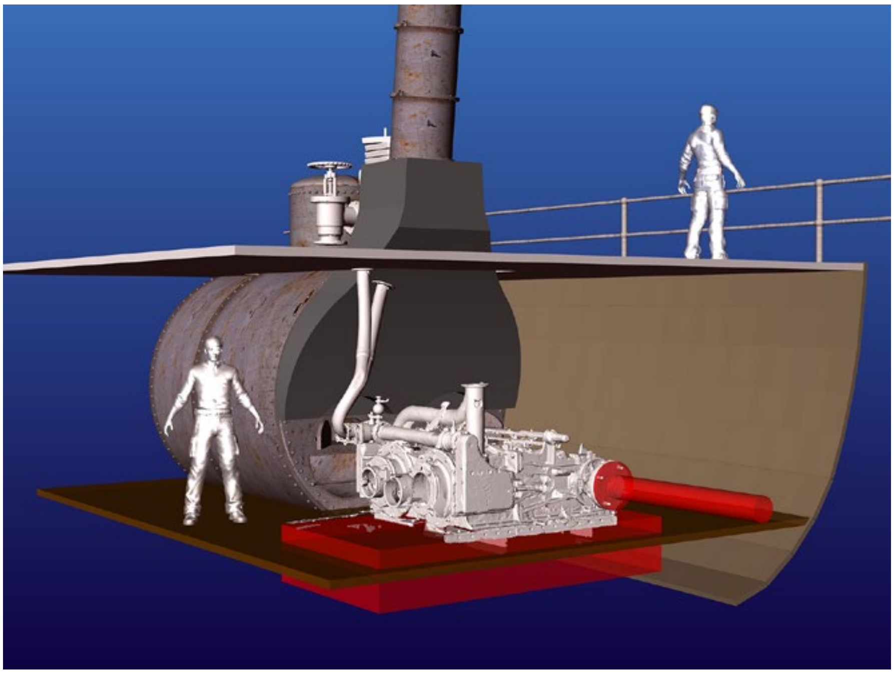

Figure 2. Kevin Edward's schematic showing his projected configuration of the SS *Xantho* engine room as per the 1985 vision (Western Australian Museum).

sense of 'being there' and 'ownership' to the objects. The ongoing reconstruction and restoration of many items turned the gallery even more into a space in which members of the public could witness first-hand the process of conservation, and interact with the specialists, visitor service officers (VSO) and volunteers involved, discussing the SS *Xantho*, its people, the engine, the conservation, disassembly and reassembly, fulfilling museum-based maritime archaeologists' role as 'public archaeologists'.

From 2012 through to 2015, the gallery was once again designed in order to better establish an equilibrium between modern exhibition design trends and the need to maintain the notion of 'museum at work'. The first objective in the new iteration was to reposition the engine, to improve access and visitor flow around the display. This involved reorganising the overall space and removing all 'non essential' items in order to 'de-clutter' the gallery. Visual and information content were also improved through the inclusion (in addition to existing thematically explanatory banners) of numerous large laminated colour photographs portraying key aspects of the project.

The original 1985 'vision statement' which incorporated a contemporary 'under-deck scene' (Figure 2) that would also allow the visitor to experience a 19th century ship engine room, was made possible in 2015 by utilising the skills of the Museum's volunteer retired marine engineers (Figure 3). They assisted museum staff in erecting, and recycled, the front face of a ship's boiler as well as steel frames (themselves sourced from a discarded interactive exhibit) to which was attached a section of hull re-used from a contemporary iron shipwreck. After being lined and then decked, this 1:1 scale replica of the engine room section was enhanced with a steam dome, gunwhales, a wheel, and a binnacle (all sourced from other vessels) to appear as they might have on board the SS *Xantho*, at the time of its loss in 1872.

Another section of the newly designed exhibit comprised a conservation corner where conservator Alex Kilpa undertook *in vivo* conservation and reconstruction projects that included the ship's boiler safety valve and the salt-water condenser. In order to show the complexity of the conservation and reconstruction processes, the safety valve is presented completely conserved, as it would have while in use, while the condenser remains unfinished, presented as an ongoing work (in effect an incomplete 3D jigsaw).

Engaging the public with the SS *Xantho*

The WA Museum has long had an active engagement with various community groups. A key support for on-going public engagement has been provided by the Maritime Archaeology Association of Western Australia (MAAWA), including continuous assistance as a liminal agent between the local diving community and the museum on various projects. MAAWA's involvement in the *Xantho* project included the relocation of the site, the survey and excavation phases, as well as preparation

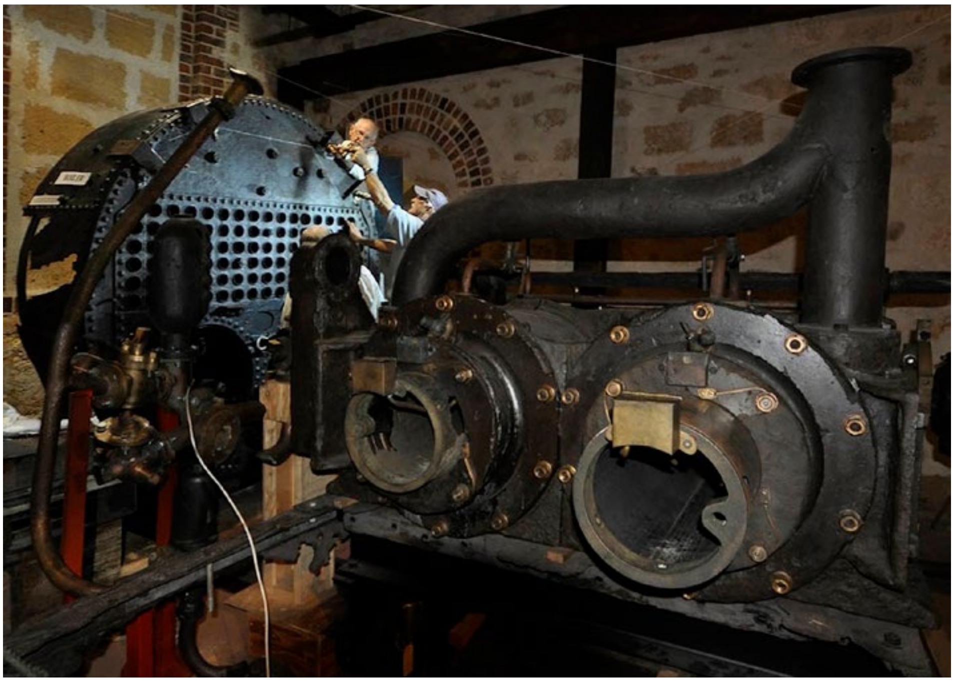

Figure 3. the Museum's Marine Engineers, with R. Garcia at work constructing the *Xantho* engine room. Foreground the engine and its piping (M. McCarthy, Western Australian Museum).

of interpretive signage representing the stages of the SS *Xantho*'s decay.

Utilising the skills of students and volunteers allowed several physical models to be created in order to illustrate various aspects of the SS *Xantho* as a vessel and a shipwreck. These included the combination of a partial model of the hull, together with full models of the trunk engine (one static in wood, the other a true working scale replica). Among them, Robert Burgess' working engine model (the first ever made produced solely from archaeological records due to the absence of original engineering drawings) together with Noel Miller's engineering drawings of the trunk engine, remain the prime source for the displayed wooden 'mock-up' model of the engine (which received also assistance from British model engineer Jon Heppel by producing in 2014 engineering quality plans of the engine). Its later 'mock-up' model became the basis of a 1/8 scale model of the shipwreck site as it would have appeared to be around 1900, designed to help adults interpret the exhibit and enhance visitors' museum experience. This model itself, based on a post-graduate student's project designed to reconstruct the *Xantho*'s stern, helped to visualise the engine's location before and after the wrecking event with the machinery and its reconstructed engine room. Children are also catered for in this shipwreck site model (Figure 4), being able to sift through the sand and seaweed on the wreck and spot the various elements of the site and the marine life including fish, octopuses and a sea snake.

Universities have also provided an essential source of volunteering assistance through the many graduate students who participated in laboratory, research and gallery work over the years. On what was also in effect work experience as part of their degrees (archaeology, history, conservation, museology, anthropology, art and architecture, Indigenous studies, and women's studies), students participated in analysing and presenting the Broadhursts and the engine to the public. Some examples among others are the involvement of Elizabeth Parrott (2001) and Amanda-Jane Arnold (2003) who produced reports on social history that concentrated on the Broadhurst women, and Daniel Gerson in 2008 who studied Charles Broadhurst as an entrepreneur. These reports comprise part of what is now a considerable corpus of well over a hundred articles, seminar reports, books, and theses relating to the broader *Xantho* project.

Further volunteers drawn from the general public dedicated their skills to the project. For instance, Curtis McKinley in 2014, specialised in engaging with museum visitors by establishing a workstation in the gallery. That same year, computer-aided design (CAD) specialist Jason Gilbert completed a number of detailed technical drawings of the trunk engine. Furthermore, despite the invaluable help volunteers can provide, as it has been the case for the entire *Xantho* project, avocational involvement in general brings an array of considerations (including personalities and expectations) requiring careful and caring management.

Figure 4. The shipwreck model featuring Jeol Gilman's hull and R. (Bob) Burgess' wooden 'mock-up' of the model engine (N. Bigourdan, Western Australian Museum).

Bringing the SS *Xantho* into a new digital era

Various digital technologies have been used to enhance links between specialists and the public, while at the same time remaining true to the philosophy of the project as a whole. These technologies included various types of 3D digitisation, modelling, and reproduction using additive techniques such as 3D printing. While part of the existing array of archaeological 'tools', much of it at the time was new to the WA Museum environment. While typically expensive, these services were made available at no cost.

The digitisation of various engine components was accomplished using a NextEngine 2020i triangulation laser scanner. While the programme of recording proved to be generally successful, alternative approaches had to be adopted when the project scope was extended to include larger items, such as SS *Xantho*'s safety valve and indeed the trunk engine itself. Towards this end, the project was kindly granted extended use of an Artec Eva structured handheld light scanner by Curtin University. Computer Aided Design (CAD) modelling was then used to create a coherent model of the trunk engine and its components. Some scan data of the objects digitised have been made available via social media and file sharing sites, such as YouTube and Sketchfab.

These 'new' techniques also presented opportunities for public engagement and exhibition. As part of the *in vivo* approach adopted in the 'Steamships to Suffragettes' gallery, a digital scanning session was typically undertaken during normal museum opening hours, with members of the public encouraged to engage in a dialogue regarding the process and its outcomes. Several public demonstrations were also carried out in the gallery, allowing visitors to witness the scanning workflow from data capture through to the production of a physical model using a consumer-grade 3D printer (Figure 5). Such physical reproductions—or 'object surrogates' (Figure 6)—have been produced at a variety of scales and used for the purposes of reconstruction and display, to augment the existing model of SS *Xantho*'s hull and trunk engine, and to allow museum visitors to have a tactile engagement with objects.

As part of this initiative, the *Xantho* artefact databases were linked to a Geographic Information System (GIS). Built around an open source software, this will enable researchers to interrogate existing datasets (such as artefact distributions) in new and novel ways, while also providing a foundation for ongoing site management. It is anticipated that the utility of the GIS will be expanded through its ability to readily accommodate data generated by other techniques, such as remote sensing and underwater 3D multi-

Figure 5. Visitor service Officer Brendan Donnellan, with Malay visitors viewing Kevin Edward's 3D printing process in the gallery (M. McCarthy, Western Australian Museum).

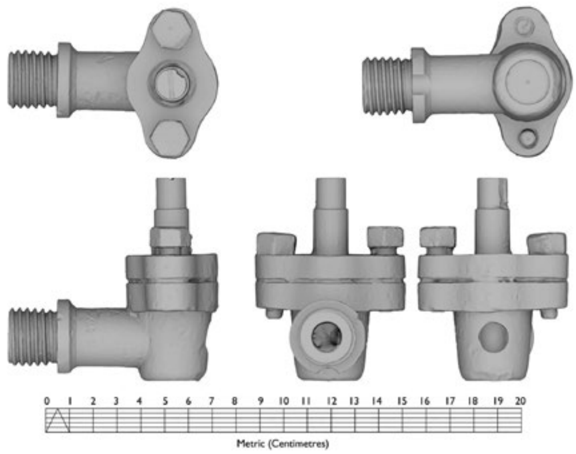

Figure 6. Kevin Edward's 3D record of the *Xantho* engine drain cocks (Western Australian Museum).

image photogrammetry. Recently, and as an example of the ongoing nature of the work, a post-graduate archaeology student intern (Aaron Bailey) developed the GIS to be accessible via the web.

Conclusion

As explained by WA Museum CEO Alec Coles (2016), its mission statement is to inspire people to explore and share their identity, culture, environment and sense of place, which makes the SS *Xantho* project fit within the context of a modern, 'socially aware' and active museum. On reflection, since its inception, the SS *Xantho* project has been intuitively built by, around, and for the community, placing the public at the heart of the gallery. The absence of budget and the need to do it 'on the cheap' have linked the community and the specialists in the *Xantho*-Broadhurst 'Steamships to Suffragettes' project throughout the years, allowing the research and gallery infrastructure, equipment, facilities and expertise to be sourced virtually gratis, making this project truly a community-based project. The SS *Xantho* exhibition has always sought through the interaction of staff and volunteers with visitors to provide a space for the public not only to be exposed to a range of issues and topics but also to be involved in the preservation of their own heritage.

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Aims and Targets of Maritime Museums and Exhibitions in Europe: Six Case Studies from Germany, Greece and Italy

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Abstract

Over the past three decades, maritime museums and museums dedicated to the complex relationship between humans and the sea have become very popular in Europe. However, their institutional aims and exhibition strategies vary widely. Museums that examine maritime topics can be divided into at least four different categories: naval, ancient navigation, maritime/marine ethnography and floating museums. Naval museums are dedicated to the discovery of single shipwrecks. Museums of ancient navigation generally have an educational function as a main goal. In the third group there are museums dedicated to the history of navigation and seafaring from ancient to contemporary times. The fourth category includes floating museums, such as vessels of historical importance anchored in a port and accessible to visitors. The purpose of this paper is to explore the way six museums in Germany, Greece and Italy present maritime heritage to the public and how they match, or mismatch, with international recommendations and guidelines on public presentation of maritime cultural heritage.

Keywords

Naval museum, marine ethnography museum, maritime museum, museum exhibition, maritime heritage presentation

Introduction

Even though the first maritime museum in Europe dates back to the beginning of the 19th century—Musée Dauphin in Paris opened in 1827 (Johnson 1996: 25)—maritime museums have become very popular in Europe only in the past three decades. Until the 1960s they had mostly a celebrative aim to create a feeling of patriotism in local communities. Nowadays they can be considered as the place where awareness of maritime heritage can be encouraged and developed. In fact, the importance of the maritime heritage is undoubted, because the sea and other bodies of water have been connecting European populations for millennia, carrying people, goods, technologies, ideas and often, even wars.

The generic category of maritime museums currently encompasses a wide variety of museums that, contrary to Johnston's view (1997: 285), do not necessarily exhibit shipwrecks. These museums have various goals, but they are all focused on the complex relationship between humans and the sea or, more generally, between humans and life on the waters. Four different categories of maritime museums can be identified: naval, ancient navigation, maritime/marine ethnography, and floating museums.

Naval museums exhibit shipwrecks, displaying the vessel themselves, their cargoes, or both. Their main goal is to preserve the remains of vessels and/or of cargos and to display them to specialist and non-specialist visitors. The Museum of the Roman ships in Nemi was the first naval museum exhibiting ships recovered underwater. The lake where they sank was dried out thanks to the installation of a pumping station and the excavation was carried out on a dry land (Moretti 1940: 6–7). After the invention of the aqualung in the 1940s, and its ensuing widespread adoption, hundreds of underwater shipwrecks were investigated in the Mediterranean and around the world, and as a consequence, a large number of naval museums were created worldwide. However, the recovery and long-term conservation of shipwrecks is expensive and time-consuming (Koschtial 2008: 68). Waterlogged wood needs constant treatment for its consolidation; environmental humidity needs to be kept constant to avoid extreme drying that could change the overall shape of a ship if timbers are allowed to continuously expand and contract—as happened to the Nydam (Abbeg-Wigg 2014: 86)—including the need to prevent fungal and bacterial degradation. Because of this extensive, expensive and constant work, adequate conservation cannot always be provided. Thence, the 2001 UNESCO Convention on the protection of the underwater heritage (rule 7, 2.1) encourages *in situ* preservation as the first option to be considered when a shipwreck is discovered. However, sometimes excavation and recovery may be necessary for research or for other reasons (2001 UNESCO Convention, rule 4).

Museums of ancient navigation were created in the 1990s and generally have education as a main goal. They are frequently included as a section in maritime/marine ethnography museums, but in a few cases, for example in Santa Severa in Italy or Mainz in Germany, these are ordinary museums. They usually exhibit dioramas, scale models of boats, life-size reconstructions of tools and equipment and, sometimes, the remains of vessels or cargos.

Maritime/marine ethnography museums address a wide range of topics dedicated to the history of navigation and of marine activities, and often originate from private collections and donations or derive from an 'antiquarian impulse' (Paine 2016: 392) to promote national identity. Generally they display archaeological finds, dioramas of harbours and shipyards, scale models of vessels, etc. Sections are often dedicated to ethnographic topics, such as nautical carpentry, fishing or sea trade. Other sections may include the history of a country's navy, showing weapons, uniforms and documents related to military life on the sea. Their main goal is to preserve the intangible heritage of nautical traditions, old equipment and techniques, but they often appear chaotic due to the haphazard origins of their collections. In Italy some of them are 'small town museums' with a local rather than national mandate, often looking like *wunderkammern* (cabinets of curiosities).

Floating museums—or 'ships as self-contained museums' (Paine 2016: 390) or 'museums ships' (UNESCO 2017)—comprise vessels of ethnographic or historical importance or 'patriotic monuments' (Paine 2016: 390) anchored at a port. The first ones were established in the 1960s and largely spread throughout the world during the 1980s. Some can still be sailed for educational aims, preserving the intangible heritage of the traditional seafaring techniques and giving the public the great opportunity to experience life on-board, like on the early 20th-century cargo ships of the Museum of Seafaring Tradition (Museo della Marineria) in Cesenatico, Italy.

Complementary to the generic category of maritime museums is underwater museums that include underwater sites, where shipwrecks, built-up structures or even entire districts of submerged cities are exhibited *in situ*. As mentioned above, the 2001 UNESCO Convention supports *in situ* preservation. It guarantees a less expensive and time-consuming preservation of the features, and makes for a fascinating and engaging visit (Koschtial 2008: 67). Responsible public access to such underwater sites is encouraged by the Convention (article 2.10). Underwater visitors, guided by official professional divers, follow a museum itinerary, marked by guidance ropes, and with informative panels. In Italy, successful underwater museums were created in Sicily (Soprintedenza del Mare 2004/2018) and at Baia in the Gulf of Naples, achieving three important goals: protection and preservation of the underwater heritage, engagement with the local diving centres, public engagement and amusement (Stefanile 2016: 219–20). In parallel with the underwater museums, virtual underwater museums and/or tours are also developing worldwide, such as the virtual tour of the underwater archaeological site of Cala Minnola, in Sicily (Bruno *et al.* 2017: 124) that offers non-divers the possibility to acquaint themselves with the sunken heritage, to enjoy it and to be aware of the necessity to respect and protect it. Floating and underwater museums will be not analysed in this paper, as they will be the subjects of future investigation by the author. After personal visits and interviews with their curators, the author presents six case studies from Germany, Greece and Italy, demonstrating how these cases match or mismatch with international recommendation and guidelines on public presentation of maritime cultural heritage (data updated to 2018).

Museum contents and display: six case studies from Germany, Greece and Italy

Case study no. 1: A naval museum in Germany: Das Nydamboot—Versenkt—Entdeckt—Erforscht (The Nydam Boat—Sunken—Discovered—Explored)

The museum is located in northern Germany and is part of the Schleswig-Holstein's State Museums, an independent foundation with the aim to give an overview of the history of the Schleswig-Holstein region from prehistory to contemporary times. The foundation and private donations guarantee the existence of the museum and the restoration of the palace that has housed it since 1949.

The museum complex is located in the large-scale Baroque palace of Gottorf, originally a 12th-century bishop's residence and later a strategic bastion in which the curators tried to find a successful dialogue between the varied exhibits and the historical architecture. The oak boat from the Nydam bog is displayed in the former Gottorf cavalry drill hall, converted into an exhibition floor space of more than 700sq m. From 2013 a new stand allows the visitor to see all the details of the boat and to walk around it, unlike the previous stand, which comprised a box filled with pebbles, partially covering the hull (Figure 1).

The 4th-century oak rowing boat was deliberately sunk for ritual purposes, complete with its equipment. It was excavated in 1863 together with other two boats. All were well preserved thanks to the anaerobic environment of the bog, formerly a lake (Abbeg-Wigg 2014: 90). In 1989–1997 over 16,000 artefacts were excavated, deposited in various occasion between *c.* 200 and 500 AD. Because of the volume of the finds, mainly of wood, an *in situ* preservation programme was developed over the last

Figure 1. The Nydam boat; the new stand allows visitors to see all the details of the hull and to walk around the boat.

fifteen years to safeguard the cultural heritage for the future (Gregory and Matthiesen 2012: 479–86). In fact, wood conservation is still problematic and the boat, restored at the time of its discovery in the 19th century, dried out and shrank (Abbeg-Wigg 2014: 86).

Approximately 70 objects on display enrich the visitor experience, and more will be integrated in future (Abbeg-Wigg 2014: 9). They are exhibited in 'homeopathic doses' because 'each individual object is given space' (Guratzsch 2002: 9). Scale models of the boats are also presented to give a tangible idea of how they looked and operated. Thanks to some touchable replica elements of the boats, the visitor can learn about the materials and the ship building techniques involved. These replicas are extremely useful for all visitors, especially those who are vision impaired. All the information about the boat, the transformation of the lake into a bog and the history of the discovery are gathered in 21 topic-based panels. They use a black and white background and have short bilingual texts, written in white for German and in black for Danish. The object captions are on a white and blue background and are bilingual as well. Directional lighting from above lights up each display case to accentuate the objects. There is diffuse, natural lighting for the rest of the hall coming from the windows and from a side gate. Persons with reduced mobility can easily access the hall situated on the ground floor. Services are located in the information centre and the main building of the complex. Opening time and admission fees are illustrated in Table 1. According to the director, Claus von Carnap-Bornheim, more than 110,000 visitors visit the museum every year and, because there is no specific audience target, the museum offers educational activities for public of any age.

The aim of the museum is to preserve the remains of the oldest rowing boat in northern Europe built using the clinker technique and iron rivets, and to make this unique heritage accessible to a large audience who can learn about the peculiarities of the history and archaeology of the Schleswig-Holstein region.

Case study no. 2: a maritime/marine ethnography museum in Germany: Internationales Maritimes Museum—Hamburg

This museum is located in Hamburg, housed in a ten-storey neo-Gothic warehouse built in the late 19th century on the south side of town, in use until 2003 (Figure 2A). In 2008 the warehouse was transformed into a large private museum dedicated to showcasing stories about the complex relations between humans and the oceans through a global lens. The warehouse floors were transformed into ship decks totalling 16,000sq m of space, dedicated to nine different topics. Peter Tamm, a German collector and journalist, created the

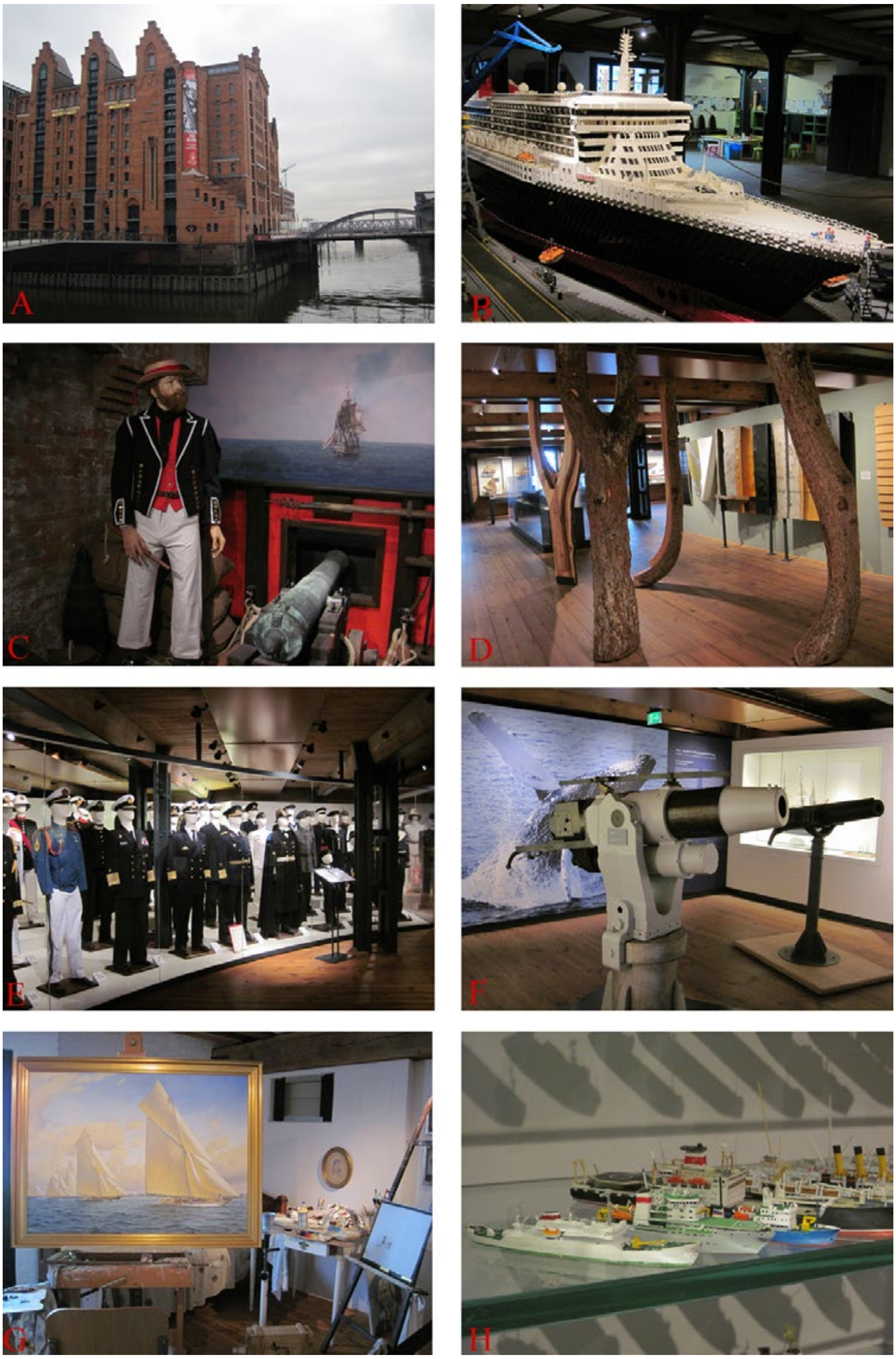

Figure 2. A) The Internationales Maritimes Museum housed in a ten-storey neo-Gothic warehouse built in the late 19th century south of Hamburg. B) An impressive model of the transatlantic *Queen Mary II* built in 2008 with about 780,000 Lego bricks. C) A life-size diorama replicating on-board pirate activities. D) A forest of tree silhouettes, parts of which naturally provided structural elements for ships. E) Uniforms of all ranks on display in deck 4. F) 'Expedition to the sea: the earth's last secret' is the topic in deck 7; a modern whaling harpoon on display. G) The life-size reconstruction of a painter's studio in the art gallery, deck 8. H) A collection of some 36,000 small waterline ship models on display in deck 9.

core of the collection. The original collection has been enlarged with new donations from private individuals. The museum is owned by the Peter Tamm Sen. Foundation. The society Freundeskreis Internationales Maritimes Museum Hamburg offers moral and material support.

The sound effects of undertow and the cries of seagulls welcome the visitor at the entrance, creating a pleasantly marine atmosphere. The visit starts from deck 1, where the main topics include navigation techniques and the greatest inventions related to them, from antiquity to the 18th century. A great attraction for all the aficionados is an impressive model of the transatlantic *Queen Mary II*, 7 x 1.4m, built in 2008 with about 780,000 Lego bricks (Figure 2B). Next to the model there is an area where young visitors can draw or play with Lego bricks. Among the other attractions of the deck is a ship-piloting simulator where the visitor can have the experience of captaining a large-scale cargo ship.

Deck 2 concerns sailing navigation from its origins through to contemporary times. Different sails, on-board equipment and samples of plant fibres used in rope manufacturing are on display. Thanks to the presence of scale models based on accurate studies, it is possible to retrace the steps involved in ancient seafaring, for both commercial and military purposes. Great importance is also given to exploring the slave trade between the 17th and 19th centuries, described without omitting shameful particulars, such as the space allocation used by the slave-ship owners to maximise the capacity of human cargo. Private donations from members of the Hamburg's Chinese community have enriched the collection relating to Chinese seafaring from the 3rd century BC to the 15th century. The visit at deck 2 ends with the section dedicated to piracy between 17th and 19th century. Life-size dioramas replicate on-board pirate activities (Figure 2C).

Deck 3 has an educational exhibit where the visitor gets almost lost in a forest of tree silhouettes, parts of which naturally provided structural elements to ships (Figure 2D). The long itinerary ends with modern samples of hulls.

Deck 4 is the world of the navy. Uniforms depicting all levels are on display together with medals, awards, examples of on-board medical equipment, weapons and even replicas of the cabins (Figure 2E).

Deck 5 concerns naval battles from 1812 onwards.

On deck 6 there are 1:1 replicas of cabins of luxury cruise liners as well as scale models of merchant steamships and of container ships.

Deck 7 was conceived to be like a real scientific laboratory with a bright and sterile clinical atmosphere. It focuses on oceanography in all its most attractive, bizarre and captivating aspects (Figure 2F). There are many videos and recordings in German and pre-booked groups can go into a children's laboratory to take part in scientific experiments.

Deck 8 is a painting gallery with sea-related paintings from the 16th to the 20th centuries from Germany, England, Holland and Belgium (Figure 2G). On the same floor, a treasure chamber houses objects made of gold, silver, ivory, amber and other precious materials. Some ship models were made by French war prisoners captured by the British navy during the Napoleonic wars.

Finally, deck 9 showcases a rich collection of some 36,000 small waterline ship models (Figure 2H).

An attic is designed for temporary exhibitions.

Clear and concise information panels enrich the visitor experience, bilingual (German and English), and usually written in black on a light grey background. The object captions are in German with occasional brief translations in English; and, are generally written in black on a white background. The lights are directional for both the showcases and the rooms. The light in the rooms also comes in through the windows of the former warehouse. People with reduced mobility access the decks via elevators. The museum services are located on the ground floor. A large library of 78,000 books and 50,000 ship drawings completes the offerings. Opening time and admission fees are illustrated in Table 1.

Gerrit Menzel, one of the curators and collaborators of the museums, stated that 100,000 visitors, 30–40% of whom are from abroad, visit the museum every year, probably because Hamburg is becoming a popular destination for summer holidays. He also says that visitors, children in particular, appreciate the pirate diorama on deck 2 while the older adults, especially the ones who served in the navy, like the navy world on the deck 4. Most visitors like the ship models made by French prisoners (deck 8) and the small waterline ship models on deck 9. The painting gallery is less popular with visitors.

The museum is a full member of the International Congress of Maritime Museums (ICCM).

As declared by Peter Tamm (2008: 15), the aim of the museum is 'to preserve the memory of humanity in a museum which lives in harmony with the future and evolves—a living museum'. He also says that 'for the visitor, our museum should be rendezvous, providing

Table 1: Opening times and admission fees for the six museums.

Museum	Country	Opening time	Closure Days	Ticket price
Internationales Maritimes Museum (Hamburg)	Germany	10 am - 6 pm (every day)	No closure days	Full price € 12,00 Reduced € 8,00
Das Nydamboot (Schleswig)	Germany	April-October Monday-Friday 10 am 5 pm Saturday - Sunday 10 am - 6 pm November-March 10 am - 4 pm Saturday - Sunday 10 am - 5 pm	Mondays from November to March	Full price € 9,00 (including the Art and History Museum in Gottorf Castle) Reduced € 6,00 Families € 19,00
The Antikythera shipwreck. The Ship, the Treasures, the Mechanism	Greece	Monday 1 am - 8 pm Tuesday – Sunday 8 am - 8 pm	No closure days	Full price € 10,00 (one ticket for 4 museums) Reduced € 5,00
Naftikò Museion tis Hellados (Zea, Athens)	Greece	9 am - 2 pm	Sundays, Mondays	Full price € 4,00 Reduced € 2,00
Museo delle Navi Romane di Nemi (Nemi)	Italy	9 am - 7 pm (every day)	No closure days	Full price € 3,00 Reduced € 1,50
Museo del Mare e della Navigazione Antica (Santa Severa)	Italy	January-February 10 am -2 pm March-24 April 10 am - 3 pm 25 April-September 10 am - 7 pm October-November 10 am - 3 pm December 10 am - 2 pm	Mondays	Full price € 8,00 (one ticket for 5 museums) Reduced € 6,00 Families € 16,00 (it includes parents and children under 18)

encounters with ships and the people who travelled on them, lived on them, suffered on them, fought on them, won or lost their lives on them, used them to trade, discovered other countries with them, voyaged on them, were wrecked, were saved from the sea, or were able to live out their scientific ambitions with their help'.

Case study no. 3: a naval exhibition in Greece: the Antikythera shipwreck. The Ship, The Treasures, The Mechanism—Athens

The exhibition, scheduled to run between 6 April 2012 and 28 April 2013 at the National Archaeological Museum in Athens, was extended to 29 June 2014 due to the success of the event. Two parallel stories were displayed, one about the discovery of the shipwreck and the other related to the ship before its sinking.

Displayed along the left wall of the first room were official documents and pictures related to the investigation of the shipwreck, identified by sponge fishers in 1900 off the coast of Antikythera, an islet north-west of Crete. In the centre of the room a case displayed fragments of the hull planks and a panel explained the construction technique, the shell-first construction. Along the right wall the visitor could discover life on board, a truly self-sufficient microcosm, and learn more about the extraordinary cargo, composed of bronze and marble statues, luxury glass and pottery vessels and expensive bronze furniture. In the second room, the view was captured by a diorama reconstructing the underwater context with archaeologists at work on the remains of the cargo. In the room, there were also marble statues, which were part of the cargo and had been partially preserved by the sediments and partially eroded by sea agents (Figure 3).

Finally, the visitor entered the third room, where the famous Antikythera mechanism was displayed. This extraordinary device, dated to the end of the 1st century BC, could be used to calculate dates and astronomical events related to different calendars in use in the Mediterranean. The 82 restored copper fragments were shown together with life-scale replicas and detailed panels illustrating how the device worked (Figure 4).

The visitor experience was completed by videos illustrating the possible ship route and the recovery of some finds in the 1970s; and, by bilingual panels and captions, both in Greek and English, written with black ink on a light grey background. The texts were detailed and interesting even if slightly too long. In the first room, directional lighting from above emphasised the finds in the display cases, especially the sculptures. The diffuse light was mainly a natural lighting coming from the windows. The second and the third rooms were windowless and consequently darker than the

Figure 3. One of the marble statues partially preserved by the sand sediments and partially eroded by the sea agents.

first. The dominant colour of the walls was blue and lights projected on the floor and on the ceiling gave the evocative effect of seawater in movement. As in the first room, a directional lightning from above was used to highlight the artefacts in showcases. People with reduced mobility could easily access the exhibition, located on the ground floor. The visitors could use the services located in the National Archaeological Museum. Opening time and admission fees are illustrated in Table 1.

Anastasia Gadolou, one of the organisers and curators of the exhibition, said that by June 2013 200,000 visitors had seen the exhibition; and 2500 students took part at the educational activities organised by the Educational Department of the museum. She also said that children had been particularly fascinated by the entire history of the shipwreck and by its unusual finds and that many visitors, even if they knew about the mechanism, had not known that it was found in a shipwreck with other extraordinary artefacts. Moreover, the visitors considered the half preserved and half eroded marble statues particularly evocative, and often compared them to modern art sculptures.

Anastasia Gadolou explained that the aim of the exhibition was to offer the public a complete overview on both the Antikythera shipwreck and mechanism, whose restoration in 2005 revealed new data about its functioning. Consequently, the well-known ancient device was displayed for the first time in its original context, with the cargo and the on-board equipment,

Figure 4. Life-scale replicas that illustrate how the Antikythera mechanism worked.

Figure 5. The eye-catching installation of the remains of the Themistoclean wall.

normally displayed in different rooms within the National Archaeological Museum.

Case study no. 4: a maritime/marine ethnography museum in Greece: Naftikò Musio Tis Ellados (Hellenic Maritime Museum)

This museum is located in the Bay of Zea, within the greater Athens area and was founded in 1955.

The idea of a museum dedicated to the long Greek seafaring tradition was first raised in 1867 when Captain Gerasimos Zohios created a fund to buy objects that could illustrate the long history of Greek seamanship and celebrate the most recent triumph of the Greek Navy against the Ottoman empire in 1821–1832. The project was resumed in 1949 thanks to cooperation between a group of citizens of Piraeus and the Greek Navy.

The museum is housed in a one-floor, purpose-built building from the 1960s, characterised by a long semicircular gallery that, in about 1850sq m, houses more than 2000 objects organised in chronological order, from prehistoric to contemporary times. The museum is organised in two sections—the left side is about the seafaring history of Greece from the Bronze Age to contemporary times, the one to the right is a curiosity cabinet in which there are numerous, diverse objects. At the entrance there is the eye-catching installation of the remains of the Themistoclean wall and the six 5th–4th-century BC anchors found on the seabed of Zea (Figure 5). To the left of the entrance hall, visitors start their time travel with the scale models of the ships used by the Minoans and the Mycenaeans, the two maritime powers of the Bronze Age. In the following section the topic is Greek seamanship from Byzantine times to the 19th century. A painting depicts Laskarina Bouboulina, the heroine of the Greek revolution against the Ottoman empire (1821–1832). In the room there are also finds related to the revolution.

A section is dedicated to the contemporary merchant navy and a large panel illustrates the logos of the most important Greek shipping companies from 1857 onwards. The last section of the gallery is dedicated to the traditional fishing boats operating in the eastern Mediterranean. In the centre of the gallery there is a big scale-model of a *perama*, a small-to-medium sized merchant boat common in the eastern Aegean and in the Marmara Sea until the beginning of the 20th century. The external planking is intentionally left

Figure 6. A small diorama showing a traditional 1900s shipyard and the different phases of the construction of a ship.

incomplete to show the details of the inner skeleton. In the external planking different colours are used, the dark brown corresponds to the caulking and the white to the completed hull. A small diorama shows a traditional 1900s shipyard and the different phases of the construction of a ship (Figure 6).

In the right wing there is a collection of 18th to 20th-century gears, devices, machines and instruments. On almost all the walls of the museum there are marine art paintings and images connected with the Greek revolution or with the history of the Greek navy.

The visitor experience is supported by panels in Greek of which only a few are translated into English, while the captions are generally bilingual. In the rooms there is diffuse natural lighting coming from the skylights. People with reduced mobility easily access the museum, as it is located on the ground floor. There are no services but there is a library with more than 12,000 books on maritime topics, a photo archive and a collection of 16th to 19th-century maps that is used every year by about 2000 researchers. A variety of educational activities are organised for school groups and children, occasionally including interactive games like the ones prepared for the European Heritage Days in 2018. A free theatre performance with a maritime topic was successfully carried out in the museum in June 2018 (Naftikò Musio tis Ellados 2018). Opening time and admission fees are illustrated in Table 1.

The museum is a member of the Association of Mediterranean Maritime Museums (AMMM). The Director of this museum was unavailable for interview.

The museum aims are to preserve the tangible and intangible cultural heritage of the Greek seamanship from prehistoric to contemporary times through the collection of equipment, documents, etc.; to inform the public about the peculiarities of the Greek maritime heritage; and, to arouse visitors' interest in maritime-related topics.

Case study no. 5: a naval museum in Italy: Museo Delle Navi Romane Di Nemi (Museum of the Roman Ships in Nemi)

This museum is located in Italy, on the lake of Nemi, about 35km south-east of Rome. It was built in the 1930s to house the two colossal ships of the Roman emperor Caligula (37–41 AD), once floating in the lake, recovered between 1929–1932 after many unsuccessful attempts carried out for over 500 years. It was the first case in Italy of a built-to-purpose museum. The side

Figure 7. One of the two accurate 1:5 scale models of Emperor Caligula's ships.

along the lake was walled up only when the two ships were brought inside after having been recovered (Avilia 2013: 125). Consequently, a strong relation between the container, the content and the context was created. From the large glass doors it was possible to see the surrounding landscape and the lake upon which the boats floated, foundered and were discovered. The museum was inaugurated in 1940 and was organised on two levels with a total surface of about 6400sq m. Unfortunately, both the ships and the building were burnt during an arson attack in 1944. The most precious finds escaped the fire because they had previously been brought to Rome and stored in the Museo Nazionale Romano.

After various vicissitudes, the museum reopened in December 1988 with a renovated exhibition.

Today the ground level is divided in two sections. In the right wing there are objects discovered in and around the nearby Roman temple of Diana. In the left wing, accurate 1:5 scale models of the ships and the few finds that survived (Figure 7) give the idea, even if only slightly, of the magnificence of these vessels that were more than 70m long and were decorated with marble floors, columns, fittings, kiosks and pavilions. Replicas of the original on-board equipment are exhibited and, as they are not in display cases, the visitors can go closer to them and see all the details.

The visitor experience is completed by a video on the discovery and the recovery of the ships and by panels with 1930s pictures illustrating the most fascinating information on the ships and on their recovery. They are bilingual (Italian and English), in black on a white background. The captions are also bilingual and are in green/blue for Italian and in black cursive for English, on a white background. The lighting is mainly natural, with the light coming from the windows and the glass doors on the ground floor. A few directional lights are positioned on pillars. The museum is accessible by people with reduced mobility. Emanuela Vasselli, Archaeologist and Department Head of the museum, said that a special itinerary for visually impaired visitors was projected but is not yet operational. Educational activities are organised by cultural associations. There are no services. Every year, the museums receives about 20,600 visitors. From 2014, the museum has been part of the Polo Museale del Lazio.

The aims of the museum are to preserve the archaeological remains related to the imperial ships

Figure 8. A life-size diorama representing an ideal excavation of a Roman cargo shipwreck.

of Caligula, together with the historical record of their recovery and destruction, and to offer an overview on the archaeological evidence of the neighbourhoods; to inform the public about the uniqueness of the ships in all their aspects; and, to make visitors aware of the necessity of respecting and protecting maritime cultural heritage.

Case study no. 6: an ancient navigation museum in Italy: Museo Del Mare E Della Navigazione Antica (Museum of the Sea and of ancient Seafaring)—Santa Severa

The museum is located in 15th-century buildings belonging to the complex of Santa Severa castle, on the coast about 60km north of Rome. This town museum was founded in 1993 (Enei 2010: 6) thanks to the cooperation of Soprintendenza Archeologica per l'Etruria meridionale, Regione Lazio and Provincia di Roma. The museum has two levels, in an area of about 770sq m. On the ground floor there are the first six rooms, organised by single topics. In the first room a life-size diorama representing an ideal excavation of a Roman cargo shipwreck displays underwater archaeologists at work with their equipment (Figure 8).

Along the walls is a collection of Roman amphorae, mainly found on the seabed near Santa Severa. They have both a short caption and a supplementary information panel, helpful for specialists and those interested in scientific details (Figure 9).

A corridor is dedicated to the geographical explorations carried out during antiquity and links to the third room where the visitors learn how ancient boats were built and find out about mortise-and-tenon plank joints and sewn joints, the two different ancient joining techniques. On the wall there are replicas of carpenters' tools, like callipers, axes and chisels that the visitor can touch. In the fourth room there are life-size replicas of ship devices based on in-depth studies of archaeological finds; and the visitors learn how a bilge or a chain-pump worked on a Roman ship. The fifth room is about ancient sail navigation. A copy of the 3rd-century AD Torlonia relief shows activities in the harbour of Rome and the characteristics of the boat sailing towards it. A scale model of a Roman boat with a square sail, constantly blown by the air of a small fan, gives an idea of how it operated in different winds.

In the sixth room the topic is life on-board on ancient Roman ships. A life-size replica of the cargo-hold of a Roman ship, based on the remains found in the Laurons 2 shipwreck, is exhibited. Two mannequins, representing sailors at work checking the cargo and the bilge, give a vivid idea of life on board. The last room is the only one located on the upper floor and it is focused

Figure 9. A collection of Roman amphorae mainly found on the seabed near Santa Severa. Fragments are integrated into wooden silhouettes to give an idea of the complete shape of the object.

on the finds recovered in the Santa Severa shipwreck and in the nearby areas.

The visitor experience is enriched by many detailed panels in Italian written in black on a light-yellow background, by captions in Italian in black on a white background, and by a loop-mode video illustrating how the ancient boats were built. The rooms are enlightened by directional lighting from above and by diffuse natural lighting coming from the windows. Visitors with reduced mobility easily access the rooms at the ground level and reach the upper floor via a moveable platform. Services are available on the ground floor. Educational activities are organised for school groups and children, together with guided tours and various events for visitors of any age.

Flavio Enei, Director of the museum, said that the museum is visited every year by about 11,000 people and 6% of them are from abroad. He also says that all visitors highly appreciate the educational approach and that children in particular are very much fascinated by the video about the shipbuilding techniques. All visitors find the dioramas extremely attractive and enjoy being allowed to touch the objects exhibited.

As declared by Flavio Enei, the aims of the museum are to preserve the underwater archaeological remains found in the seabed near Santa Severa and to present them through an educational approach; and, to inform the public on the ancient seafaring traditions and techniques through fascinating replicas, reconstructions and dioramas, the result of research in cooperation with specialists.

Discussion

Until the second half of the 20th century, maritime museums had mainly a celebrative function and consequently their collections, often gathered by aficionados or by retired seamen, were centred on the histories surrounding the glory and triumphs of national navies (Paine 2016: 392). From the 19th to the first half of the 20th century this purpose was addressed by the necessity to build national identities in countries redesigning their borders, creating empires or freeing themselves from foreign occupations. Even a naval museum such as the one in Nemi, had a celebrative intent—showing how similarly great and powerful were the Romans and the Fascists and emphasising how, under Fascism, the goal of recovering the enormous Roman ships, a project which had failed for centuries, was achieved. Illustrations of the Nydam boat were used in the National Socialism racial propaganda to emphasise the achievements of the Germanic populations (Abbeg-Wigg 2014: 93). Celebration was the aim also of the Hellenic Maritime Museum in Zea. In this museum the celebrating approach is still visible and even if it was understandable in the 1950s when the museum was created, nowadays looks slightly anachronistic. In the 21st century, successful naval, ancient navigation and maritime museums should have preservation, interpretation and public information as their main goals.

Preservation is the first goal that a maritime museum should achieve. Unfortunately, the museum in Nemi failed it in 1944 when, during the withdrawal of the German troops and the advance of the Anglo-American forces, the boats burnt in an arson attack set inside the museum. One of the boats discovered in the Nydam bog was destroyed during the Prussia and Denmark war in 1864 (Abbeg-Wigg 2014: 85). These episodes demonstrate how delicate maritime cultural heritage is and how easily it can be destroyed or damaged, especially during wars. Hence, the ICOM Code of Ethics for Museums (2.21) states that 'careful attention should be given to the development of policies to protect the collections during armed conflict and other human-made or natural disasters'. Everyone should be aware of the importance of the preservation of maritime cultural heritage in all its forms. This is why informing the public is another fundamental goal, strictly connected with the interpretation of the collections exhibited. Interpretation is the bridge connecting the scholars to the visitors and makes the information of the public possible (Desvallées and Mairesse 2010: 46). Obviously, interpretation is not possible before the research on what is exhibited, consisting of the intellectual activities aimed at the advancement of new knowledge on the museum collections (Desvallées and Mairesse 2010: 73). Research is an ongoing activity, as demonstrated, for example, by the Antikythera shipwreck exhibition. The mechanism has been continuously studied from 1902 onwards and from the 1990s has been analysed with the most recent diagnostic technologies (Bitsakis 2012: 97–98). In the 1990s, research in the Nydam bog made possible the recovery of new elements of the boat (Abbeg-Wigg 2014: 88), providing additional data on the boat.

In the museums discussed here interpretation is well presented and, from a displaying point of view, the most useful interpretive infrastructure is represented by scale models, dioramas and life-scale replicas, which are particularly incisive and charming in Hamburg and Santa Severa and much appreciated by the public. Panels and captions represent traditional interpretive infrastructure. They should be clear, complete, not banal but also not too technical. The panels of the museums analysed here often contain too much text and in most of the cases the typeface is too small for a comfortable reading. Panels closer to ideal criteria are the ones in the Antikythera shipwreck exhibition and in Nemi. They have many large pictures, text not too long and good-sized typefaces. Contrary to Mottola Molfino (2008: 21) technical data should not totally omitted, because museums are also the place where specialists share their ideas with other specialists. The technical data could be explained for the non-specialists or could be denoted by using different graphic expedients, like in the captions in Santa Severa. However, more detailed information can be communicated to visitors via different supports like audio-guides or tablets. In this way the visitors are engaged in choosing the level of detail, deciding when to linger and what to skip, according to their interests. Audio-guides have usually a fee between €2 and €3.50 per person but, even if the cost is not high, not all the visitors hire them as they represent an extra expense. A very good compromise between cost and communication is represented by QR codes, a way to communicate contents with multi-media experiences and direct engagement, not yet used in the museums presented but with an increasing popularity in museum exhibitions since 2008 (Government of Canada 2016: 1). QR codes are two-dimensional barcodes with a big capacity for storing any kind of data, readable on smartphone via free applications. They are free for both the museums that create the codes and for the visitors who download the reader application (QR codes 2017: 1). They release museums from providing the equipment while enriching visitor interaction and engagement. Visitors with learning difficulties can also easily use them because it was noted that their use is more efficient in the learning process than the 'standard wall of words' (Davis-Hofbauer 2016: 6) thanks to the possibility to control and interact with the flow of information. The more seemingly minor disadvantages of QR codes may be represented by the necessity to have an operating smartphone or by the distrust of digital technology by some visitors.

Interpretation and information activities should be physically accessible to the public, in all its variety (ICOMOS, Principle 1.5). These include persons with special needs, to whom particular regard should be given (ICOM Code of Ethics for Museums, 1.4). In all the museums analysed the admission and the exhibition itinerary are accessible for customers with reduced mobility and for wheelchair users. Visually impaired visitors can touch the replicas exhibited in Schleswig and Santa Severa, but there is not this possibility in the other museums.

Informing the public is one of the Rules of the 2001 UNESCO Convention (rule 35) and this third goal can be reached through education. Educational activities, intended as a process of acquisition of new knowledge regardless of age, are offered to schools and children in all the case studies. In Hamburg activities are also offered to families, while in Schleswig and Santa Severa they are organised for visitors of any age. The knowledge process should be always pleasant and emotional and consequently these activities often use entertaining expedients for an active engagement. In Hamburg, for example, children learn about piracy by watching museum staff performing pirates' assaults, after which children themselves simulate pirates' battles. In Zea, in June 2018, a theatre performance with a maritime theme gave the visitors the possibility to immerse themselves in a maritime atmosphere and to learn about seafaring trade and related topics in this unusual way.

The opening time and the ticket price are the two fundamental elements which persuade potential visitors to enter a museum and for these reasons the ICOM Code of Ethics for Museums (1.4) recommends that museums should be open during reasonable hours. For all the museums presented the opening time is generally from 9:00am or 10:00 am to 6:00pm or 7:00 pm and can be considered sufficiently extended. Only the museum in Zea closes at 2:00pm and this opening time appears too short and somewhat unreasonable especially in the summer, when the morning hours are too hot to encourage a visit.

ICOM's Code of Ethics for Museums (3.2) suggests museum availability as freely as possible. Usually the admission fee for the museums described is reasonably cheap, between €3 and €4 for a full-priced ticket in Zea and Nemi, between €8 and €12 in the other museums.

Lighting is generally fine, but it should be enhanced in Nemi, as the museum is slightly too dark during the winter and the cases in the left wing are not well lit. The lighting was remarkably evocative in the Antikythera shipwreck exhibition where the dominant colour was blue and a projector gave the effect of seawater in movement.

Except for Nemi and Zea, all the museums offer services, like bookshops, cafeterias, cloakrooms and audio-guides. Only the museum in Hamburg is a member of the International Congress of Maritime Museums (ICMM), while the museum in Zea is a founding member of the Association of Mediterranean Maritime Museums.

Conclusion

The way to present maritime heritage in the museums discussed depends by two main factors—the museum category and the socio-historical context during which the museum was built. The naval museums use a very accurate scientific approach, offering the visitors detailed information on the shipbuilding techniques or on other technical aspects and on the history of the discovery and the recovery of the shipwrecks. What are missing are time and space connections that allow visitors of any age and from any place to have a better understanding of the exhibition and a deeper engagement. For instance, in Nemi a panel comparing the biggest known ships in antiquity might be improved offering, for example, parallels with the dimensions and the luxury of the *Titanic*, a ship better known to most visitors including those from abroad. In fact, because maritime heritage is international in character and the 21st-century public live in a globalised world and travel worldwide much more now than in the past 30 years, interpretation should be from a local to a global perspective. Maritime and ancient navigation museums tend to have a more global approach to their collections, but only the one in Hamburg, which is the most recent, builds different chronological and geographical connections. Generally speaking, if museums presenting on maritime heritage want to capture new visitors, they should focus on a wider audience, potentially coming from anywhere in the world.

Public information—through emotional, entertaining and engaging educational activities—gives the public an appreciation and awareness of maritime cultural heritage, and demonstrates the necessity to guarantee its preservation for future generations. In the case studies presented, these activities are targeted at children and adults, but not yet for people with special needs.

From an audience experience perspective, in all of the museums discussed, traditional interpretive infrastructures might be integrated with QR codes, an inexpensive, interactive and engaging support that can be easily used also by visitors with learning difficulties. Regarding lightning, the predominance of blue colours and of light recreating water moving should be seriously considered for naval, maritime and ancient navigation museums and exhibitions, and accompanied with sounds related to the sea, such as the undertow and the cries of seagulls. In fact, studies have demonstrated the positive impact of blue spaces on human health and views of water are considered attractive and fascinating, as well as the sounds (Völker and Kistermann 2011: 454).

The services are as important as the exhibitions because they welcome visitors and give them the friendly feeling that their presence is desired (The Wallas Foundation 2001: 3, 15). For these reasons the absence of services in Zea and in Nemi is a severe lack and a gap to be filled.

Relative to the international recommendation and guidelines on the public presentation of maritime cultural heritage, the biggest issue is to really achieve the goal of accessibility for all the visitors. Tactile itineraries for visually impaired visitors and activities for those with visual and hearing impairments should be definitely increased in all the museums discussed to give these users the chance to experience maritime heritage through charming and engaging multisensory exhibitions. Moreover, the access of people with learning difficulties should be increased as well. Some maritime museums, such as the Mary Rose Trust in Portsmouth, has successfully experimented the access of such visitors, assisted by trained personal (Mary Rose 2018).

Finally, the networks of museums on maritime heritage should definitely be strengthened, as only the museums in Hamburg and in Zea are part of two of them. Being in wide museum networks, like the one accessible through the ICMM, is surely a great advantage because a constant interaction and interfacing between the museums help to share ideas and experience on maritime heritage among specialists worldwide. In fact, ICOMOS (Principle 7.7) encourages international cooperation, sharing of experience and exchanges of professional staff, particularly important for an international shared heritage like maritime heritage.

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Apoxyomenos—Underwater Cultural Heritage and Museum in the Service of the Local Community

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Abstract

Seventeen years ago, a bronze statue of a young athlete was discovered near the island of Lošinj. It was named Apoxyomenos. Immediately after the statue was discovered, its extraordinary cultural and artistic importance initiated a more general discussion about cultural heritage and the need to preserve it. The beauty and portrayal of details of this unique artistic underwater find have put Croatia and the island of Lošinj on the world heritage map. The Museum of Apoxyomenos in Mali Lošinj is fully dedicated to underwater archaeology. In this museum exhibition, one exhibit, presented in an entirely modern concept of artistic projection and promotion, changes the perception of the cultural-heritage space, extending it from the coast to under the sea. Ever-growing public interest in underwater cultural heritage has changed the perception of underwater archaeology, and even the local community has begun to see it as a scientific discipline, which is not an end in itself, but serves and benefits the community. In this social environment, Apoxyomenos, which started off as a tourist attraction, is gradually becoming a brand and a basis for cultural tourism and, as such, makes an essential contribution to the economy of the region.

Keywords

Apoxyomenos, museum, local community, cultural tourism

Introduction

The Adriatic is a marginal sea of the Mediterranean. In the past, it used to be described as its largest bay, the Most Important Sea or even the Great Sea. The northern Adriatic as a whole and particularly the islands of Cres and Lošinj, are places of many mythological events, as well as being the main strategic points of maritime trade routes. Because of the amber trade, they are associated with the name 'Electrides', or Amber Islands, while their alternative name of the 'Apsyrtides' refers to the voyage of the Argonauts and the tragic destiny of Apsyrtus, son of King Aeetes of Colchis. The earliest forms of the name of the island have been preserved in works of Hellenic and Latin writers (Pseudo-Scylax, Pseudo-Skymnus, Apollonius of Rhodes, Strabo, Pliny).

Since ancient times, the islands of Cres and Lošinj, with their surrounding islands and reefs, have been an unavoidable feature of the navigation route through the northern Adriatic. This is partially because of their indented coastlines and numerous protected and sheltered bays, but the main reason is the ancient method of navigation, which mostly involved sailing along the coast.

The sea off the islands of Cres and Lošinj and the surrounding islands abounds with diverse archaeological material and is a source of rich and precious cultural heritage. Numerous archaeological discoveries have established that the islands of Lošinj and Cres have been important elements in navigation routes throughout history. The discoveries also confirm the continuity of traffic between the Croatian and Italian coasts and the high standard of living in this region.

In 1996, a bronze statue of a young athlete was discovered on the seabed near the island of Lošinj. It was named Apoxyomenos. Most ancient bronzes did not survive, since the bronze of the statues was later melted to make dishes, weapons, tools and coins. This statue thus provides us with a rare and precious insight into a little-known art. Apoxyomenos represents a unique discovery in the Adriatic, and also in the world. Its integrity and beauty of design distinguish the statue from other finds as a work of art of exceptional quality. It was made in Greece in the 2nd or 1st century BC.

The statue has been entirely preserved, with only the little finger of the left hand missing. Part of the original bronze plinth was still attached to the sole of its right foot. Immediately after the statue was discovered, its extraordinary cultural and artistic importance provoked a more general discussion about cultural heritage and the need to preserve it. The beauty and portrayal of

Figure 1. Entrance to the Museum of Apoxyomenos in Mali Lošinj (Bosnić and Dorotić).

details of this unique artistic underwater find have put Croatia and the island of Lošinj on the world heritage map. There are nations much bigger than Croatia, and world-famous museum centres, which cannot boast an artefact as sensational as this one.

Cultural tourism and the local community

In contrast to the situation in Croatia, in many places around the world cultural tourism makes up a very important portion of the activities on offer to the tourist and contributes significantly to the economy. In Croatian tourism as such, and in island tourism in particular, what is offered is still based primarily on sea and sunshine, and only occasionally includes cultural heritage, which is abundant in Croatia.

In Croatian tourism, especially at the local level, museums are not appreciated at all. During organised tours of towns, tour guides sometimes only mention that there is a museum here somewhere, but never take visitors to it, not even when those museums host exceptionally important national or international exhibitions! What is the reason? Despite being locals, tourist workers have no awareness of heritage and its value. However, the situation cannot be blamed on tourist workers only. The need to present cultural and archaeological heritage in a more attractive fashion has existed in Croatia for quite some time. Museums are crying out for exhibitions, which depart from the usual structure and offer their visitors a multimedia approach. Museum collections present a rare creative and informative potential, which will attract visitors if presented in a professional and attractive way, in line with the expectations of today's travellers.

However, we need to be aware that not all cultural products can attract the attention of visitors in the same way; and, nor do they all have the same value as tourist products. For tourism, the perception of a cultural property as precious is sometimes more important than its objective value, and here the marketing can play a key role. Although it is clear that the excellence of a cultural item will probably lead to its positive perception, it is important to gauge whether the presentation of that cultural item is perceived as a special event, as unforgettable, or a pleasant experience.

The promotion of cultural values should primarily target the local population, which should become fully aware of the richness of their cultural heritage. Cultural heritage and a museum, as its main promoter, play a very important role in the development of a local community's specific identity, and without it, one destination can hardly be distinguished from other similar localities. On the island of Lošinj, the most important part of the local cultural heritage are the underwater archaeological finds and sites, used to create specific experiences and to attract visitors—and place this destination on the market. An unforgettable experience or a special moment is key factors for the perception of the museum, and amongst of the main reasons for the selection of this destination.

The museum

Until the Museum of Apoxyomenos was opened, neither the local nor the regional tourist industry considered museums as one of the main baits for attracting tourists. The reason for this lay in the fact that museums could not or did not know how to put their cultural products on the tourist market, or they lacked the support of the local tourist boards to achieve it. Artefacts that form our cultural heritage can be seen as cultural products, which should be wrapped nicely and offered on the market. In the case of museums, the product should be wrapped nicely in a story. Thus, the key question for any museum is how to tell the story.

The Museum of Apoxyomenos has succeeded in doing this. The fact that this is a specific museum, dedicated to a

Figure 2. The Black Room (Bosnić and Dorotić).

sole exhibit, has greatly impacted the development and design of its permanent exhibition. With their inspired vision of the building and its interior, architects Turato and Randić have presented this globally sensational archaeological find in an extraordinary way.

The Museum of Apoxyomenos and its exhibition represent the spatial materialisation of the ceremony of passing through various rooms and halls on the way to the sculpture. The architecturally shaped body of the new museum has been inserted in a space defined by the exterior walls and the roof of the existing Kvarner Palace (Figure 1). The museum is built inside the shell of an old building, with the architects incorporating a completely new design within it, 'a house within a house'. The museum structure is enclosed inside a steel construction, created inside the building.

The exhibition display is defined by the idea of passing through the building by visiting nine scenes and transition zones shaped by time and space and accompanied by the corresponding audio background. Visitors enter the museum via the multi-functional atrium, known as the 'blue room'. The striking room is coloured deep blue, transforming the inner walls of the palace.

From there an escalator takes groups of up to 20 through a white-painted tube, leading them to the main exhibition hall—the 'black room' (Figure 2). In this cold, dark area, visitors can experience what it feels like to be 45m under the sea, and they can learn about the history, context, discovery and restoration of Apoxyomenos from illuminated displays detailing the statue's past.

Visitors then move on to the 'colourful room'—an amphitheatre clad in merino-wool carpet designed by Studio KulenTurato, with its bright and contrasting design intended to create the feeling of walking over a seabed, symbolising the unique story of how the statue was recovered and its visual history (Figure 3). The 'red passage' is next, in the form of a narrow staircase leading to the 'yellow room'—a media-inspired room by MKF&AT and Bosnic+Dorotic—looking at the media coverage relating to the statue (Figure 4).

In the build-up to the grand unveiling, the 'olive passage' is a staircase made of olivewood, with inset chambers containing natural elements such as wood and leaves originally found inside the sculpture. The scent of oil and olives is also pumped into the room as visitors get a first glimpse of Apoxyomenos. By visiting and experiencing those various, dynamic and impressive rooms, and by getting acquainted with their content, visitors are getting ready for the final scene: the 'white room', a completely white and silent room whose walls are covered in textile, and whose only occupant is the bronze Apoxyomenos (Figure 5). After meeting the sculpture, the visitors get to experience one final emotion by visiting the 'kaleidoscope room', a look-out at the top of the Museum situated in a space

Figure 3. The Colourful Room (Bosnić and Dorotić).

Figure 4. The Yellow Room (Bosnić and Dorotić).

Figure 5. The White Room (Bosnić and Dorotić).

Figure 6. The Kaleidoscope Room (Bosnić and Dorotić).

in which various sequences from the Lošinj harbour are reflected in the mirrors on the ceiling (Figure 6).

This museum activates all the senses.

The opening of the Museum of Apoxyomenos in Mali Lošinj—the first museum on the Adriatic exclusively dedicated to underwater archaeology—indirectly presents the northern Adriatic (the Kvarner Bay) as an area of high classical civilisation. In this museum exhibition, one exhibit, presented in an entirely modern concept of artistic projection and promotion, changes the perception of the cultural-heritage space, extending it from the coast to under the sea.

The ever-growing public interest in underwater cultural heritage has changed the perception of underwater archaeology, and even the local community has begun to see it as a scientific discipline, which is not an end in itself, but serves to benefit the community. Thus, underwater archaeology and underwater archaeological heritage have become an exceptionally valuable 'home-made product', a resource for cultural tourism and the local economy.

In such a social environment, from being a tourist attraction and the most important element on offer to the tourist, Apoxyomenos is gradually becoming a brand and a basis for cultural tourism, and as such it makes an essential contribution to the economy of the region.

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Pursuing Sustainable Preservation and Valorisation of Underwater Cultural Heritage: Okinawa's Pilot Project for an Underwater Site Museum

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Abstract

Archaeological sites are often turned into site museums as places for tourists and other non-archaeologists to visit. This phenomenon is widespread, even for underwater sites; it is not limited to terrestrial sites.

This article proposes a way of establishing sustainable and locally oriented management of underwater cultural heritage (UCH) in the form of an underwater site museum. We present our experimental trial of model cases for underwater site museums by holding open day events at two underwater sites off the coasts off Kume and Ishigaki Islands in Okinawa.

Baiae Underwater Archaeological Park is a famous example of an underwater archaeological site constantly open to the public. It is completely different from popular recreational wreck dives as public visits are supervised by the managing body of the archaeological park consisting of the specialists including archaeologists, architectural historians, conservationists and similar, who investigate, evaluate, preserve and valorise the site.

In the case of Baiae, the state government directly manages the park. In Japan, however, where day-to-day cultural heritage management is largely the responsibility of local government, the decentralised structure of Cultural Heritage management (CHM) should result in a variety of different ways of managing underwater site museums.

Keywords:

Sustainable, valorisation, underwater site museum, Okinawa

Background of UCH management and the attraction of UCH in Okinawa

The past few decades have seen an increased interest in cultural heritage management. In addition to preserving the sites themselves, which has traditionally been the primary purpose of cultural heritage management, the need for them to be used more widely and for their value to be enhanced has been recognised and prioritised. Archaeological sites are often turned into site museums for the wider public - tourists and non-archaeologists – to visit. This phenomenon is widespread, even at underwater sites. This paper proposes a way of establishing a sustainable and locally oriented management of UCH in the form of an underwater site museum.

Okinawa consists of the southern half of the Ryukyu Archipelago with 199 islands scattered over a stunning and vast sea area of 1200km between Kyushu Island, located at southern end of the Japanese Archipelago, and Taiwan. Unlike other parts of Japan, the islands have a subtropical climate, warm throughout the year. The area is surrounded by amazingly beautiful ocean with thriving coral reefs. The sea is very famous and popular amongst scuba divers, as well as those interested in other marine activities. Many of those who visit the area are interested in the sea and many are repeat visitors. Some experienced divers or snorkellers may tire of watching fish and corals, and they come looking for something different and attractive. UCH has the potential to fulfill such needs. Indeed, UCH attracts non-archaeologists, as wreck diving is a very popular and fun activity. In some countries such as Malta it is a major tourist attraction (see Figure 2).

Methodology of investigation and analysis

Firstly, to elucidate potential problems in enhancing the value of UCH, the authors have compared various examples of UCH management in peninsular Italy, Sicily, Malta and England. By comparing these examples with Okinawa, we attempt to create a suitable model for UCH valorisation in Okinawa.

Two more detailed case studies in Okinawa will then be presented. The first results from experimental trials of organising site open days at Ohajima underwater site off Kume Island. The other is an ongoing project at Yarabuoki underwater site. Both are very challenging projects in trying to involve local professional divers, as well as local communities.

By comparing those cases, this paper aims to present a model of UCH valorisation which will be implemented at the Yarabuoki underwater site in the near future, thus formulating an approach suitable for UCH in Okinawa.

Case studies from international preceding examples

There are many opportunities for the public around the world, and in Japan, to enjoy scuba diving and snorkelling at UCH sites. Some sites are organised so as to present precious UCH together with historical information which adds value to the site. Others are purely for leisure diving, such as wreck dives or the like. The former are relatively rare. The latter exist in many cases and are not under the control of archaeologists or heritage managers.

Baiae Underwater Park (Italy): a national underwater park

Baiae Underwater Archaeological Park in Italy is a famous underwater archaeological site organised to be constantly accessible to the public. UCH that is constantly open to the public and is organised and maintained in a form of an archaeological park is very rare. Baiae Underwater Park is one such rare example, opened in 2007; a new one is about to open in Greece.

The current city of Baia faces Baia Bay, near Naples. The Roman city has subsided due to bradyseism and has ended up forming UCH. The city had long been a famous health resort for the ancient Romans. Famous persons like Augustus, Cicero and Claudius loved the place thanks to its hot spring and scenic beauty. One of the most famous structures is the nympheum of the villa, which is dated to Julio-Claudian period. The national government of Italy recognising its significance, located an on-site supervising office (the ‘Baiae office’ from now onwards) at the site itself in 2003 under the Soprintendenza Archeologica of Naples. A commercial port was turned into a nationally managed underwater park in 2007. The park presents archaeological sites to the public under national supervision, as well as leading research into and protection of the site (Figure 1).

The Baiae office is responsible for research into and protection of the sites, developing the dive sites, organising training of guide divers and other pedagogical activities, controlling the booking for diving and for many other activities related to the management and valorisation of the site. It also deals with the terrestrial parts of the site and presenting the archaeological sites of Baiae as a whole. Access to certain areas is restricted at the underwater park and only limited activities are allowed in these areas. They are ranked from A to C according to the significance of their archaeological structures and their depth. Scuba diving is allowed only when accompanied by the guide divers registered to the Baiae office who have completed their official training course. The registered divers greatly contribute to monitoring the site. Any anomalies found by them are reported to the Baiae office. The Coastal Security Guards also help to protect the site by controlling illegal activities in the restricted sea area.

Bristol Beaufighter (Malta Island): wreck diving as recreational diving

Malta belongs to the Republic of Malta, one of the major industries of which is tourism thanks to its brilliant ocean resorts and UNESCO World Heritage sites. Many divers visit the islands for wreck diving. Technical divers with very high standards are also involved in wreck dives there. Malta was at the centre of severe battles in the Mediterranean Sea during the Second World War and, thus, many sunken World War II wrecks are scattered around the islands.

Malta is the largest island and home to the capital, Valetta. The Bristol Beaufighter is a British heavy fighter plane during the Second World War. One of them has sunk off the coast of Malta. As it is relatively accessible, located about 1km offshore of St Julians and on the sandy seabed at 35m depth, it is a very popular

Figure 1. Baiae Underwater Archaeological Site.

wreck dive site among leisure divers in Malta. Many dive charters take divers to the site for recreational diving if requested even though it is limited to relatively experienced divers and costs more than other dive sites due to the challenging conditions. Malta is a world famous wreck diving destination. Cresta Diving Centre at St Julians that the authors have visited is one of the diving centres which takes leisure divers to do wreck dives. The centre had experienced guides with knowledge of historical wrecks and one of them has even published a book on Malta's wreck sites (Hadnett 2016).

Academic investigations of UCH have been very actively undertaken in Malta and sites have been thoroughly evaluated (c.f. Gambin 2015). While local diving services have individually developed many historical wreck dive sites, the government and academics are now organising official UCH protection (Gambin 2016) and systems to protect and valorise those sites after detailed investigation, recording and evaluation (Figure 2).

Wreck Dive Day by the Nautical Archaeology Society (England)

Protection of UCH can be split into two categories in England—sites that are legally protected by The Protection of Wrecks Act, and those that are not. There are 47 legally protected wrecks in England under the surveillance of Historic England (previously, English Heritage) with limited access (English Heritage 2010). Historic England issues licenses to dive on protected wrecks to over 2000 individuals on more than 70 applications after consultation with the Advisory Committee on Historic Wrecks. Historic England publishes guidelines for this. Applications considered as contributing to and profitable for the protection and dissemination of UCH are accepted. The license is valid from the day of issue to the following 30 November and those who want to continue their projects have to apply to renew their license. At the expiry of every license, the licensee is obliged to hand in reports and photos, which serve as monitoring records of the wreck sites accessed. Monitoring by over 2000 people is far better than when it is done by the limited resources of Historic England.

The Nautical Archaeology Society, a charity based in Portsmouth, organises Wreck Dive Days twice a year. A licensed diver, a staff member of the society, leads the dive. It is advertised on the society's own web site as well as mail magazines and to other similar groups. It is a very popular event for the society and places are booked up very quickly.

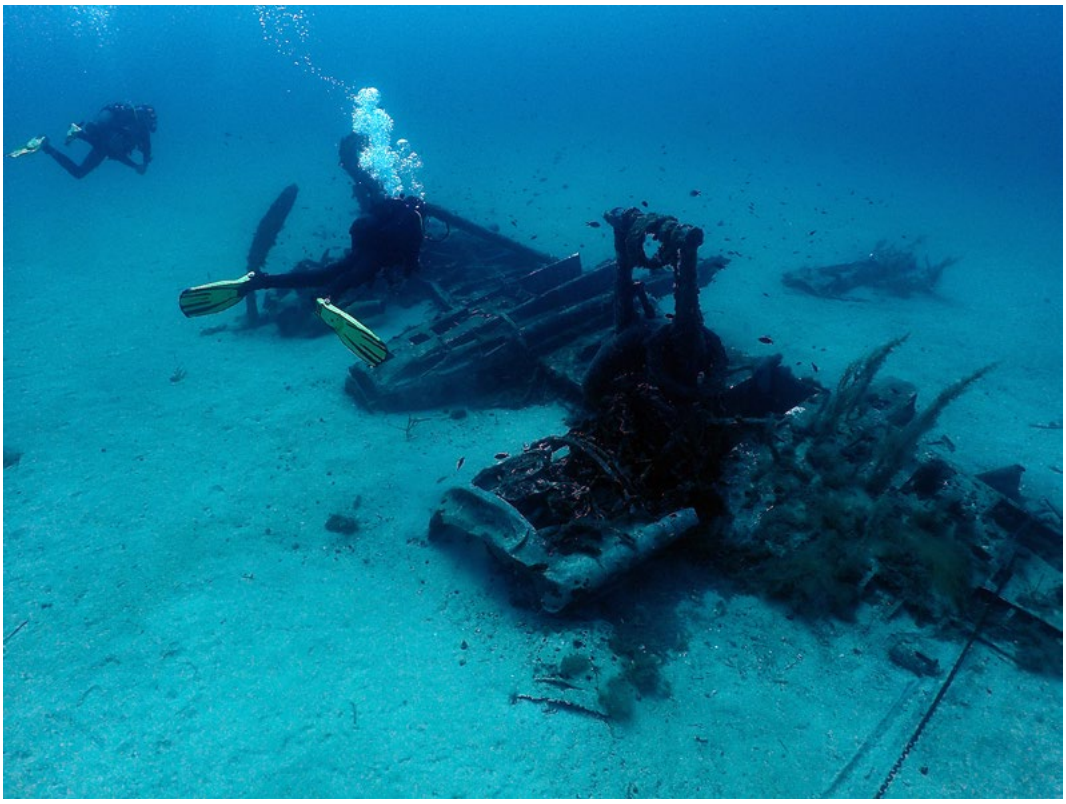

Figure 2. Bristol Beaufighter.

Ohajima site off Kume Island, Okinawa (Japan): site open day

Ohajima Underwater Site is located off the coast of Oha Island annexed to Kume Island in Okinawa. The site contains a dense distribution of Chinese pottery dating back to between the second half of the 14th- and beginning of the 15th-century. A public site open day was experimentally held there twice, in 2011 and 2013. Participants, having heard lectures about the history of the island and site, followed by related terrestrial site visits, finally viewed the sites either by snorkelling or from a glass-bottom boat. The local board of education (Kumejima Museum) and local diving services were involved as well as other underwater archaeology groups and individual organisers of the event (Katagiri *et al.* 2012).

The major attraction of the day was the visit to Ohajima Underwater Site either by snorkelling or glass-bottom boat. For a better understanding of issues of UCH, archeologists delivered a 30-minute introductory lecture before the site visit, as well as an observation tour of the artefacts already raised, such as pottery pieces collected from the seabed at Ohajima and a stone anchor found at Uegusuku (Castle) site. Furthermore, an hour-long tour related to cultural heritage sites on land, such as Tenkogu site, Kuramoto-ato site, Maja-ko port site, quarries and the like, was organised and led by archaeologists. This aimed to explain why the underwater site had been formed on the seabed of Ohajima (Katagiri *et al.* 2012) (Figure 3).

The public were given two options for the actual visit to Ohajima Underwater Site, both of which lasted for about an hour. The visitors were divided into two groups of twenty people each, one for visiting the site by snorkelling and the other in a glass-bottom boat for those who were not willing to get into the water (Katagiri *et al.* 2012).

This pilot project provided a model for the package of a site open day for public visiting of UCH, which could be copied by the other sites in the Ryukyu Archipelago (although we still have to evaluate how far this case can be applied to other cases as well as to the wider public).

Case study—Yarabuoki Underwater Site

Location and characteristics of the site

Yarabuoki Underwater Site is located off the coast of Yarabuzaki in Nagura Bay of Ishigaki Island in Okinawa (Figure 4). The site consists of seven iron grapnel anchors of various sizes and a cluster of early modern Okinawan ceramic jars (*tsuboya-yaki*), which were

Figure 3. Site open day at Ohajima Underwater Site: step 1: Lecture 'History and culture of *Kume* Island'; step 2: Observation of excavated ceramics from underwater site; step 3: Tour of land site involved in the trade; and, step 4: Snorkelling practice.

originally produced on Okinawa Island from the 16th to the 19th centuries, during the early modern Ryukyu kingdom period in Okinawa and the Edo period in Japan (Figure 5). They are the first grapnel anchors found in Okinawa and within the region as a whole.

A local professional diver, Mr Seiji Fujii, who has been running a dive charter for more than 30 years on Ishigaki Island, discovered the site in 2009. He reported the approximate location of the site to Okinawa Prefectural Archaeological Center. In 2010, the centre conducted a site inspection survey with the assistance of the Nansei Islands Underwater Cultural Heritage Study Group (Katagiri 2009, 2010, 2011; Katagiri *et al*. 2014). Our team is currently undertaking an interdisciplinary research project to evaluate the historical and archaeological significance and potential of the site as a cultural resource (Ono *et al.* 2016).

Workshops with the local professional divers

Since he reported the discovery of the site to Okinawa Prefectural Archaeological Center, Mr Fujii has been involved in archaeological researches there, and we have been trying to build up a network of the local professional divers who dive the site most frequently. The aim is for them to monitor the site in the future with the support of academic evaluation of the site by archaeologists providing instructions on how to enjoy visiting the site without disturbing it. With the cooperation of the Ishigaki City Board of Education, the local authority responsible for cultural heritage in the area, we organised several workshops with local divers to visit the site together and exchange opinions about sustainable valorisation of the site on condition that the site should be preserved *in situ*.

In November 2015, we conducted an experimental site visit tour and a workshop to exchange views with local professional divers. Seven local divers working at the local diving services on Ishigaki Island participated in the site visit and thirteen participated in the workshop for opinion exchange. At the site visit, teaching material for the archaeological significance of the site was distributed and a short lecture by an archaeologist from the research project team was delivered, in

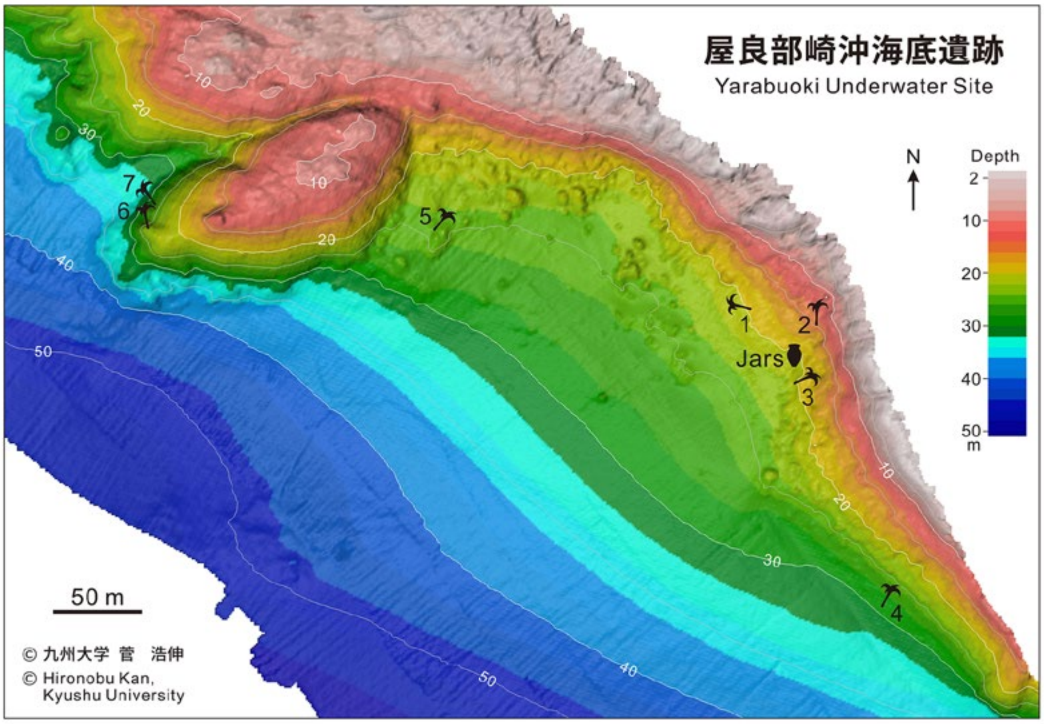

Figure 4. Multibeam bathymetric map of Yarabuoki Underwater Site
(produced by Prof. Hironobu Kan, Kyushu University).

Figure 5. Assemblage of Okinawa-produced pottery in good condition at Yarabuoki Underwater Site
(Okinawa Prefectural Archaeology Center).

preparation for the visit. All participants showed great interest in the sites and seemed to be willing to develop it as the point to take their guest divers. Opinions were very actively expressed and we were able to establish relationships to a certain extent with a view towards further cooperation.

Moreover, we also explained to them that they should not to touch or move the UCH, as well as the significance of contextual information for archaeologists. When local divers visited the site, archaeologists were measuring and drawing the archaeological structures on the seabed so as to show local divers how and what kind of information is essential for archaeologists (Figure 6).

Questionnaires were distributed to seek the divers' impressions of the site. The answers gave us significant information for sustainable future management and valorisation plans for the site. All seven participants often go diving in Nagura Bay and five out of the seven dive frequently at Yarabuzaki, right near the site. This is partly because Nagura Bay is a good diving location when the north wind blows and makes it challenging to dive at other parts of the island. Two divers answered that they go diving at Nagura Bay particularly in winter when the north wind frequently blows. Three divers knew that the site contained UCH before our workshop. Four divers (two evidently and other two somehow) think that the site can be recognisable with UCH without explanation, but three think it is recognisable only with interpretations. Nevertheless, all seven thought that the site could be a very attractive diving spot for the leisure divers with good explanation and some effort, and all seven answered that they are willing to cooperate when we organise the public site open day to recreational divers in future. As the results of questionnaire show, local professional divers are

Figure 6. Site visit at Yarabuoki Underwater Site for local professional divers (all photos except bottom right taken by Yuji Yamamoto).

evidently interested in and have a positive impression of Yarabuoki Underwater Site.

Public viewing of the site by Skype

We also organised a live public viewing event of Yarabuoki Underwater Site in October 2016, to introduce the site to the wider public at the shopping area in Osaka. Video footage, recorded using a small-sized and low-cost underwater robot, was viewed there. For the event, the project engaged local high school students by letting them control the robot to introduce the precious UCH of Ishigaki Island to the people outside. Before starting the footage of the UCH, an archaeologist outlined information about the site and gave out handouts about the site to the audience. Two archaeologists who had participated in research at the site were also present to give supplementary explanations and answer questions. The live viewings were screened twice a day and 51 people in total came to see them.

Due to the nature of the location, in the shopping area at the very busy city centre terminal, the audience came from a wide variety of backgrounds. Increased recognition of UCH should lead to more people supporting it. Nevertheless, we must be very careful to differentiate underwater site museums from amusement theme park concepts.

Discussion: towards a future underwater site museum

In reviewing international examples of UCH valorisation, a few issues have been elucidated towards sustainable valorisation of UCH in the Okinawan region.

Firstly, the system to protect UCH in each country is based on a similar system to those applied to terrestrial sites. For instance, in case of Baiae and Sicily, the central government takes the leadership for the management and valorisation of UCH. The national government established an office at the Baiae site for the direct control and management of the site, and the Sicilian Soprintendenza have contracts with respective diving centres at the UCH sites. In England where charities play a significant role in terrestrial heritage, they are also actively involved in such activities for UCH. Therefore, in the case of Japan, where local authorities are at the centre of cultural heritage protection supported by over 5000 archaeologists working for local authorities throughout Japan, those must play a key role in UCH protection and valorisation in their respective areas.

Secondly, local public involvement is also essential, as they are the ones who take care of and pass the site down to future generations. Collaboration between local authorities and the local public is essential. Local divers are the ones who visit, watch and can monitor underwater sites most frequently. They can report any anomalies, as well as new discoveries, to the local authorities where a proper network is in place.

The goal for the sustainable valorisation of the site is a cycle: when local diving centres guide their guest divers (customers) to sites, UCH becomes an essential part of their work and life, which makes them automatically self-monitor and care for the sites.

Differences with normal leisure diving, such as uncontrolled wreck diving, are based on capacity building. Specialists should provide the guides with high-level archaeological information and evaluation, so that both guides and guests should recognise what is to be protected, as well as how to enjoy the history behind UCH. This process is involved in all the cases discussed in this paper.

Our pilot projects in Okinawa, on both Kume and Ishigaki Islands, show that the public, as well as local diving centres, are interested in being involved in UCH. We now need to develop further local networks and capacity building to implement the results of our pilot projects there.

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Sensing Tidal Landscapes: Remote Sensing for Identification of Underwater Archaeological Heritage in Shallow Waters

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Abstract

Remote sensing—the methodology that uses aerial, radar and satellite imagery to pinpoint potential buried archaeological sites across landscapes or waterscapes— has been long proved suitable for the detection of archaeological objects under water and is being increasingly adopted for archaeological investigation of coastal and lagoon or tidal environments. Depth limitation, water reflective properties and water turbidity are only partially limiting the discovery opportunities its use can provide and the advantages of its application over shallow waters in favourable circumstances are manifest. Standard image processing and more complex Computer Vision approaches applied to aerial and satellite imagery of wetlands offer the opportunity to visually detect underwater structures. They also adopt classification methods to identify potential submerged archaeological features based on the automatic learning of patterns, regularities and shapes. These approaches can both overcome the limitations of simple optical recognition and allow for recognising underwater patterns/shapes produced by a variety of natural or artificial factors.

This paper will expand on some of the applications of these approaches over the tidal landscapes of the Grado-Marano Lagoon (north-eastern Italy) set at the head of the Adriatic Sea, under which lay the southern fringes of the suburban development of ancient Aquileia, once one of the largest cities of the Roman Empire. Trials have demonstrated the potential of Computer Vision techniques in the identification and mapping of submerged natural and archaeological features such palaeo-channels and linear structures that concur to redefine current hypotheses on the extension of the Aquileia's *suburbium*.

Keywords

Remote sensing, image processing, computer vision, coastal tidal wetlands, submerged landscapes, Aquileia

Introduction

Aquileia (north-eastern Italy) is located at the head of the Adriatic Sea, about 20km from the modern seacoast line (Figure 1). Ancient sources state that the city, founded by the Romans in 181 BC, was built in a marshy environment and equipped with walls ('*in paludibus moenia constituta*' – Vitruvius, *De Architectura*, I, 4, 11) and it was connected to the sea through a sophisticated network of artificial canals and natural waterways. The city is defined by Ausonius as '*moenibus et portu celeberrima*' ('highly famed for its walls and harbour'): its fluvial port, a nodal point of the trade between the Danubian regions and the Mediterranean basin, determined through time the progressive growth of the commercial importance of Aquileia, to the point that Ausonius during the 4th century AD defines it as *ninth amongst the celebrated cities* of the Roman Empire.

Soon after Aquileia's foundation, the original hydrological network surrounding the city was reshaped to increase its navigability and to integrate it into the Roman road system which complemented it (Maggi and Oriolo 1999; Maggi and Oriolo 2004); local rivers, thus, started to play a fundamental role as part of the communication and trading network. The potential of the natural river network was increased by the excavation of large navigable canals flowing into the Adriatic Sea a few miles south of the city.

The Aquileian fluvial port, set close to the ancient forum and to the city centre, was the focus of this network, but, as a number of scholars have suggested, it is unlikely that it could have received and handled all the ships and goods destined for Aquileia (for a bibliographic review on this topic see Gaddi 2001). Thus, the city was probably equipped with a more complex and articulated port system involving port docks near the sea, intermediate stops, and warehouses, distributed all over the southern *suburbium* of Aquileia (Gaddi 2001). Ancient sources, however, provide very poor information about these.

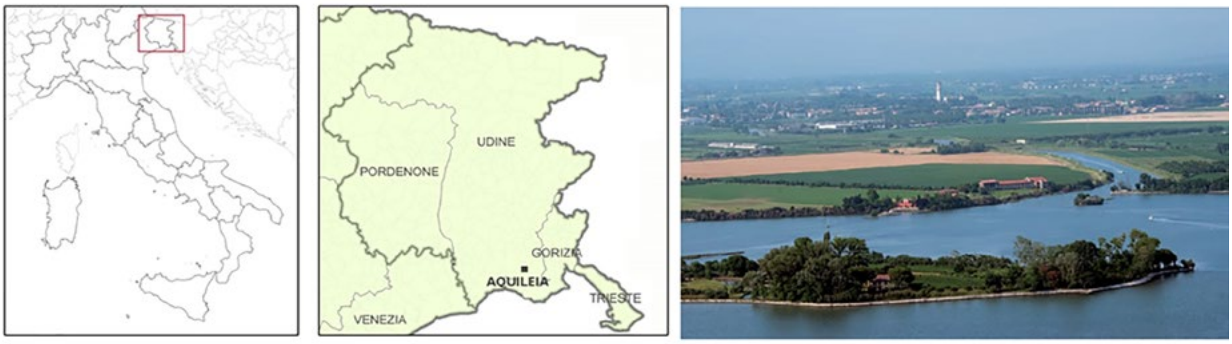

Figure 1. Aquileia's location in north-eastern Italy, at the edge of the Adriatic Sea.

The reconstruction of the port system of the city has been hampered so far by the fact that nowadays Aquileia sits at the edge of a brackish water lagoon (Grado-Marano Lagoon), which largely occupies its once vast southern suburban landscape. The current aspect of the southern fringes of Aquileia is arguably very different from antiquity as the coast line was modified after the Roman period both by alterations of the natural river flow and subsidence phenomena: a large part of the current lagoon was likely a plain above sea level two thousand years ago (Tortorici 1997) and a number of islands dotting the lagoon nowadays are plausibly the only remains of it. The reconstruction of the ancient coastline is also rather problematic and is still debated.

Reconstructing tidal landscapes

The study described here was developed within the framework of two multidisciplinary projects—'Beyond the city walls' (BCW) (Traviglia 2011) and 'Visualising Engineered landscapes' (VEiL) (Traviglia and Torsello 2017), which contributed over the last ten years to clarifying the complex relationships between the urban core of Aquileia and its dependent landscapes, including tidal ones. The study focuses particularly on the area south of the ancient city and aims at 'sensing' tidal landscape using advanced innovative techniques involving a combination of remote sensing and computer vision approaches. The goal is to detect on aerial/space imagery (and map) submerged features such as sections of canals, environmental features and potential archaeological sites, including infrastructures—like roads—and structures that reflect the complex suburban landscape not currently visible; secondly, to integrate such features with elements of the past landscapes—as known from archaeological excavations and occasional discoveries—to compose an overall picture of past settlement dynamics (Figure 1).

A variety of datasets were collected to investigate the Aquileian suburban and tidal landscapes and verify information detected through remote sensing imagery, including cartographic, archival, historical-archaeological and bibliographic datasets as well as environmental, topographic and remote sensing ones, which were integrated with data generated from survey and other fieldwork activities. When not available in digital format, datasets have been digitised, geo-referenced, processed, normalised and merged into a GIS. Details about different datasets will be discussed in the following subsections.

Revisiting literature

Starting from the 1930s (De Grassi 1950) several archaeological sites have been identified both underwater and above sea level at small islands of the Grado-Marano Lagoon, providing evidence for dense anthropisation of the southern *suburbium* of the city during the Roman age (Bertacchi 1979; Morelli De Rossi 1969; Schmiedt 1979). Those early studies represented the first attempt to demonstrate that the southern fringes of the suburban development of Aquileia lay under the tidal landscapes of the Grado-Marano Lagoon. At that time, in fact, the period of formation of the lagoon and its existence during the Roman age was still a subject for debate. More recent geomorphological studies confirm what was originally suggested by archaeological evidence: the lagoon probably originated 1200 years ago, after the Roman age, prior to which the entire area had been a plain crossed by the branches of the delta of the Natisone-Isonzo rivers and by artificial canals (Tortorici 1997). Several scholars (Bertacchi 1979; De Grassi 1950; Schmiedt 1979) identified and mapped archaeological and environmental features discovered in the lagoon; however, they did not fully attempt to systematically describe the nature of the sites and to conjecture what their function was or analyse their distribution. It was not until later that sites have been classified as warehouses, religious spaces, residential areas, cemeteries, fluvial and sea dockings and dated between the Republican age to the 5th century AD (Gaddi 2001). Their distribution, according to Gaddi

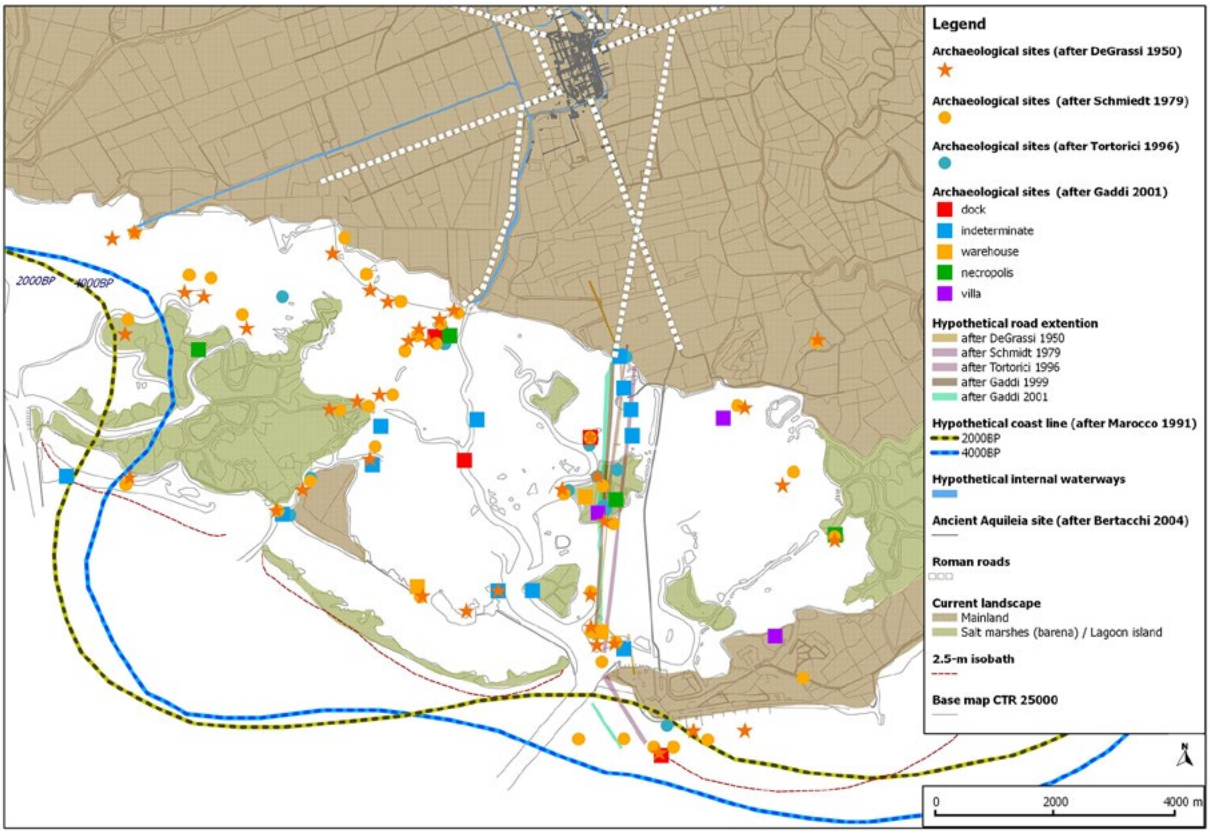

Figure 2. GIS map of the current Marano-Grado lagoon with positions of all the known archaeological sites.

(2001), may suggest a functional organisation of the southern *suburbium* of Aquileia as follows:

- A northern area, closer to the city, occupied by burial areas, production facilities and residential spaces: those features are typical of the suburban landscape of Aquileia (Maggi and Oriolo 2012);
- A southern area dominated by warehouses and landfalls, acting both as a buffer between the city and the sea (against enemy attacks from the sea shore) and a logistic connection between them.

Following a careful review of the existing literature and the maps included in it, the locations of all the identified underwater and above-sea-level sites have been recorded within a GIS and tagged (Figure 2). The mapping shown in Figure 2, with several pinpointed sites often really close to each other does not, however, reflect the real number of sites identified in the lagoon, and published. In fact, it is manifest that the same site often appears twice: this is because it is reported in literature by different scholars in slightly different positions, an error due to the inappropriate scale of the published maps and lack of accurate topographic instruments at the time of the surveying. Thus, the most challenging task at the beginning of the literature review was to refine the position of the sites and understand when two separate locations indicated the same site.

Modelling the southern *suburbium*

In order to refine the process of modelling the suburban Aquileian landscape, geological and hydro-morphological information was overlaid on site locations in the GIS. The definition of the ancient coastline was a crucial mapping step to complete in order to provide a realistic geo-morphological representation of the areas in which the southern *suburbium* was set before the shallow basin near the shore gradually eroded in the post-Roman period and the sea water seeped in between the sandbars and above-sea-level soil, determining the formation of the lagoon. The task was complex as there is not yet a full agreement on the matter. Thus, coastline extension hypotheses proposed by Arnaud Fassetta *et al.* (2003) after Marocco (1991a) and by Bottazzi and Buora (1999) were all recorded, but the coastline configuration that was chosen as the base map for this study was the one related to the hypothesis that recognises the current 2.5m isobath as ancient coastline. Positions of internal

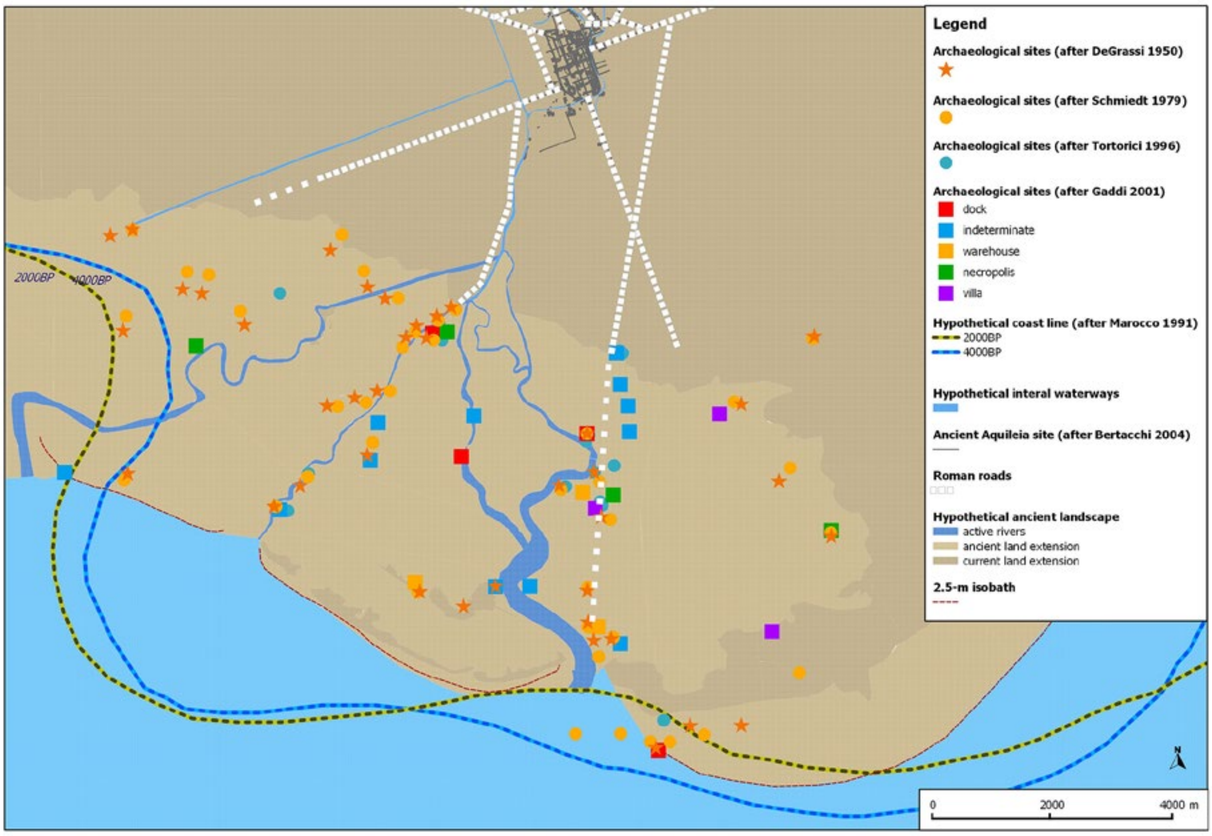

Figure 3. reconstruction of the ancient southern suburbs of Aquileia including archaeological and environmental datasets.

waterways, including river branches and artificial canals, visible on remote sensing datasets (see below), were also added to this base map.

The reconstruction obtained by the merging of those elements shows the southern Aquileian landscape during the Roman period as a wide alluvial plain crossed by the branches of the delta of the Natisone-Isonzo (Figure 3). According to this interpretation, some of the islands presently dotting the lagoon represent the sole remnants of the plain occupying the area at the time. Roman roads, artificial canals, rivers and other waterways complete the picture of the area: as a whole, these were the means of communication and the connection axes between the urban and suburban spheres of the Roman city. Preliminary interpretation of settlement dynamics in this area leads to recognition of a fairly typical organisation of Roman suburban spaces, similar to that already hypothesised (Muzzioli 2007) for the northern part of the Aquileian *suburbium*. Just as in the northern suburban space, in fact, sites identified as potential dwellings also appear clearly connected to axes of routes embedded in the centuriation grid and located in the vicinities of the main or secondary road axes; for example, in the case of two potential suburban villas lying along the hypothetical extension of the *cardo maximus* of the city leading to the town of Grado to the south. Concentrations of diverse types of sites are identifiable along main communication routes (either canals, waterways or roads) similar to the clustering of settlements organic to the centuriation parcels' internal routes in the northern suburbs. Other unidentified structures appear to be aligned along hypothetical straight routes, possibly roads or canals, the traces of which are not visible anymore on the ground or through remote sensing, but the presence of which can be inferred by the disposition of archaeological remains.

Integrating remote sensing datasets

The picture of the Aquileian landscape that emerged by systematically combining and revisiting literature and environmental datasets was finally integrated with the results of the interpretation of remote sensing datasets.

In the domain of underwater archaeology the term 'remote sensing' is mainly applied to the group of techniques used for underwater remote data gathering and survey, such as side-scan sonar or sub-bottom profiler (Sakellariou 2007). Here, instead, the term refers to the archaeological research methodology that uses aerial, radar and satellite imagery to pinpoint potential sites of interest on landscapes or waterscapes. (Far-range) remote sensing is being increasingly adopted as a critical component of the suite of research methodologies normally employed for addressing archaeological landscape questions. It is also progressively being used in the analysis of coastal and shallow aquatic/marine (lagoon or tidal) environments as its water penetration capabilities have long proven suitable for remote detection of underwater archaeological features. Depth limitation, water reflective properties and water turbidity are only partially limiting the discovery opportunities its use can provide and the advantages of its application over shallow waters in propitious circumstances are clear.

This work took advantage of different remotely sensed datasets including:

- Satellite multispectral imagery: satellite coverage included DigitalGlobe IKONOS and Quickbird imagery. Quickbird data include RGB bands in association with Near Infrared (NIR) bands and very high spatial resolution Panchromatic images (respectively 2.62m and 0.62m of ground resolution). Similar characteristics can be found in IKONOS images, although at a lower level of spatial definition: its capabilities include capturing multispectral (RGB + Near-Infrared) at a 3.2m resolution and reach a 0.82m panchromatic resolution at nadir. Both the sensors (now decommissioned) have been extensively used for coastal monitoring and are particularly suitable for map details that require elevated spatial resolution to be identified;
- Airborne hyperspectral data: the airborne sensor Daedalus AA5000 MIVIS (Multispectral Infrared and Visible Imaging Spectrometer) provided hyperspectral data. The sensor records a range of wavelengths from visible to Thermal–IR regions of the spectrum, with a high spectral resolution and elevated number of channels (102). The hyperspectral MIVIS sensor can, in specific circumstances, provide excellent water penetration in shallow waters and produces imagery where, for example channels, and underwater objects of interest are easily identifiable. This characteristic can help to overcome the limitations determined by its coarse spatial resolution (3 to 4m ground resolution, depending on flight altitude); and,
- Aerial photographs: airborne coverage included both historic and modern imagery, spanning a period between 1938 and 1990, and orthophotos ranging from 2000 to 2007. Particularly relevant for the identification of underwater archaeological remains and palaeo-environmental features were a number of shots dating between 1938 and 1954, which represent an interesting document of the *status quo* of the lagoon in those periods: favourable light, environmental and seasonal conditions (and likely the absence of pollutants in the lagoon waters) ensured that the photographs, sharp and well contrasted, showed—with an impressive degree of accuracy—natural and human-made canals and secondary canals, several of which are no longer charted on current Lagoon Chart or no longer visible in remote sensing imagery.

Remote sensing data analysis was undertaken in two steps: an initial stage of selection and pre-processing of the images, and a second step of image analysis and feature recording (Figure 4).

During the first step selected images were processed to increase the visibility of potential archaeological remains and to heighten the presence of possible traces within the water body using basic emphasising techniques (linear, Gaussian, equalisation stretches; filters; density slicing; decorrelation stretch). More complex image processing (such as Principal Component Analysis or band ratios) was applied to multi and hyperspectral data in order to visualise information that otherwise would not have been detectable, like information recorded in the Infrared band (Traviglia 2011). Pattern Recognition (PR) techniques were then applied to aerial and satellite imagery to explore classification methods that can support the identification of underwater archaeological objects in tidal wetlands based on the automatic learning of patterns, regularities and shapes (Traviglia and Torsello 2017). These approaches, which enable machine learning of patterns and the use of learned patterns for classification, can overcome the limitations of both simple optical recognition or methods based on automated pattern matching, and allow for detecting underwater patterns/shapes produced by a variety of natural or anthropic elements.

The second step of remote sensing data analysis involved the visual inspection on screen of all the considered images, including enhanced aerial images, and multispectral/hyperspectral images analysed both as single bands and as composites (in true and false colours), and in all their processing outputs. In order to support the interpretative process and to map identified objects of interest, images have been imported into the GIS where they were georeferenced (historical photos) and examined (Figure 5). The traces and anomalies recognised in the water body during this process were recorded by digitising them on screen. Information that could support its interpretation was encapsulated within each trace; metadata recorded in

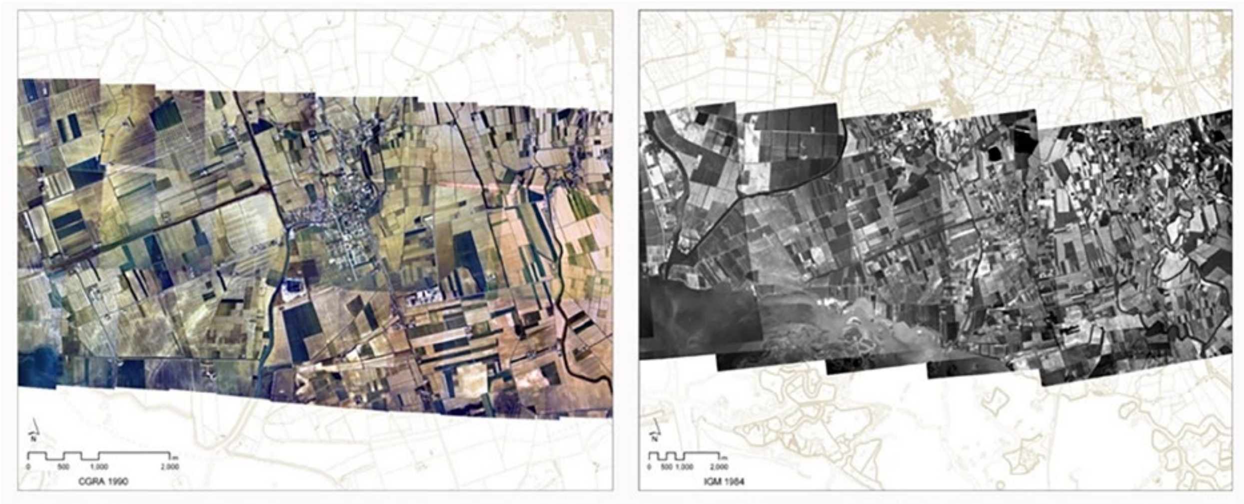

Figure 4. Historical and modern photos mosaicked and overlaid on basemap (courtesy of Regione Friuli Venezia Giulia).

this process were, for example, the degree of visibility of the feature, its archaeological reliability, and the image that the trace had been detected on.

This process led to recognition and tagging of 105 features, mostly identified under sea level or in wetlands: the mapped traces included both potential archaeological sites and environmental features (such as sections of dismissed secondary canals and the so called '*ghebi*', minor canals crossing the wetlands). Some of the most striking features identified in the processed imagery were long and criss-crossing perfectly straight structures, in orthogonal fashion at varying inclinations, often compatible with that of the local centuriation grid (Figure 5).

Mapped features were then contrasted with the environmental and historical datasets to provide correct interpretation of each identified trace. This analysis led to observed patterns in the distribution of the identified potential archaeological sites and structure.

Merging diverse datasets has revealed, for a start, that a number of well-known archaeological sites were connected to (now) deactivated ancient canals detected through remote sensing. These sites had not been related to each other previously or recognised as parts of a settlement system located along a waterway until the deactivated canals were identified through remote sensing. Abandoned old canals, moreover, were observed to present potential ancient remains and structures along their banks in a number considerably higher than what was visible along canals which are currently in use. The latter are often the result of modern excavations or extension/diversions, and may not reflect the location of canals/waterways that were active in the past. Abandoned canals are often relics of canals and waterways that existed in antiquity.

Conclusion

The distribution of potential archaeological sites and structures in the area nowadays occupied by the Grado-Marano Lagoon that has emerged through remote sensing, is key to decoding the settlement dynamics of the overall Aquileian suburban space. Added to the other datasets, this offers a picture of an intensely occupied southern *suburbium* where manufacturing, commercial infrastructures and residential dwellings co-existed along waterways, banks and roads. Remains identified as roads in previous studies and through remote sensing emerge as attractors for necropolis areas, a typical pattern of Roman suburban spaces. Dwellings, likely suburban villas, placed along the hypothetical extensions of ancient roads suggest their route, even when the roads themselves cannot be identified on the ground. Canals and other waterways appear to attract manufacturing and commercial infrastructures identified through inspection or remote sensing. This corroborates the hypothesis of the existence in antiquity of a rather complex and articulated port system consisting of port docks, intermediate stops and warehouses placed strategically between the sea and city. This picture contrasts with the mainstream vision of Aquileia being largely enclosed within its city walls and only surrounded by suburban low-density settlements for a few km from its core, and almost 'self-contained'.

The number of hypothetical new sites identified through aerial and satellite imagery in the Aquileian lagoon waters provides a measure of the potential of far-range remote sensing approaches for studying tidal

Figure 5. GIS record of traces and anomalies recognised in the Lagoon of Grado water body.

landscapes under favourable conditions. Particularly relevant is the ability to identify the location and course of old canals and the paths of roads, which are key components in landscape reconstruction because of their role as the main axes of the suburban settlement expansion of Aquileia towards the sea. At the same time, the limitations of the sensing approach become apparent when handling imagery not suitable for analysis, i.e. where the body of water is masked by adverse conditions (reflectance, turbidity, etc.); inspection of tidal landscape through remote sensing requires images with specific characteristics that are mainly related to environmental, timing and sensor conditions and, therefore, are not always easily planned. As such, successful results depends very much on availability of data collected at the most opportune time and in the correct way. The availability of multiple images from different sensors and periods can, thus, increase the chances of making successful discoveries. The development of new airborne bathymetric laser scanners is also providing opportunities for high resolution hydrographic surveying in very shallow waters (Doneus *et al.* 2012), and their use in tidal environments is highly desirable; however, flying these sensors is still very costly and flexibility in flight arrangements is not always possible. The ability to plan both the timing and sensor characteristics is now enabled by the use of unmanned aerial vehicle (UAV, aka drones), which promise to be the next ‘big thing’ for the exploration of tidal environments.

Information obtained through remote sensing is, at this stage, to be considered preliminary: survey activities, core samples and systematic comparison with data from historical cartography of the lagoon area will be essential steps in clarifying the nature and chronology of the newly identified sites.

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Mapping Submerged Stone Age Sites Using Acoustics: Some Experimental Results

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Abstract

A central problem for maritime archaeology has been to find survey methods that facilitate efficient and precise mapping of Stone Age sites on the seabed down to the lowest sea level (approximately −140m) during glacial periods, as well as sites embedded in sea-floor sediments. As predictive landscape modelling has proven to be inadequate for this task, a different approach based on direct detection is required. The observation of an acoustic phenomenon associated with human-made flint debitage, but not naturally cracked pieces of flint, has opened a window for development of an alternative and efficient direct mapping method. This paper discusses the development of the idea, as well as experimental documentation of the principle on which it is based. It includes a preliminary analysis of how far away on each side of the transducer flint debitage emits an acoustic response and, consequently, the required distance between sailing lines for a comprehensive survey to be undertaken at a specific depth.

Keywords

Flint debitage, Stone Age, sea-floor sediment, acoustic resonance, Denmark

Introduction to flint debitage resonance

Flint knapping is a popular activity among Stone Age archaeologists, and is a good basis for a better understanding of the lithic tools they excavate, describe and analyse in their work. The archaeological literature describes the reduction of a core by flint knapping as the controlled removal of sharp pieces of debitage. More specifically, a shock wave (created, for example, by a hammer stone) is used to release the so-called Hertzian cone phenomenon, thereby removing a section conjoining a Hertzian cone running approximately parallel to the side of the core (Knapp 2010). However, sound appears also to play a part in this process.

This latter sonar element of flint knapping is not yet fully understood even though it is under investigation. Acceptance of the full consequences of it, however, appears to provide a method for direct mapping of submerged Stone Age settlements that avoids the methodological problems of predictive modelling and can even detect sites embedded in the sea-floor sediments (Grøn *et al.* in prep; Hermand *et al.* 2011; Hermand and Rasmussen 2013).

In 1980, Grøn observed a strong resonance phenomenon associated with flint knapping. As it is flint (predominantly) and other silicate minerals knapped by humans that define the term 'Stone Age', this was of potential interest for mapping of Stone Age sites;

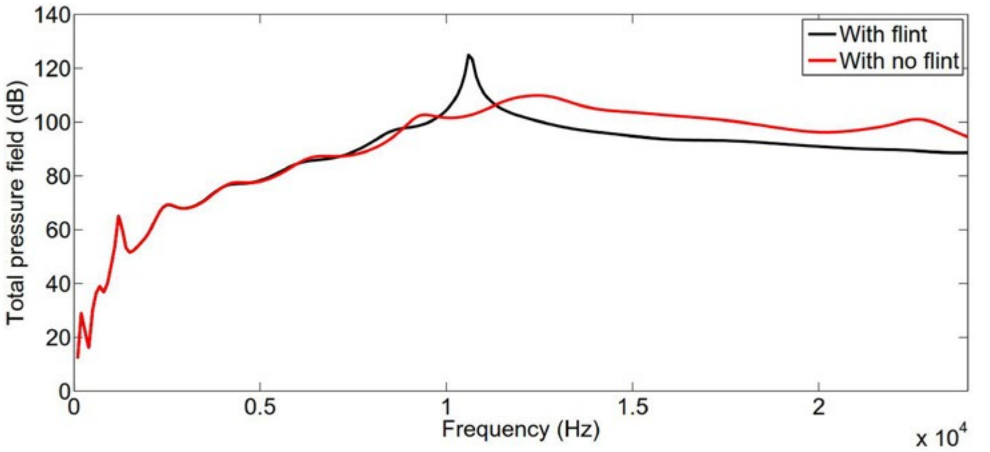

Figure 1. Prediction of the total pressure field resulting from the insonification of a flint blade embedded 5cm into a cultural layer. The simulated acoustic source and hydrophone are placed above the seabed, symmetrically about the flint piece, with an incidence angle of 5°. The sea-floor model consists of thin layers of sand and mud overlying the cultural layer, a thin underlying sand layer and moraine substrate. The red curve is the returned signal spectrum with no flint embedded in the cultural layer, while the black curve is the spectrum with a flint blade embedded. The resonance frequency is 10.6 kHz.15 (Hermand and Rasmussen 2013).

especially so if it could also be used to detect debitage embedded in, and thereby damped by, sediments. He therefore asked Rasmussen, who had links with the Bang and Olufsen (B&O) sound laboratory, to analyse some pieces of knapped flint debitage to investigate whether they had any interesting acoustic properties.

In 1982, sixteen knapped flint 'blades' and 'flakes' from nine different Stone Age sites in Denmark were analysed by Rasmussen and others in the B&O sound laboratory. The resonance from these pieces proved to be so strong that the pieces had to be damped during the experiment so as not to damage the receiver. The promising preliminary conclusions of these laboratory analyses were that:

- Flint debitage knapped by humans respond acoustically (like a tuning fork) when excited with an appropriate acoustic signal within the interval 3-20 kHz.
- Flint debitage should respond in a similar way to appropriate acoustic signals even though it is embedded in damping sediment, and it should be possible to detect this response.

Major acoustic-research environments outside the B&O laboratory, however, rejected the archaeological usefulness of the observed resonance phenomenon, citing problems resulting from the damping effect of surrounding sediments. The project was consequently shelved untill 2010, when Grøn and Hermand met within the framework of the SPLASHCOS project (EU COST Action TD0902). Hermand, who became involved at an early stage in the relatively new discipline 'geoacoustic layer characterisation', agreed that it was time to give the old idea another chance. The discipline focusses on the acoustic characterisation of submerged geological layers on the basis of acoustic properties of the elements they contain. It seems obvious to attempt to detect an element such as resonating lithic debitage by acoustic means (Hermand *et al.* 2011; Hermand and Rasmussen 2013).

In 2011 Grøn and Boldreel began to collaborate on developing a methodology for mapping of archaeological features buried in sea-floor sediments based on high-resolution sub-bottom profiling. While it was possible to detect embedded poles, shipwrecks and other similar features, and the application of high-precision navigation made it quick and easy after the survey for divers to locate and verify or reject the observed recorded anomalies without having to open up larger excavations, mapping Stone Age sites represented a problem. It had been demonstrated that Stone Age cultural layers could be identified in the sub-bottom profiles. The problem was that it was impossible to distinguish between 'artificial' Stone Age cultural layers and natural geological layers in the records (Grøn *et al.* 2007; Grøn and Boldreel 2014).

The solution appeared to be to attempt to develop a system that employed the debitage resonance phenomenon, if the efficiency and effectiveness of this could be further underpinned by experimental data.

Finite element modelling

In the Acoustics and Environmental Hydroacoustics Laboratory at The Free University of Brussels (ULB), Hermand and some of his PhD students developed a

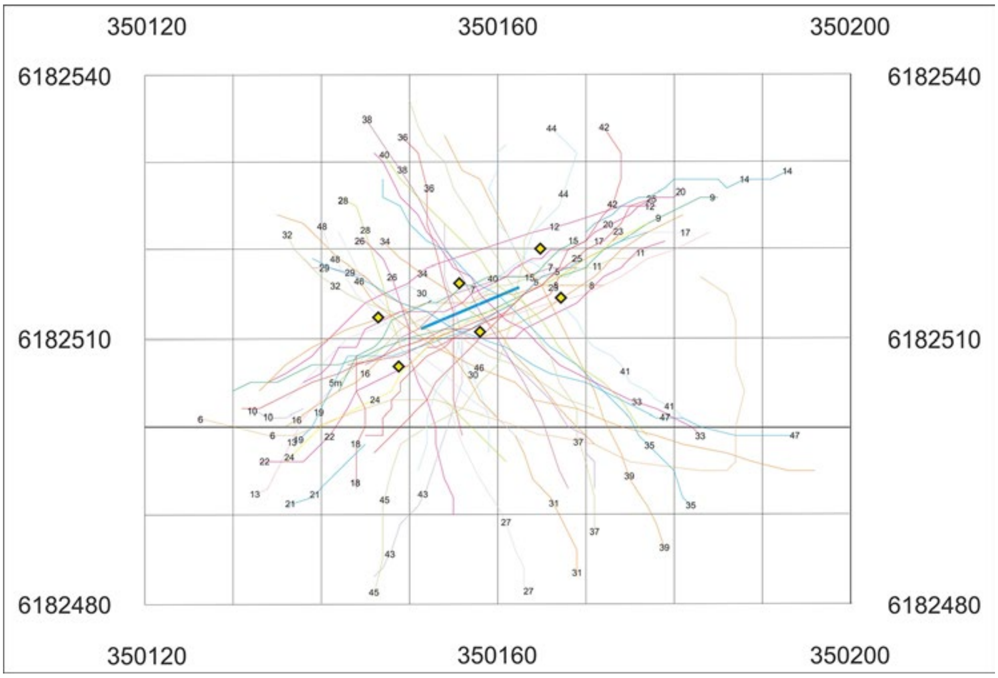

Figure 2. The 48 sailing lines at the experimental site off Skovshoved Harbour. The 12m long blue line marks the position of the linear string of samples placed on the seabed. The six yellow rectangles mark the buoys used to control the boat's approach to the target.
Coordinates in UTM zone 33.

realistic 3D digital model of a piece of seabed consisting of several geological layers for the purposes of finite element modelling (FEM). This is a way of mimicking physical processes in a digital space divided into extremely small spatial units with physical properties matching those in the real world: density, elasticity, heat conductivity, etc. In this case, the major advantage was that high-resolution digital models of flint debitage could be implanted in the sea-floor sediments and removed again without disturbing the sediment layers. As a consequence, the sea floor's responses to different acoustic signals, when different pieces of flint debitage were embedded in it, could be modelled without disturbing, and thereby changing, the sediment stratigraphy. The results of the modelling exercises could, therefore, be directly compared. In the 'real physical world', the insertion and removal of debitage would have disturbed the layers so that the experimental results would not be comparable (Hermand and Rasmussen 2013).

The downside is that finite element modelling is time consuming because of the data capacity required. In this case, one 3D modelling takes one day to run, even though a super computer is used. But control over the details and comparability of the results compensate for this. The process can also run without a human operator, so the operator time required is significantly less than the processing time.

The 3D finite element modelling produced results that strongly support the existence of the pronounced resonance phenomenon detected in the B&O sound laboratory. Significant resonance peaks are evident for single pieces within the same frequency interval as found in the sound laboratory (Figure 1). This confirms that acoustic responses can be expected from flint debitage embedded in water-saturated sea-floor sediments, and that—according to the model—a single piece of debitage can produce such a response (Hermand *et al.* 2011; Hermand and Rasmussen 2013).

The experiment at Skovshoved Harbour

To test the flint debitage resonance phenomenon in a real-world setting, Boldreel and Grøn, under the auspices of the Department of Geosciences and Nature Resource Management, University of Copenhagen, carried out several experiments (Grøn *et al.* in prep). We shall here report the results of one carried out off Skovshoved Harbour, north of Copenhagen.

A 12m long line of samples, marked by the blue line in Figure 2, was placed on the seabed at water depths of between 7 and 7.5m. A 6m long stocking of plastic net was filled with flint debitage and placed on the seabed, extending from the eastern end of the blue line in Figure 2 and 6m to the WSW. It contained less than 1kg of flint debitage per metre. This concentration is similar to that which can be expected in a Stone Age

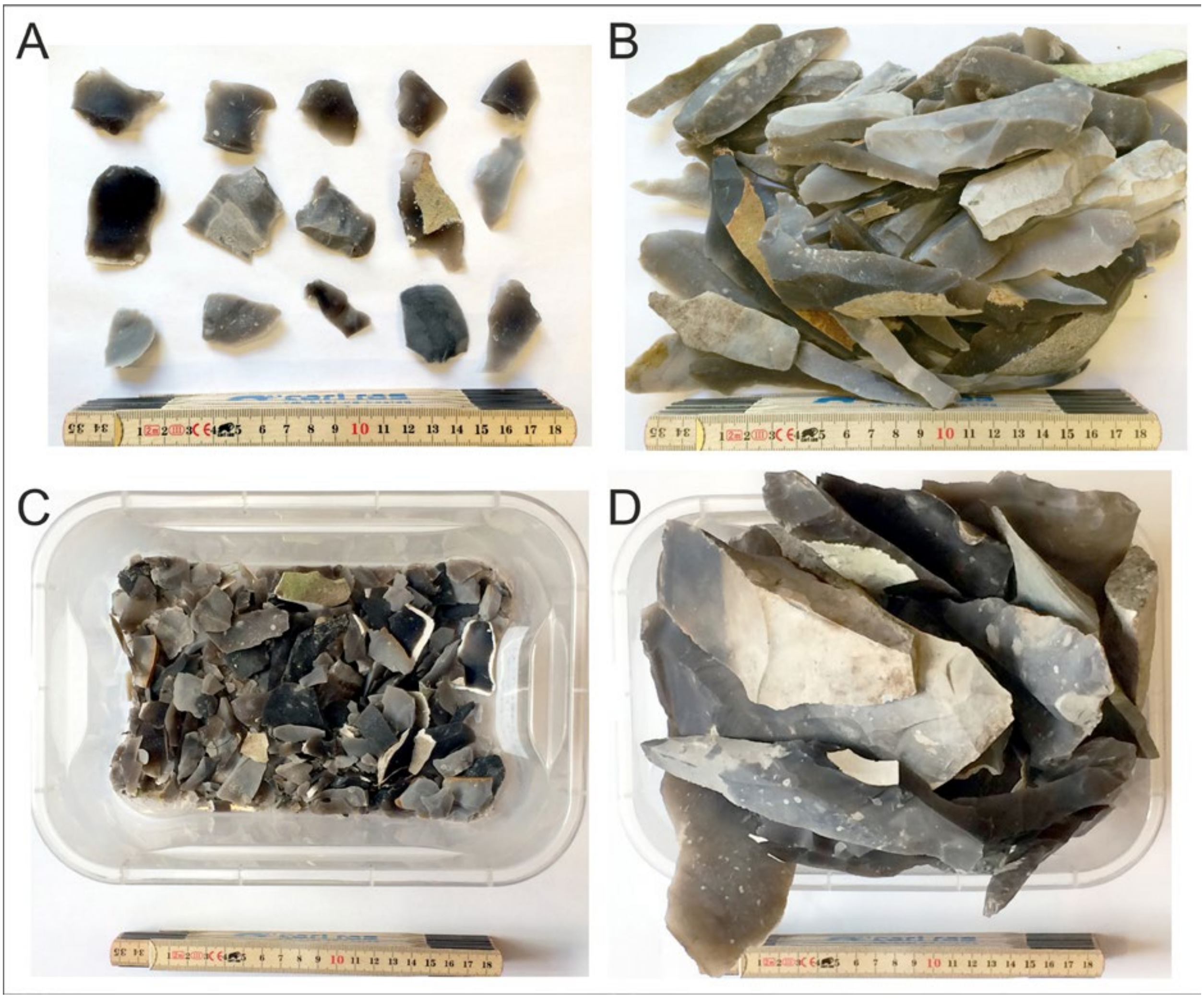

Figure 3. Examples of the flint debitage samples placed on the seabed in the experiment.
A: sample 1; B: sample 4; C: sample 6; and D: sample 7.

cultural layer containing a reasonable amount of flint debitage.

The stocking was divided into six sections which, from the east, contained the following: sample 1: 15 small flakes (Figure 3A), sample 2: 15 blades, sample 3: 15 blades, sample 4: 36 blades (Figure 3B), sample 5: 36 blades, sample 6: 72 flakes (Figure 3C). Furthermore, three bags containing lithic debitage of different types were placed, 2 m apart, on the seabed to the WSW on the blue line in Figure 2. Nearest to the stocking was sample 7, a bag containing very large flakes (Figure 3D), then sample 8, a bag containing axes, and then sample 9, a bag containing cores. The aim of the two latter was to enable study of the acoustic response from knapping products that had very limited or no ventral surfaces preserved.

Before the samples were placed on the seabed, the area was checked for possible anomalous acoustic features, such as responses from unrecorded submerged Stone Age sites, gas pockets etc., which could disturb the recordings from the artificial target. Our experience is that acoustic responses from true ancient human-made features and structures, are a potential problem for controlled experiments in Danish waters where the number of submerged Stone Age sites in some areas can be overwhelming. For instance, during experiments in the artificial lagoon of Amager Strandpark, east of Copenhagen (Grøn *et al.* in prep), significant localised acoustic responses of the type produced by flint debitage, were recorded in locations where one could expect to find submerged Mesolithic sites or Mesolithic material dumped together with the material used to construct the lagoon barrier. These anomalies have not been verified by us but we have passed their positions on to the appropriate museum authority. Well-preserved Stone Age cultural layers were actually found during the maritime archaeological evaluation of the area prior to construction of the artificial lagoon, but these were not excavated (Dencker 2004).

One aim of this experiment was to attempt to understand the differences in the acoustic responses arising from different categories and amounts of debitage. Problems with communication to the calibration source that should have enabled a navigation precision as high as ±10 cm, however, made it difficult to relate the individual samples to specific responses from the individual sections of the stocking or the individual bags.

The experiment produced a series of records of identifiable acoustic responses from the flint debitage and artefacts placed on the seabed. This demonstrates that flint debitage produces an acoustic response to specific types of acoustic signal. These responses were, however, not as distinct and significant as those recorded at actual Stone Age archaeological sites with greater densities of flint debitage (see Figure 6). However, they are interesting because they demonstrate that rather ordinary settlement debitage densities can produce responses that are recordable with the present acoustic set-up.

The density of flint debitage in the area where the stocking was placed was not extreme relative to the norm for a Stone Age settlement. This experiment therefore indicates that it should be possible to detect a reasonable proportion of actual submerged Stone Age settlements using the existing preliminary acoustic set-up. Our experience suggests that detection should still be unproblematic even when these remains are covered by up to 1–1.5m of sediment. We have no reliable experience of detecting deeper-lying material and potential adjustment of the signal to obtain a response from this.

What is clear from the results we obtained is that the target must be no more than *c.* 3–4m to one side of the transducer at this depth for it to respond: Line 38 (Figure 4) runs perpendicular to the line of targets. It produces a response ‘haystack’ that is *c.* 7m wide, tallest in its central 2–3m and declines steeply at each side. This sideways acoustic response is also a factor that makes it difficult to isolate different responses from samples located as close together as in this experimental design. This is one of the positive results of this experiment.

Line 13 (Figure 5) runs parallel with the line of targets from ENE to WSW and records a response over 7m, from the first to the last peak. Unfortunately, the low precision of the navigation does not permit identification of which samples are producing which responses. A significant variation in the height of the haystack phenomenon can be observed, which must be related to the variation in the samples. It is, however, impossible to relate this variation to specific samples.

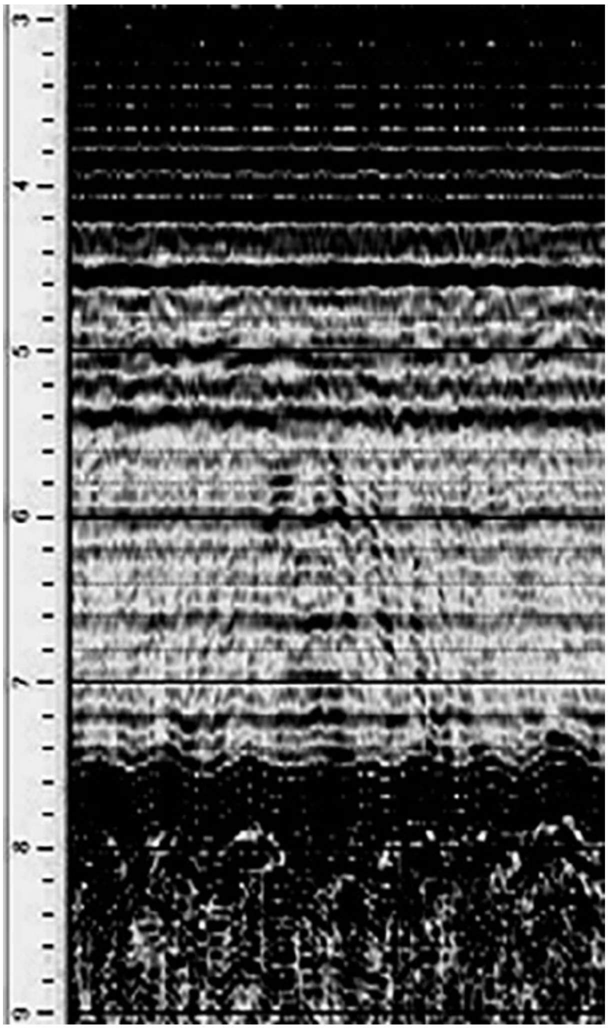

Figure 4. Line 38 cutting across the line of targets resulting in an acoustic response that is approximately 7m wide at its base.

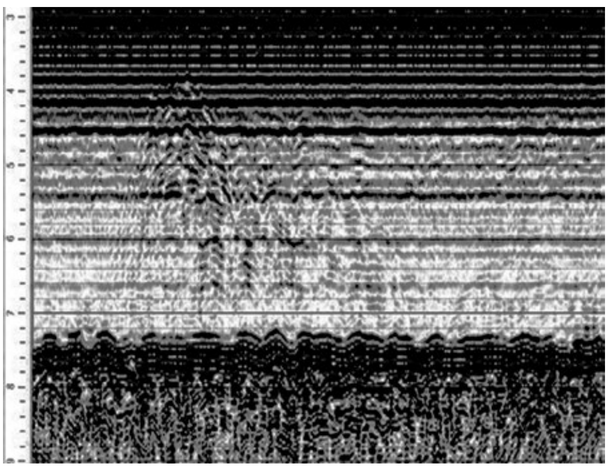

Figure 5. Line 13 running parallel to the line of targets showing a difference in the height of the ‘haystack’ feature.

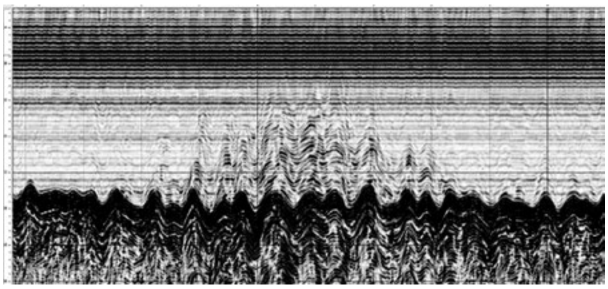

Figure 6. Record of significant acoustic haystack features at the submerged Stone Age site at Atlit-Yam, Israel.

Discussion

The Skovshoved experiment confirmed that flint debitage responds to specific acoustic signals. It is encouraging that such low concentrations of flint debitage, as used in this experiment, can produce recordable acoustic responses. This, in turn, means that it should be possible to detect a large number of submerged Stone Age sites using the technique at its present state of development.

The fact that the acoustic responses from flint debitage recorded here and in several other cases, from experimental targets or from known submerged Stone Age sites, are evident as 'haystack' features predominantly in the water phase seems to be because they represent delayed responses to the emitted signals from which they originated. This appears to reflect an interesting aspect of the physical properties of flint debitage knapped by humans, which is currently being investigated.

The Skovshoved experiment was not able to reveal a simple relationship between amount/density, type and size of the debitage pieces on the one hand and acoustic response features on the other. It did reveal, however, that an acoustic response can be obtained from a target at water depths of 7 to 7.5m, with transducer positions up to 3–4m to one side of the target, equivalent to an angle of approximately 25–30°. Further experiments investigating the maximal distance between sailing lines that permits total coverage of the seabed at specific depths would be useful in relation to future routine surveys.

The results obtained here underpin the potential practical exploitation of a strange acoustic phenomenon that is only evident in flint debitage and not in naturally cracked flint (Grøn *et al.* 2018). They indicate that a better solution can be found to the problem of mapping submerged Stone Age sites, including those located at depth and embedded in sediment, than that currently available.

Acknowledgements

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Archaeology of a Great War U-boat Attack Off Southern Portugal: Development and Adaptation of Methods and Techniques

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Abstract

On 24 April 1917, the German U-boat U-35, commanded by Lothar von Arnauld de la Perière, halted, attacked and sunk one wooden sailing ship and three metal cargo steamers off the coast of Sagres and Lagos, Algarve, Portugal.

On the eve of the centenary of this Great War episode, a team from the Portuguese Navy Research Centre (CINAV) started a historical and archaeological project on the U-35's mission and these sunken ships.

The sailing ship was the first to be searched at a depth of more than 650m, in what was also the first Portuguese underwater archaeology mission on a large technical scale in Portugal. The location of one of the steamers has been clarified, and the identification of the other two was proven.

During our archaeological and historical research into the three steamers, we developed or adapted diverse methodologies in order to survey and record them, such as 3D printing, and to identify crewmembers in historic photographs, by using an advanced algorithm for biometric recognition.

Sharing these hopefully useful methodologies is the objective of this paper.

Keywords

U-35, Great War, 3D printing, biometric recognition

Introduction

On 24 April 1917, the German submersible U-35, of the U-31 class, commanded by the 'ace of aces' Lothar von Arnauld de la Perière, sunk four ships off Sagres and Lagos, on the south coast of Portugal. Germany had been officially at war with Portugal since 9 March 1916, after the Portuguese requisition of all German and Austro-Hungarian ships anchored in Portuguese continental, colonial or insular ports. This action was followed by the consequent German declaration of war.

From the War Diary (SM U-35 Kriegstagebuch, 1917), we know that U-35 left the Austro-Hungarian Adriatic naval base of Cattaro, today's Montenegro, on 31 March, heading to the west Mediterranean and the south of Portugal, aiming at the busy merchant lanes from and to the Mediterranean through the Straits of Gibraltar. Even with battery problems and a torpedo attack by a French submersible, de la Perière was able to safely cross the dangerous Otranto Strait and the Italian blockade. The U-35 then crossed the Mediterranean by way of Sicily and Sardinia and stopped at the African coast on 8 April. It crossed the Straits of Gibraltar to the west on the night of the 13 to 14 April.

During the two-week journey to the Atlantic, de la Perière halted and sunk several merchant ships, and exchanged gunfire with some of them. He reported in the War Diary an intense naval coastal patrol, off both the African and Spanish coasts, east of Gibraltar.

After engaging several merchant ships, where some were halted and others sunk, the U-35 positioned itself off Cape Saint Vincent, in Portuguese waters, on 24 April. Shots from U-35 actions were heard on the Portuguese coast and the small-armed tug *Galgo*, serving the Portuguese Navy, was sent to investigate. Armed with a 37mm Hotchkiss canon, *Galgo* engaged the German submersible, but the Hotchkiss 2nm range was no match for the 15nm 105mm gun of the U-35. After a short exchange of fire without consequences, the Portuguese Navy tug oriented its efforts on rescuing the men from the ships which had been sunk by U-35.

The first interaction with the merchant traffic occurred at 8.50am, when the Danish merchant steamer SS *Nordsoen*, heading from Scotland to Italy, under British charter, was halted. Its papers were confiscated, the crew released but the ship was sunk by explosive charges set by the submersible crew. Only 25 minutes later, the Norwegian merchant steamer SS *Torvore*, travelling from Swansea to Naples under British charter and loaded with 1667t of locomotive coal bricks, was sunk, also by explosives.

Now the U-35 headed east in the direction of Lagos, where it engaged the armed French merchant steamer SS *Caravellas*. The French Navy auxiliary ship was armed with 90mm guns, and fought the submersible for 30 minutes, firing 18 shells. The submersible fired five shells and stopped the pursuit because it was short of ammunition, allowing the French to escape heading east. Meanwhile, a previously halted ship was on hold, and was sunk after the fight by gunfire. She was the Norwegian 3716-ton merchant steamer SS *Vilhelm Krag*, formerly *Nordpol*, travelling in ballast but under British charter, between Genoa and Barry Roads.

Heading back to Cape Saint Vincent, de la Perière discovered that the charges that were placed earlier on the Danish ship had not exploded and that it was now aground on the Algarve's shore cliffs. He ordered his crew to place another set of explosives and, this time, the ship was sunk. Before returning to Cattaro, the U-35 sunk the 265-ton Italian brig *Bienaimé Prof. Luigi*, 10nm south-east off Cape Saint Vincent. The Italian vessel was heading from Fowey to Genoa with a cargo of China clay.

Between 25 and 26 April, U-35 crossed the Strait back into the Mediterranean, arriving at Cattaro safely on 6 May 1917, after a navigation of 36 days, travelling 2230nm on the surface and 321nm submerged. During this navigation, the U-35 sunk 24 ships, in a total of more than 80,000 tons, using all the nine torpedoes it carried, 541 of its 105mm grenades and 29 explosive charges.

Almost 100 years after the U-35's actions that brought the Great War to the continental Portuguese waters, far away from the Belgium trenches and the African remote territories, and out of history books, a team from the Portuguese Navy Research Centre (CINAV), supported by the Portuguese Great War Centenary Commission and Vila do Bispo Municipality, started Project U-35[1] (2014).

Project U-35 aims to research the history of the episode and to investigate the archaeology of the four ships sunk on 24 April 1917. The main objectives of the archaeological project were: to determine if the alleged U-35's wrecks were indeed the ships sunk by the submersible that day; to clarify the location of the Danish ship SS *Nordsoen*, which appeared in different spots, on different dive guides; and, to locate the Italian brig, more than 650m deep.

During the archaeological work, the team felt the need to adapt methods and techniques, and / or to develop and apply some that we had never tried before. For example, the archaeography around the SS *Torvore* lies more than 30m deep. In this wreck the use of multibeam echo sounder geophysics data, besides the obvious results, allowed the production of an analogical model of SS *Torvore* and SS *Vilhelm Krag*. On the human factor, the application of biometric algorithms helped to identify a crewmember from one of the sunken ships in historical photographs where he was not safely identified. The team also needed to find a way to enable the use of heavy and very expensive means for searching at that depth to find material evidence of the Italian ship. The project did not have the money for these costs, which are usually enormous.

Looking for the Italian brigantine *Bienaimé Prof. Luigi*, more than 650m deep

The U-35's War Diary indicates the sinking of the Italian sailing ship on a set of coordinates that puts her more than 650m deep, 10nm south-west of Cape Saint Vincent, perilously near to today's commercial navigation lanes. To conduct a scientific mission looking for an almost 100-year-old wooden wreck, at that depth, offshore, and near a commercial navigation lane, was outside the very small project budget. The project needed a seagoing oceanographic ship and a deep sea ROV. The team begin seeking alternative ways of achieving the needs of the project. The answer came in the form of a synergic collaboration, that was indeed symbiotic.

The Portuguese Task Group for the Extension of the Continental Shelf was setting off on a new mission to the Azores Islands. Each time, before they go on a mission, they need to do a test dive with their ROV *Luso*, not far from their base, in case an anomaly is detected. Having identified this opportunity, the project team provided them with an objective for their test dive—the position of the Italian sailing ship that is written in the U-35's War Diary. This was the first time the ROV and its pilots were involved in an archaeological task.

With all these issues considered, including the new field of research, we were allowed to use the only Iberian deep sea ROV and one of the Portuguese Navy's oceanographic ships—the NRP *Gago Coutinho*—on our search mission. It was a truly symbiotic collaboration that did not end there and is still continuing today.

We departed the Lisbon naval base on the morning of 27 May 2014 and headed south to Cape Saint Vincent. After a night of sailing and an echo sounder beam survey, the *Luso* ROV commenced the long descent down to the acquired targets and the historical coordinates we had. The team was very excited; the hours spent in the dark control room in front of dozens of television screens

[1] http://projectu35.wixsite.com/projectu35

Figure 1. ROV control room, with screen showing the wooden plank.

seemed like minutes. Suddenly a small dot appeared on the ROV's sonar. The ROV pilot headed to the spot and minutes later, a wooden object appeared from the darkness of the abyss (Figure 1).

It was the only object the team found from all the targets investigated; and, we did not find any convincing evidence relating that wooden plank to the Italian brigantine. However, the size of the slow growing corals on it, suggests at least the possibility.

Was Hans Johan Larson on two historic group photos?

The application of biometrics

Hans Johan Larson (1885–1925) was born in Bergen, Norway, on 15 January 1885, and died on 12 August 1925 (pers. comm., Nielson 2015). He obtained his navigation certificate at the age of 23 and was part of the SS *Nordpol*'s crew as foreman, for eight months in 1906/1907, and again as second pilot, until 1911. His last job was at the port of Bergen.

Larson would have his share of the war when one of the ships he sailed on was torpedoed off Murmansk, in Russia. He was sent to a hospital in Arkhangelsk, Russia, where he stayed for some time in the company of a helmsman from the same ship. In the last four years of his life, as an employee of the port of Bergen, he was always very sick, suffering from back problems, rheumatism, kidney failure and heart. He died in 1925 from a heart attack.

In 2015, Larson's grandson, Hans Nielson, contacted the project, informing us his grandfather was a former crew member of the SS *Nordpol*. It happens that Larson's SS *Nordpol* was our SS *Vilhelm Krag*, sunk by the U-35 as a result of gunfire, on 24 April 1917. German submersibles, thus, constituted a conceptual link, which bound this Norwegian man, not only to our SS *Vilhelm Krag*, but also to the submarine warfare on the merchant navy during the Great War, and the neutral victims.

Hans Nielson gave the team all the information he knew about his grandfather, along with an impressive set of historic photographs. Amongst them was an image of the SS *Vilhelm Krag* as SS *Nordpol*, which had never been published before. He also gave the team some photographs of his grandfather. In these photographs, there were two group photographs, one with the crew of the SS *Nordpol*, on board the ship, and another in what appears to be a marriage. Nielson's mother claimed that Larson was in these group photographs, but as Nielson did not recognise him in any of them, he did not believe that Larson was included.

The project had gained a new objective: to determine if Hans Larson was in the group photos. The question was: how was this to be achieved?

The team began by considering who had the ability to identify specific persons amongst groups of people: security agencies! Airports are a good example as they largely use biometrics for face recognition. The team then looked into companies that develop and build biometric systems for airports. We discovered that the world leader in this field is Portugal (Vision-box[2]), and that their head office is in Lisbon. We contacted the office immediately, and after some short briefings, they accepted the challenge and agreed to assist the team. They adapted some of their biometric algorithms and tested the two single photos of Larson against both group photographs.

What the algorithm delivers is the number of times the facial recognition fails to identify someone specific, in this case, Larson in the group photos—comparing his notable facial features with those of everyone else in these photos. From the Vision-box perspective, the curve that characterises the algorithm that was chosen for this evaluation relates the number of false acceptances as a function of the value to the match scores obtained. A score of 44, meaning around 0.070% of false recognitions every 100 positive tests, is acceptable to claim a positive correspondence. The test resulted in 36.25 in the crew photo and over 44 to the marriage photo.

So, even without 100 % certainty, the method and the test resulted in a very strong claim that Hans Johan Larson was in fact in both group photographs; and, that this method can work and be applied to identify people in historic photographs (Figure 2).

[2] http://www.vision-box.com/

Figure 2. Application of biometrics on facial recognition in the identification of Hans Johan Larson in historic group photographs.

Building an analogical 3D model from multibeam echo sounder geophysics x, y, z data

Conducting geophysics on submerged heritage, including wrecks, is today quite commonplace and almost mandatory in any archaeological survey. Multibeam echo sounder is one of the methods employed, and the project conducted, in 2015, a multibeam survey field season on the three steamers sunk by U-35 off Sagres and Lagos.

We always look to our data acquired during field seasons and ask ourselves what uses we can apply it to, besides the obvious. Reusing data, or using it for several objectives and for different purposes, is a way of making it less expensive. The answer to this question came in an analogical 3D model of the wrecks on the SS *Torvore* (30m+) and SS *Vilhelm Krag* (40m+).

The process was very simple. We transformed the x,y,z data from the multibeam echo sounder survey data to a STL file,[3] that is, printable on any common 3D printer.

With the 3D model printed, we looked for lost information that came from resolution problems, and add them to the model. After that, the model was undercoated with a neutral colour, and hand painted to simulate rust, concretions and biological life (Figure 3).

We understand the subsequent analogical 3D model has a considerable and serious amount of interpretation, but it revealed itself to be a very useful tool to brief and debrief the team's divers; and, to explain to people

[3] The STL file format is the most commonly used file format for 3D printing.

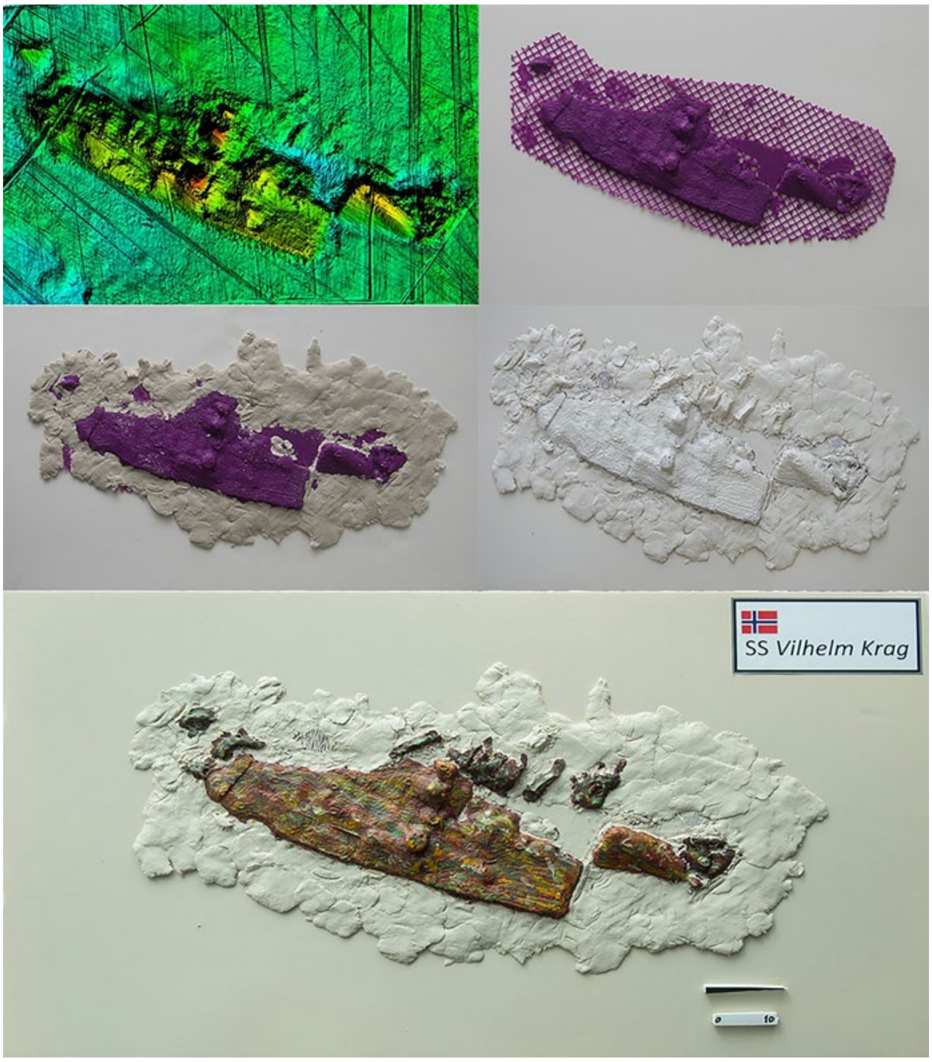

Figure 3. Analogic 3D model of the SS *Vilhelm Krag*'s wreck.

about features of the wreck, especially those who had never visited the wreck, or never will.

The model proved extremely useful especially in the case of SS *Vilhelm Krag*. The Norwegian 3700-ton ship that is now a large and horizontal metal parallelepiped on the bottom, where only the boilers stand out, makes navigation and archaeography, particularly at that depth, not an easy task. Divers, briefed on the model, stated that after the very first dive, they had no problem navigating the wreck site, immediately finding the boilers and other features, as if they already known the wreck by diving it. The analogical 3D model, produced by printing a STL file made from the x,y,z multibeam echo sounder data, increased the safety and the diving team efficiency.

The archaeography of a 72m long metal wreck

Our main archaeography objective for the wreck of the SS *Torvore* was to record the outline of the hull, location of the engine room with its boilers and steam engine, as well as starboard and port profiles. The issues were the depth (more than 30m), a short field season available, the large extent of the wreck (more than 70m), and a diving team consisting mainly of non-archaeologist divers who had either a brief or no experience in archaeography. Other important aspects to consider were the desire to involve the local diving community in the project, on a long-term basis.

With these conditions, it was necessary to define the methodology to perform the archaeography of this specific wreck, given the objectives outlined and considering the need for it to be feasible for an inexperienced team of non-archaeologists to undertake it. The diving team was made up of non-archaeologists, who were nonetheless very experienced and competent technical divers, with closed circuit (rebreathers) set up, including plans for decompression dives with 90' bottom time, implicating long 150' total run time dives, including decompression.

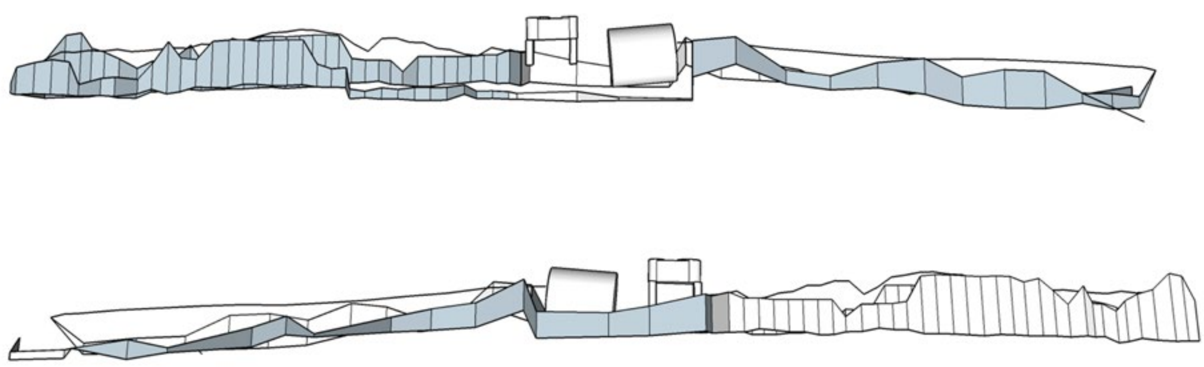

Figure 4. SS *Torvore´*s wreck archaeographic profiles.

With two teams of two divers each, we designed, implemented and tested the traditional baseline-offset method. In this case, we set two baselines, one from the stern to the engine, and other from the boiler to the bow. The stern baseline was marked at every metre, and the bow baseline every 3m. The objective of different markings was to test the outcome of the two resolutions (1m and 3m). Divers measured direct distances, from the baseline to the starboard and port outline of the wreck, using fibber measuring tapes, and depths between the outline of the wreck, on the points where the direct distances were measured, and the perpendicular respective point on the bottom, to record the wreck profiles (Figure 4).

As it was not possible to establish straight and levelled baselines due to wreck debris, both baselines were, in fact, a group of baselines set together (1m or 3m long). The Pythagorean Theorem was used to determine real distances between the baseline and the wreck outline selected points. As we were using depths, to determine real distances and record profiles, during very long dives over several days, we had to consider tides and the need for depth calibration.

To calibrate depths, we set a control point (P0) in the overpressure valve of the high-pressure cylinder cover of the steam engine, as the first task of the first dive. The dive running time of the P0 first measurement was recorded in order to calibrate it to the Lowest Astronomical Tide (LAT). With the P0 LAT calibrated, we just had to measure the depth on P0 at the beginning of every dive and add or subtract the difference to the depth registered with every measurement made during the dive. We could even measure P0 depth immediately after the last depth measurement, as the last task, to introduce the tide weight during the dive bottom time in the calibration process, to increase accuracy. All depths were considered as the Average Depth, meaning the average value derived from the maximum and minimum recorded depth, for each depth measured (AD = (Pmax+Pmin)/2).

To calibrate P0 depth to the Lowest Astronomic Tide, we used the rule of twelfths. In a simple and short explanation, we start with Tide Tables that gives us low and high tide levels, for a specific port, day and time. Using the rule of twelfths on the local tide table, we were able to determine the Lowest Astronomical Tide for our specific time, day and port, knowing that tides evolve the following way: 1/12 on the first hour, 2/12 on the second, 3/12 on the third, 3/12 on the fourth, 2/12 on the fifth, and 1/12 on the sixth hour.

In this specific case, this was the calculation used to LAT calibrate SS *Torvore*'s P0:

To Sagres and Lagos, we needed to use the Tide Table for the port of Lagos (Table 1), on 1 September 2014, 10h55 UTC+1, when we first measured P0 depth.

Table 1. Tide Table for the port of Lagos on 1 September 2014.

Date: 2014-09-01	**Port: Lagos**	
Summer Legal Hour (UTC +1)	(m)	
Monday, 2014-09-01 00:42	1.09	Low-tide
Monday, 2014-09-01 07:04	2.87	High-tide
Monday, 2014-09-01 13:04	1.18	Low-tide
Monday 2014-09-01 19:28	2.80	High-tide

At the start of the first ever dive (Run Time = 08h04), P0 depth was:

P0 Max = 24.9m
P0 Min = 25.0m
Average P0 = 24.95m

The difference between high-tide and low-tide was **2.87m – 1.18m = 1.69m**
Using the rule of twelfths:
08h04, one hour after the Low-tide = **1/12**
09h04, two hours after the Low-tide = **2/12**
10h04, three hours after the Low-tide = **3/12**
11h04 (10h55 is closer to 11h04 than to 10h04), four hours after the Low-tide = **3/12**
Total = 9/12
So:
09/12 = 0,75 x 1,69m = 1.2675m
We then should subtract **1.2675m** from the Low-tide value of **2.87m** = **1.6025m**
As **P0** was recorded **24.95m** (**Average P0**) – **1.6025m** = **23.348m**

Reference LAT Calibrated P0 = 23.348m

From this point onwards, any depth will be subtracted or added with the difference between the **P0** measured at the beginning of the dive, and the **Reference LAT Calibrated P0** (**ΔP0**).

After only three dives, the team managed to fully record the outline of the wreck, position of boiler and engine (Figure 5), and profiles. In reviewing the results, the divers observed that it looked like what they remembered seeing on the bottom. And, to verify accuracy, we decided to overlapped the record with the multibeam echo sounder record (Figure 6).

Obviously there were issues, easily corrected in a subsequent field season, but the method proved to be sufficiently accurate for the objective we had, and perfectly feasible for teams of non-archaeologist divers with minimal experience in archaeological recording and survey.

Conclusion

In conclusion, we have tried to demonstrate how a very low budget maritime archaeology project, around a Great War episode, almost unknown in the history books, was successfully conducted and concluded.

The success of the project and its results were critical, we believe, for rethinking some classical archaeological methods and adapting others, developing methods according to the project’s needs, and building close and strong symbiotic relationships. This approach allowed us to use highly technical and expensive logistics and technology, and to involve non-archaeological divers.

The adaptation of the classical baseline and offset method allowed us to successfully record a 70m long metal wreck which is 30m deep, with a team of four divers, and in only three days. The use of simple depth measuring and Lowest Astronomical Tide calibration methods allow us to record, with the desired accuracy, both the port and starboard hull sections, within the same framework and team.

The use and adaptation of state-of-the-art biometric algorithms designed and developed for airport security facial recognition allowed us to identify a crew member related to the historic episode, from simple to group historic photographs, and to prove the applicability of this methodology in similar cases.

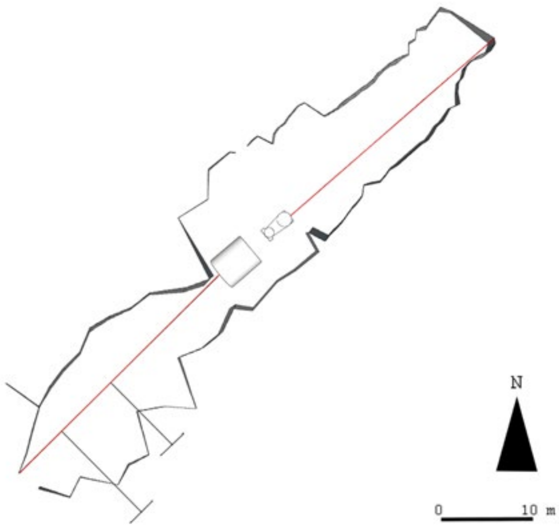

Figure 5. SS *Torvore*´s wreck archaeographic outline.

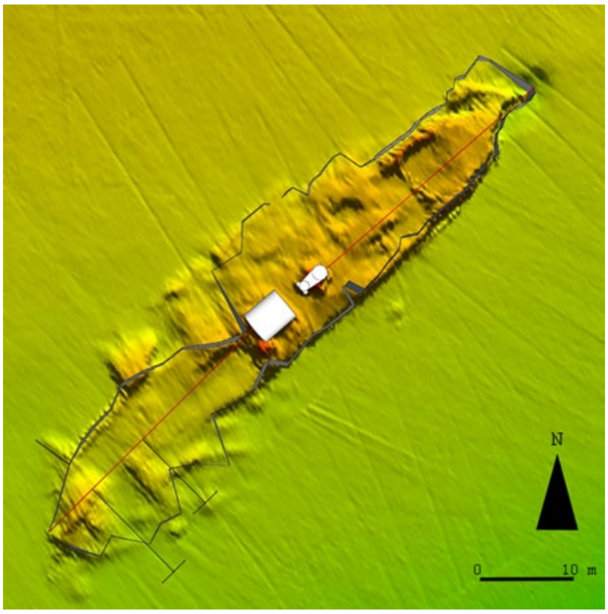

Figure 6. SS *Torvore*´s wreck archaeographic outline and geophysics comparison.

This was possible due to a symbiotic relationship with technology world leader Vision-box, as was the case with the symbiotic relationship with the Portuguese Task Group for the Extension of the Continental Shelf, that allowed the project to look for the Italian brigantine *Bienaimé Prof. Luigi*, more than 650m deep, with an oceanic hydrographical vessel and a 3000m deep operation with an ROV.

The involvement of non-archaeologist divers with technical diving skills, allowed us to conduct our tasks in a deep environment, proving the feasibility of carrying out important archaeological tasks in a successful way with recreational divers and enabling us to assess what is critical if we want to involve local communities in safeguarding underwater heritage.

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Further Reading

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Digitising Wrecks on the Foreshore: The Case of a Seventeenth-Century Wreck in Brittany, France

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Abstract

Studying archaeological sites on the foreshore gives rise to its own set of specific problems. Historical wrecks buried in the sands at intertidal zones usually come to our notice through natural erosion or human activities, or both. Such threats affecting the sites can also accelerate their deterioration, even their obliteration. Intertidal wrecks are evidently a precious and irreplaceable testimony of maritime heritage, and yet they are very fragile. It is a real challenge for researchers to find adequate ways to study them.

One such study undertaken in France focused on the small tonnage ship known as Erquy-les-Hôpitaux on the Brittany coast. This was a small coaster, which carried mainly lime mortar and foundered in the seventeenth century.

In 2015 DRASSM, France's Underwater Archaeology Research Department, conducted a special study of this wreck in order to define and assess various approaches to collecting archaeological data. The first phase of the study looked at three-dimensional digitisation techniques. Generating a 3D model of the wreck enabled the archaeologists to continue their studies after the excavation, and in greater detail. It also proved to be a valuable asset for presenting the project to the general public.

Most foreshore sites of archaeological interest are subject to the action of the tide, a constraint which requires archaeologists to rethink their usual methods for working on land or underwater. They also have to define technological tools that allow them to document artefacts effectively and in a short period of time, in particular, the merits of 3D laser scanning compared to photogrammetry.

Keywords

Wreck, coaster, 17th century, foreshore, digitisation

Introduction

The foreshore is a zone situated at the interface between the land and the sea. While its configuration may vary from one coast to the next, its value as an abundant repository of our maritime heritage is considerable. It contains sites from every age, such as submerged megalithic tombs, Palaeolithic settlements, fish weirs, cemeteries for the drowned whose religion was unknown, wrecks of ships and aircraft, and so on.

These remains face a double threat which consists, on the one hand, of coastal erosion, human-made constructions and safety works; and, on the other, of looting from, in particular, detectorists who at best damage sites if they do not destroy them forever (Poudret-Barré 2013: 127–36).

Background

Ships that have beached during storms or because of technical failure often find themselves entombed within the sands of these intertidal zones. Surveys are, of course, carried out at such locations but they are perfunctory and rare for want of suitable tools for the job, and the capacity to document artefacts in between tidal movements.

DRASSM, a department of France's Ministry of Culture and Communication, is responsible for underwater archaeological research at the national level. It has, for many years, been looking at technological solutions and, above all, methods that can ensure surveys and studies of sites lying in intertidal zones. For this reason, in 2014 DRASSM launched in France, on the coast of Brittany, a long-term programme to try out a range of methods and solutions on a series of wreck sites.

The first of these wrecks is known as the Erquy les Hôpitaux. Discovered along the Breton coast in 2002, the wreck underwent an initial survey the same year but had to wait another twelve years before a further study of the site was conducted. Since 2014 the site has become a testing ground for excavation methods that could be suitable for intertidal zones, in particular the deployment of three-dimensional recording techniques. Excavations on the wreck were directed by Olivia Hulot and Marine Jaouen (DRASSM) in collaboration with Eric Rieth (CNRS).

Constraints

The wreck is 9 m long, 3 m wide and completely buried in the sand in an area of the beach which gets submerged at high tide. After stripping the surface mechanically, the remains were uncovered by hand.

The excavation strategies deployed were adapted to the constraints of the surrounding environment, in particular a nearby river—the Islet—which flooded the site on numerous occasions. To get around this, we installed drainage channels and a soakaway which, in conjunction with a pump, displaced the excess water from the centre of the hull to a point further down the beach. Between each tide window we protected the structures from the pounding waves and the encroaching sediment by covering them entirely with plastic tarpaulins which were held in place by sandbags.

In addition to the usual manual recording techniques, we tested two digital methods:

Laser Process

First, data was acquired in the field through the use of a FARO Focus 3D-X-330 scanner. It was operated by a technician from the Conservatoire Numérique du Patrimoine Archéologique de l'Ouest, which is based in Rennes, Brittany. The technician completed seven measuring sessions, each lasting ten minutes. In total, we devoted two hours to laser surveying. We processed the data using SCENE software which allowed us to generate a point cloud, while the rendering was done with Unity 3D.

Where this laser method encountered problems was in the mirror effect (Figure 1) created by the ground water which, during the measuring sessions, rose progressively and could not be discharged. This constraint interfered with data acquisition and, unsurprisingly, had significant repercussions for the accuracy and detail of the resulting point cloud. In view of the length of time required for the acquisition, this method had to be rejected.

Photogrammetry Process

The second digitisation method under consideration involved taking a series of 3D photographs—done by a professional photographer—of the remains, in compliance with certain criteria, the principal ones being:

- Photos must overlap with at least four other photos by sixty to seventy percent of their surface and be spaced approximately fifteen degrees apart;
- Photos must contain metre sticks to allow for determining scale and calculating errors; and
- Photos must be free of shadows.

One of the 3D images comprised 885 separate photographs, which, once processed with the software Agisoft PhotoScan, produced a dense point cloud for the wreck. The mesh resulting from the dense point cloud gives a 3D model or, in the case of the Erquy wreck, a 2.5D model because the underside of the hull was not digitised. Texture can be added to the point cloud, it being calculated from the photomosaic of the model. Errors are calculated from standardised reference points placed on the ground, and this enables the model to be adjusted to scale.

The 3D model is georeferenced with help from topographical points that are determined during the excavation and used to generate a digital model of the terrain (Hulot *et al*. 2015). A vertical, azimuthal projection of the 3D model provides an orthophotograph of the remains. The planimetrics of the remains were obtained by vectorising the orthophotograph of the site (Figure 2).

Contributions from GIS

Importing this post-excavation process into a GIS project, in this case QGIS, saves a considerable amount of time when working in the field during low-water windows.

The planimetric view of the site, obtained from the orthophotograph and imported into a GIS project, allows the archaeologist to make a spatial analysis of the data. Thus, all the components of the hull, including treenails and metal nails, can be vectorised piece by piece and joined to an attribute table. This table allows the user to generate planimetrics that highlight the

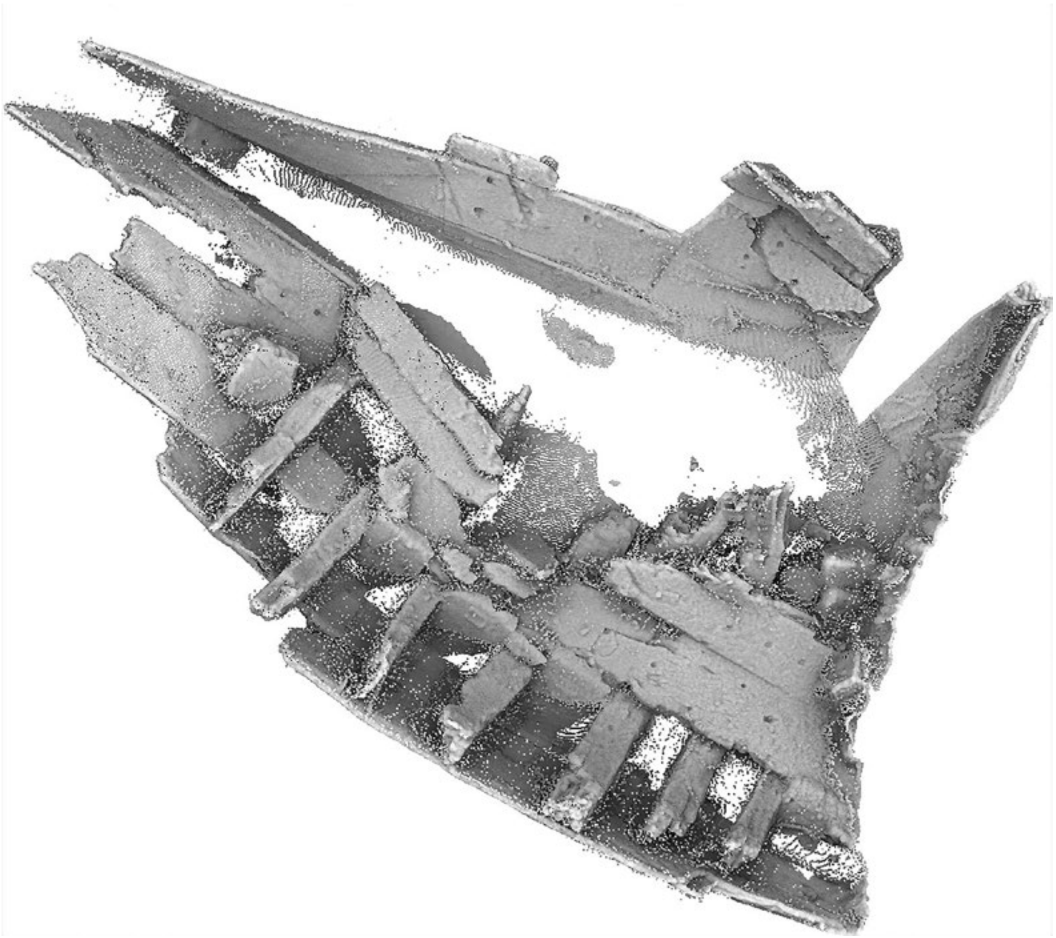

Figure 1. Mirror effect with laser process (Y. Bernard/Université Rennes 1).

Figure 2. Orthophotography of the wreck (Service 3D).

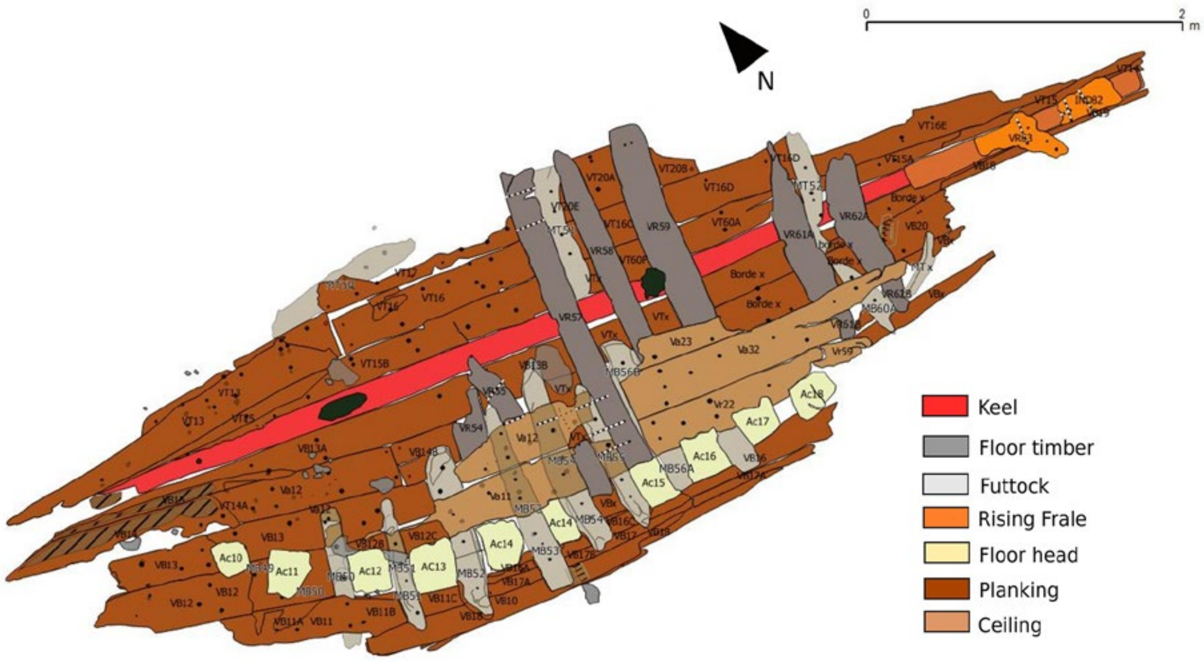

Figure 3. Vectorisation of the hull (MCC/DRASSM).

conserved items according to their type (keel, floor, plank, and so on) or depending on their material (Figure 3).

Importing the digital model of the terrain into a GIS project also allows the user to generate cross-sections and longitudinal sections (Figure 4). When we compared the measurements of the sections obtained from the post-excavation work with those obtained in the field, the results were very satisfactory. That said, interpreting the results of the manually obtained sections is clearly easier because the archaeologist can analyse the features in greater detail.

Archaeological data

When we analysed the design of the wrecked ship we discovered some very unusual architectural features, which make it a unique archaeological find. For example, all but one of the floor timbers were not fastened to the keel. In addition, except for two, none of the futtock timbers was fastened to a floor timber. These unusual design features of the Erquy wreck cannot be described in terms of 'primitive frames' or even 'primitive planking'. For the moment, without another archaeological example of this type of vessel, it is difficult for us to determine whether we have stumbled on an isolated case or are dealing with architectural features that are characteristic of some regional shipbuilding tradition.

The dimensions of the vessel have been estimated as follows: she was 9m long, had a 3.38m beam, and an approximate tonnage of nine. This suggests she was a small coaster involved in regional trade. Sailing in waters bordered with numerous sandy shores, the Erquy vessel was built for beaching both empty and laden. Wheat, firewood, slate tiles and lime were typical products of the Breton hinterland and undoubtedly constituted the main cargoes for the coaster as she worked to and from the great shipping hub in the region that was Saint-Malo (Le Bouëdec 2008: 9–37).

Wood Analysis

For the wooden components of the wreck Catherine Lavier of Paris 6 University identified the species used and dated them by dendrochronology. Elm was predominant in the ship's frames and planking, although some of the frames were made of oak. Only the keel was made of beech. The construction timbers were felled in the autumn of 1628 and were probably put to use the following year. Environmental periods were determined for the felling of the timber used in the frames and the barrels.

Restitution of the hull shape and sails

By analysing and interpreting the data from the 3D reconstruction, we were able to reconstruct the vessel's lines. We chose Rhinoceros 3D software, which has already been used by many international teams, to aid us in our subsequent study of the hull (Figure 5).

Three-dimentional drawings of the architectural elements are essential if the archaeologist is to analyse

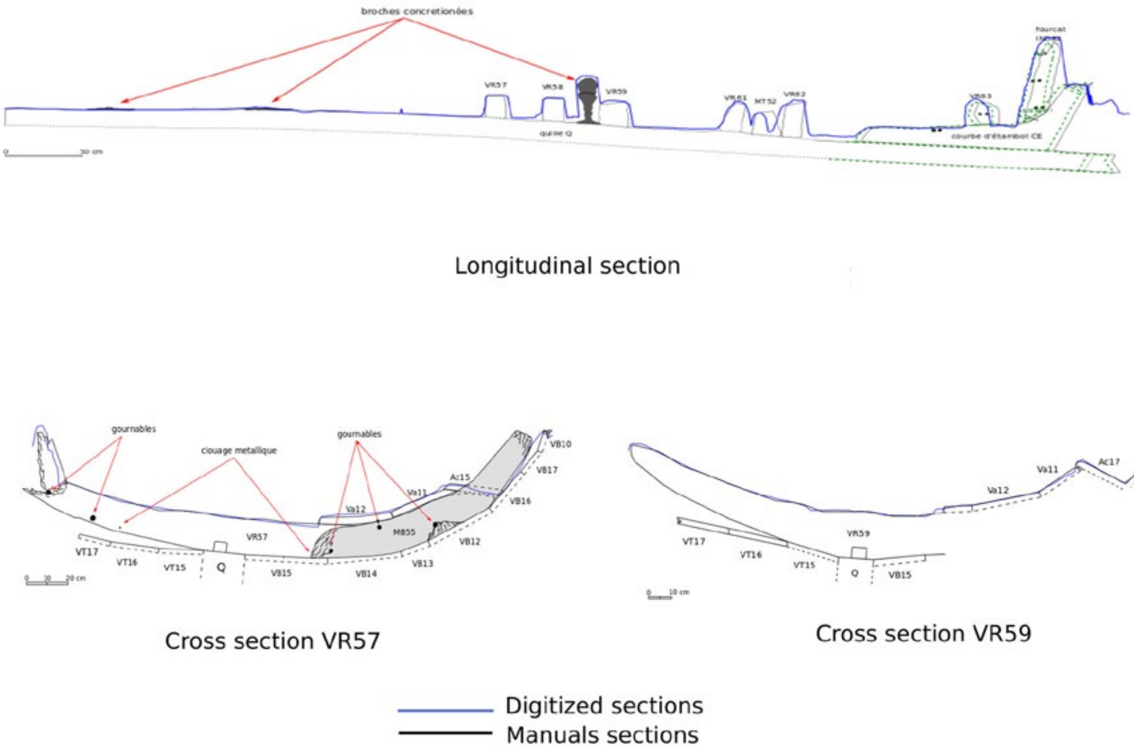

Figure 4. Comparison of manual and automatic cross-sections (MCC/DRASSM).

distortions piece by piece. In the case of the Erquy wreck, we made twelve cross-sections at characteristic points. These uncorrected sections were then placed on the keel in order to reproduce the shape of the hull as it was at the time of excavation. This allowed us to visualise the lines of the ship's bottom.

By modelling the stem we were able to appreciate the rake of the bow. The initial rake of the sternpost was reconstructed thanks to the skeg of the keel and the curve of the existing part of the sternpost. The waterlines were then established. These lines, which define the 3D shape of the hull, allowed us to reconstruct the lines plan for the ship after much refining.

Finalising the wreck's lines plan helped us formulate hypotheses concerning the ship's mast and sail plan. Despite our efforts being hindered by the absence of any keelson or mast step, the fact that one of the floor timbers had a heavier section than the others allowed us to be confident of the mast's position.

We were also able to compare this data with a few rare written sources, as Pâris (1882) Forfaix (1788), Morineau (1763) or more precisely an anonymous album (1679) of drawings, which shows various inshore and offshore vessels that worked the Atlantic coasts. This source is both contemporary with the wreck and geographically coherent with our study. It depicts only one type of rigging: square sail. From this premise, two hypotheses are suggested: the vessel could have been single-masted or two-masted, the latter comprising a foremast and a mainmast (Figure 6).

Conclusion

Somewhat more accurate, the laser system could provide a significant amount of measurements and a higher density of points for the point cloud than the photogrammetric technique. However, these advantages are to be weighed against the practical issues that arise from the laser technique. For this, the following should to be taken into account:

- The cost of the equipment;
- The deployment time required in the field—more than twice the time is needed for an equivalent coverage via the photogrammetric way; and
- The relative complexity of the whole process from the acquisition to the restitution.

It is most likely this last point that led us to prioritise the photogrammetric method, since it can be used single-handedly by any archaeologist and photographer skilled enough to follow simple rules of acquisition, and does not require the enlisting of any technical specialist

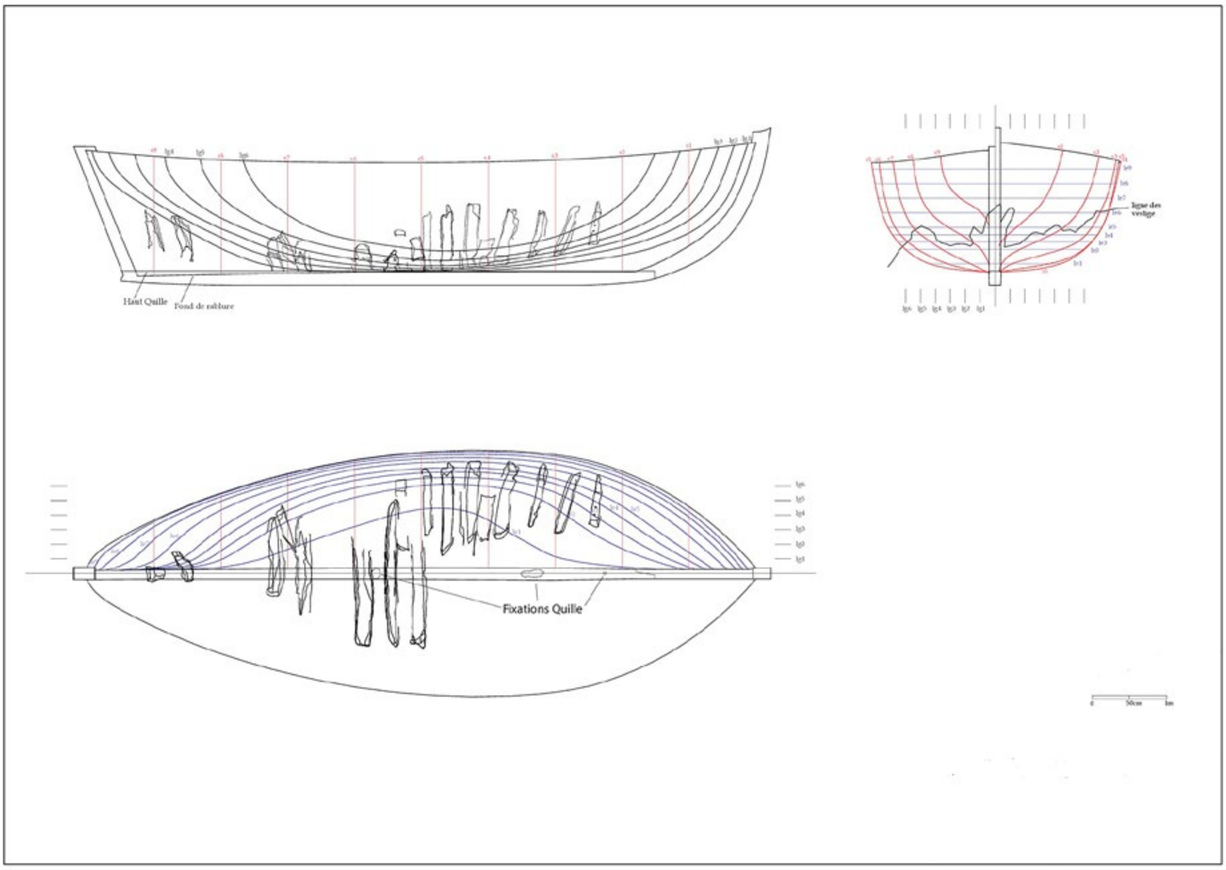

Figure 5. Reconstruction of the vessel lines (S. Bertoliatti).

specifically trained to be deployed on fieldwork during the acquisition phases. The delivery products can also be managed by archaeologists provided they learn to use software such as Agisoft PhotoScan, which are more commonly being used in archaeology.

Three-dimensional digitisation from photographs is a useful tool for both documenting and analysing—post-excavation—wrecks found on the foreshore. It also helps communicate the archaeologist's work to the wider world. In addition, we were able to present one of the models on the platform Immersia at Rennes 1 University in Brittany. Measuring 10 x 3 x 3m, Immersia is one of the largest virtual reality rooms in the world.

Since the trials on the coaster of Erquy-les-Hôpitaux, other studies have been carried out on wrecks situated on the foreshore of France's coasts and these confirm, if confirmation were necessary, the essential contribution 3D digitisation techniques make to the study of archaeological remains in intertidal zones.

Acknowledgements

We would like to thank the town of Erquy and town hall officials, all the field team, Denis Degez the DRASSM geomatician and of course Yves Meslin who discovered the site and closely followed every step of this work.

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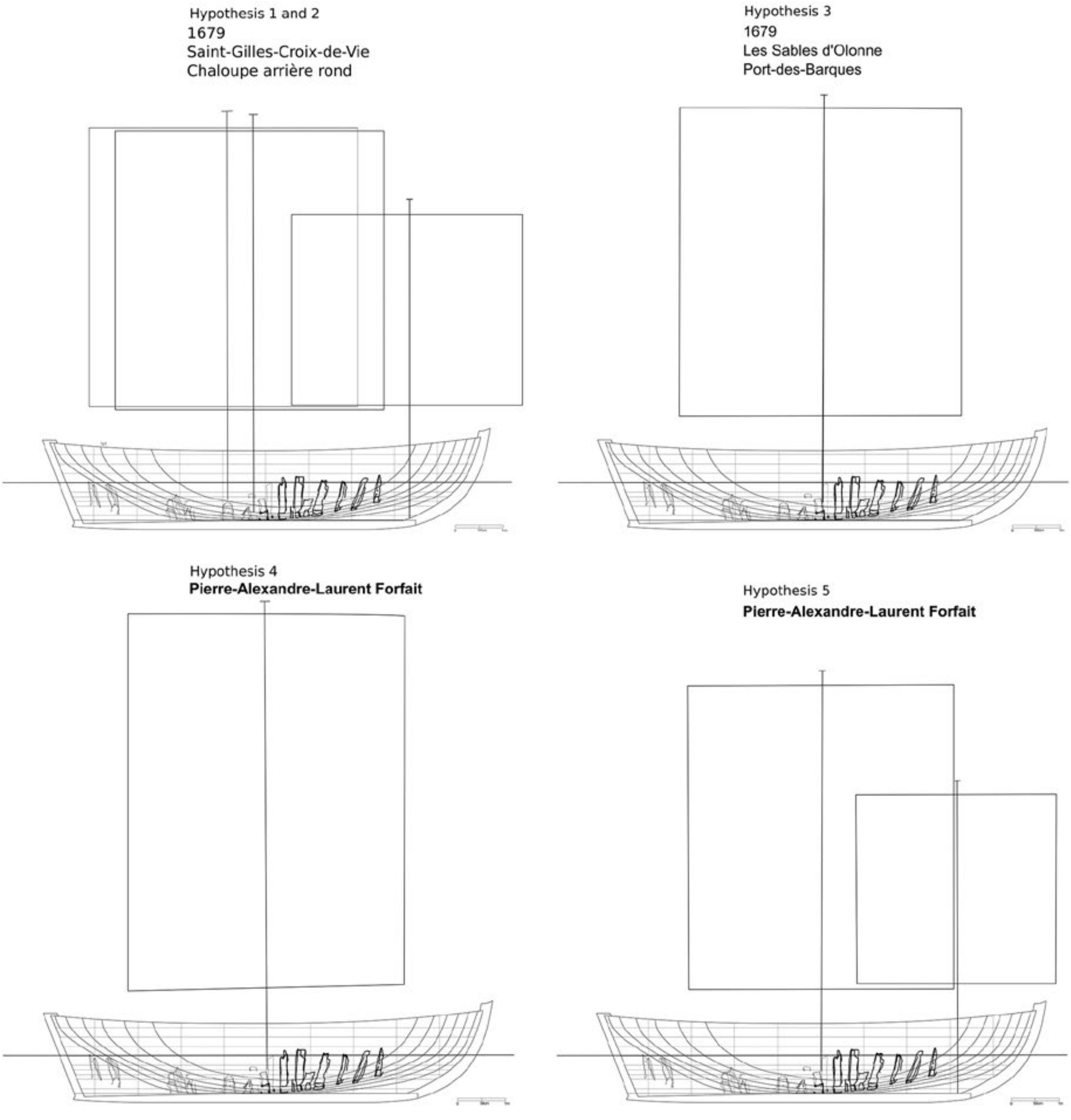

Figure 6. Hypothesis of the hull's shapes and sails (CNRS/DRASSM).

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How an Amateur Group Produced a Smartphone App for Shipwrecks
'We wanted to bring History out of boxes' —and Direct to the Public

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Abstract

In 2014 the Maritime Archaeological Association of Western Australia (MAAWA) produced a webpage and smartphone application (app) showing details of 30 known shipwrecks in the Swan and Canning Rivers and 12 shipwrecks around Rottnest Island, west of Perth city. The website and smartphone app are now easily accessible for schools, libraries, commercial and recreational tourism operators, and the general community.

The smartphone app contains historical and pictorial information about various vessels and covers the ship's operation, sinking, current state of the wreck (complete with underwater photographs and drawings), and locational data via Google Maps.

Since the launch of the website and smartphone app, research and interpretation has continued, particularly relating to shipwrecks found off the Mid-West Coast. This area is rich in historical interest with major Dutch shipwrecks such as *Batavia* (1629) being located in this area. Over 2017, another 250 shipwrecks will be added from the north-west coast and south coast of Western Australia, as well as wrecks around Perth.

The smartphone app will also have a major rewrite of code to comply with the many up-dates conducted by the major operators, Apple, Android and Windows over the past three years.

Financial assistance has been given by Lotterywest in the form of their heritage grants to benefit community not-for-profit groups.

Keywords

Technology, shipwrecks, phone apps, amateur group

Introduction

Maritime Archaeological Association of Western Australia (MAAWA) formed in 1974—the group consisting of divers, historians and enthusiastic volunteers, who are interested in Western Australia's rich maritime heritage. MAAWA is closely affiliated with the Western Australian Museum (WAM). Over the past 40 years a database dedicated to the historical and underwater research of shipwrecks had been developed. During this time MAAWA members discovered masses of historical information stored in libraries, boxes, sheds, etc. which had never been made available to the general public.

A book, *Swan & Canning River Wrecks*, by MAAWA member Colin Scrimshaw had been published in 1980 (Figure1). The question arose as to whether the group updates and republishes the book, or was there a better way to offer all of this information direct to the public? Whilst books are a valuable source of information, they do have limitations such as being a permanent record that cannot be updated without an expensive reprint, limited availability, as well as being bulky to carry around.

The group felt that a modern smartphone application could be the answer.

Historical information

A MAAWA member had just returned from England and reported that they had seen a new smartphone app on Shakespeare. While walking along the River Thames, users of the app could see where William Shakespeare ate, wrote and slept. This started the idea for the association's smartphone app (Figure 2).

Perth's Central TAFE (Technical and Further Education) Art College was just starting to teach smartphone app design as part of a graphic design course. The students produced various design concepts as a class project. With these visual concepts MAAWA was able to approach app developers to obtain quotes for development. MAAWA also sought community support and Lotterywest funding for the commercial development of the app.

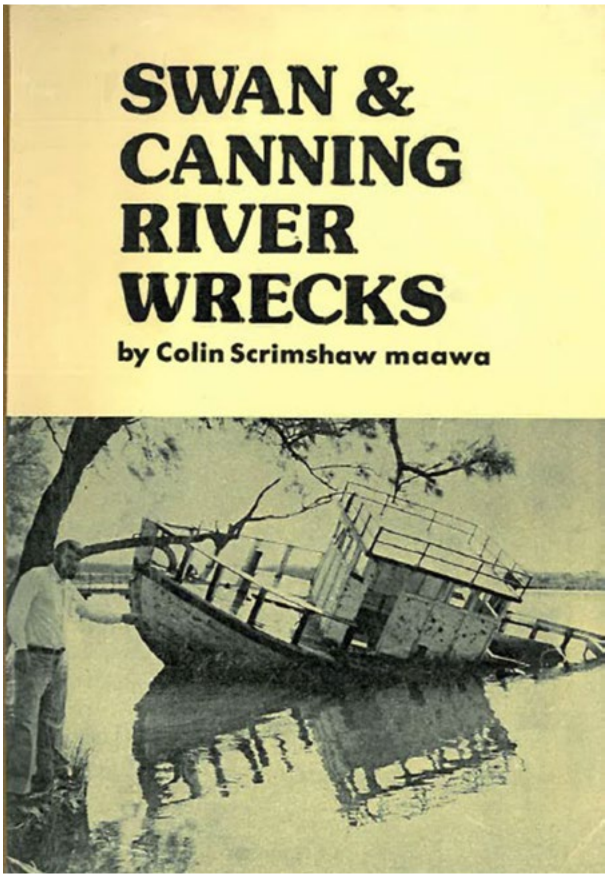

Figure 1. *Swan & Canning River Wrecks* by Colin Scrimshaw (cover). Published by MAAWA 1980, Perth.

Other graphic design students looked at the navigation called 'wireframe design'.

This demonstrates the navigation process: what happens if you press this button? Where you are taken? To a different page or screen, then how to get back to the menu or home screen? (Figure 3). It was important to have all the pages and navigation mapped out, so the app is intuitive for the public and the IT people understand what navigation is required to prepare the correct coding.

A team of IT students at TAFE developed a prototype smartphone app and looked at the challenge of writing a common database to be used by all applications. This was a huge task as at the time most smartphone apps required their own unique language codes. The students were able to design a database that was able to be read by all smartphones plus the webpage, which were all using different codes.

Quotes were received from three local smart phone app developers with quotes ranging from $20,000 to $80,000. The successful tender used the students' designs and draft codes as a basis for their work and one of the TAFE students was hired to complete the database task. After months of development the smartphone app was officially launched in November 2014 by Dr Ian Macleod in the Shipwreck Galleries (now Shipwrecks Museum) of Western Australian Museum in Fremantle.

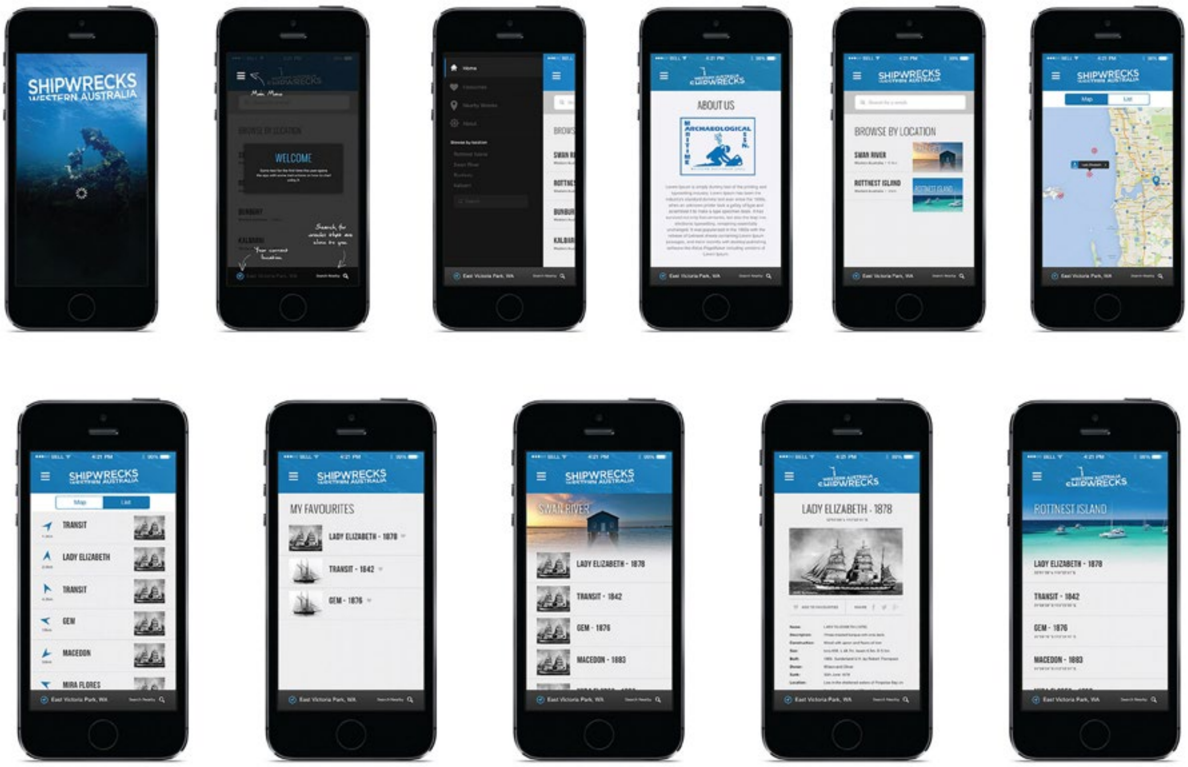

Figure 2. Concept by Diploma Graphic Design student, Leigh Maisey. Perth 2014.

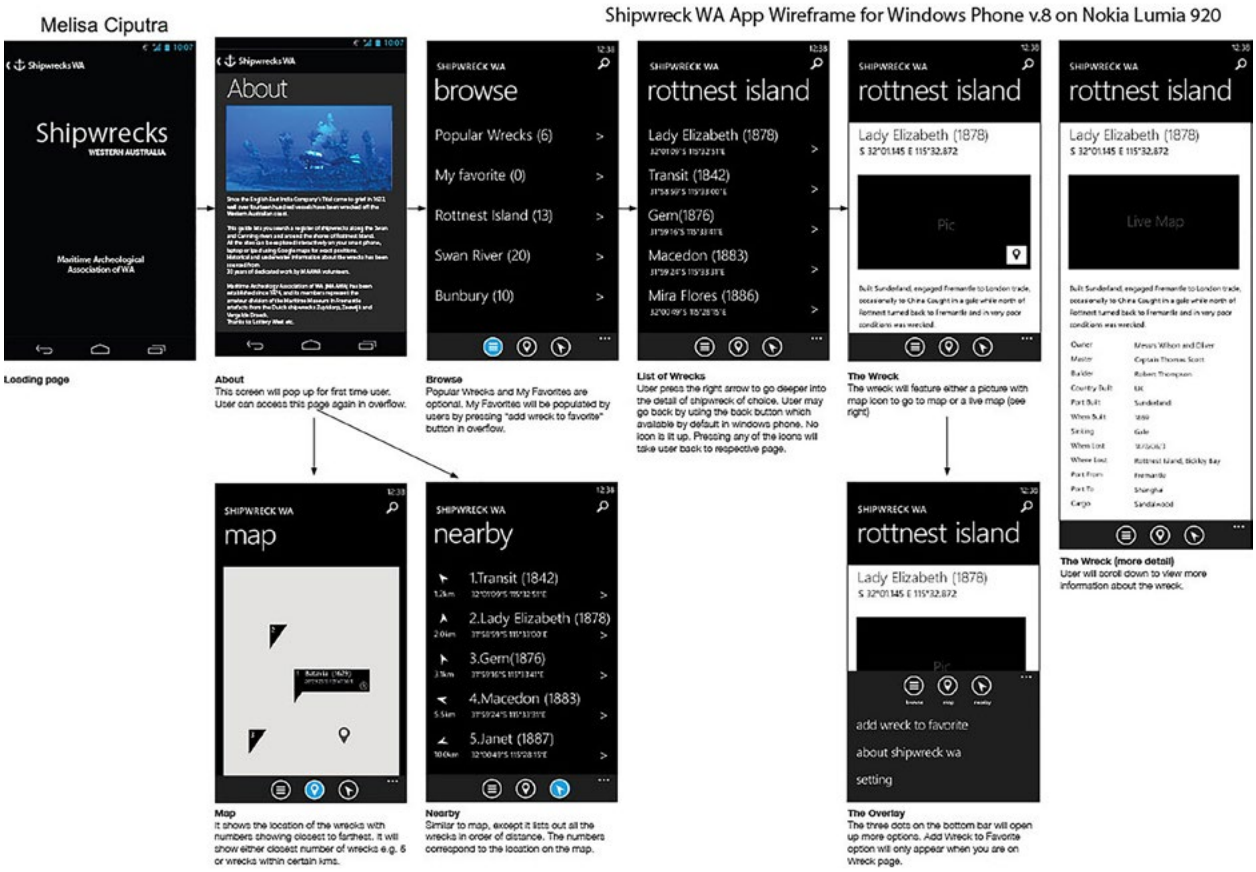

Figure 3. Wireframe design: a detailed design of all navigation aspects of the phone application by Advanced Diploma Graphic Design student, Melissa Ciputra. Perth 2014.

Main features of the smartphone app

Firstly, the home page of the Shipwrecks Western Australia website provides a location to download the app by providing a link to the different smartphone 'app stores' (Figure 4).

Currently, there are over 200 shipwrecks listed around the Swan River, Rottnest Island, Perth and the Mid-West Coast with more to be added from the north-west coast over the following months. This includes adding Australia's oldest known shipwreck, *Tryall* (1622).

The website has all the same information as the smartphone app making it accessible to schools, libraries and people without smartphones. When a user has the 'shipwreckswa' smartphone app downloaded on their device, they can search for a wreck by map, list or browse by region or 'geographic zones' to make searching easier.

Once into each shipwreck, an image heads the listing using an historical photograph, or a painting of how the ship may have looked whilst in service.

Figure 4. Webpage introduction: the 'splash' or first page of the webpage <http.shipwreckswa.com>.

Details of the shipbuilder, owners and skippers are listed plus other data such as details of the sinking and its exact location (Figure 5).

OMEO *EXAMPLE*: Each shipwreck has a large illustration of how the ship may have looked while in operation. If

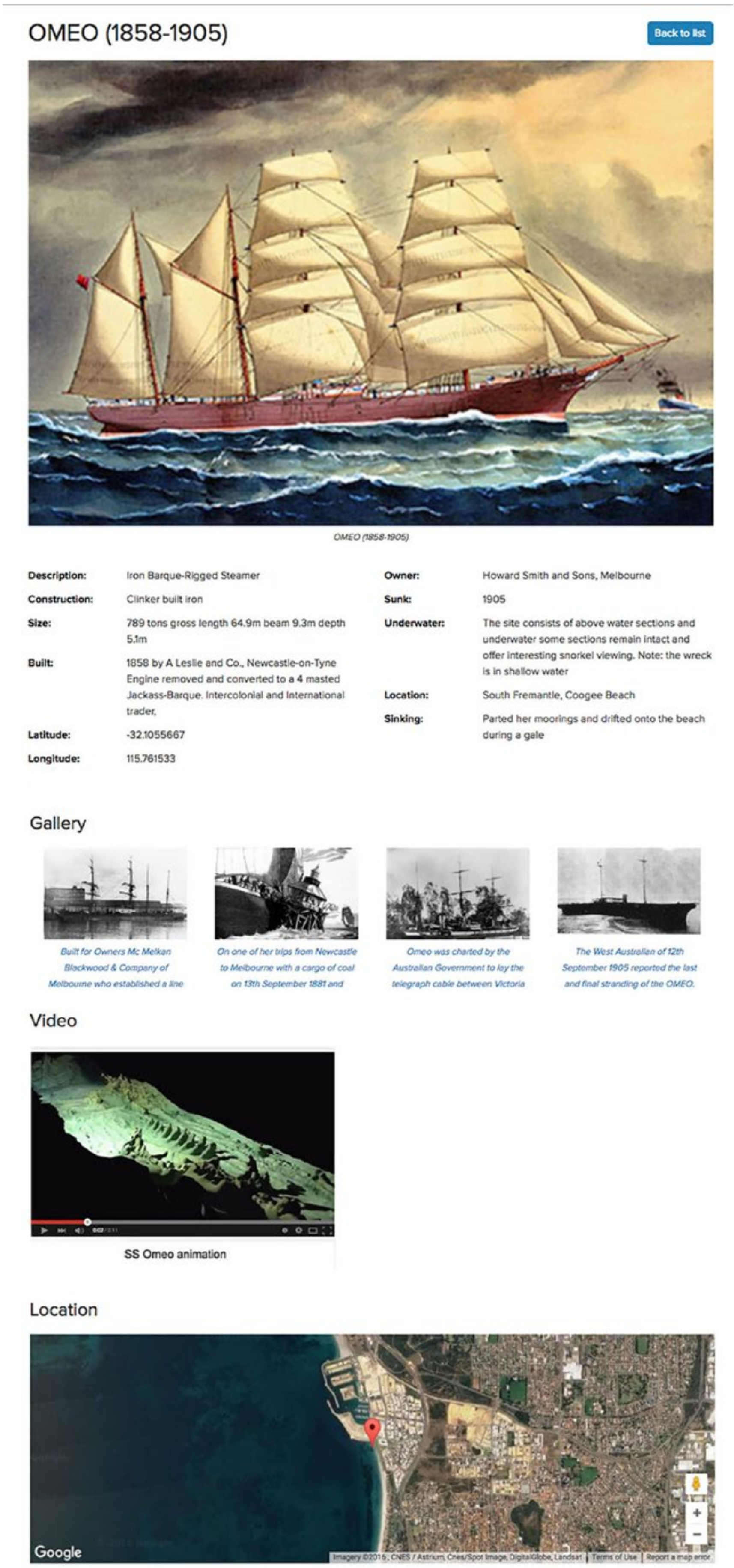

Figure 5. Sample page: *Omeo* showing the maximum amount of information that can be displayed for each shipwreck. <http.shipwreckswa.com>.

no illustration can be found, a generic picture is used. Details of owners, builders, construction and sinking are listed from the central database.

GALLERY: Up to four more historical illustrations or underwater drawings with captions.

VIDEO: When available, an underwater video or new 3D mapping project is streamed from YouTube.

LOCATION: Exact latitude/longitude via Google Maps of each shipwreck.

Results

Much more digitised information is now available on-line from museums and libraries in the form of newspapers, reports, photographs and even full coloured paintings.

MAAWA's membership and profile

The really big benefit to come out of this smartphone app plus the 3D mapping project is a greater interest in MAAWA by young people. One young member said he became interested in joining MAAWA solely based on the smartphone app.

Most young people do not read newspapers and few read books but are inseparable from their phones. The association tapped into this and now have enough young and eager members to carry on the work started 40 years ago, embracing and using new technologies and techniques of the digital age. In the 1990's two MAAWA members plus ten volunteers spent hundreds of hours hand drawing a site plan of the *Omeo* shipwreck in 5m grids. This year two people with a camera and computer did the same and with better results in only a few hours.

Lucky finds are exciting!

We are continuing to seek help from the public in locating more photographs and historical information about existing shipwrecks in the database. This photo was entitled 'Children fishing' and is the only known detailed photo of this iron steam paddle ferry when it was still operating (Figure 6). The *Harley* was built in 1897 at Coffee Point, South Perth, with parts sent out from Scotland.

New dive trails are being enthusiastically used by divers who are providing feedback and donating new photographs and videos for us to include in the database. A joint project over this summer will give more updated material for the Rottnest Island sites including 3D mapping of major wrecks.

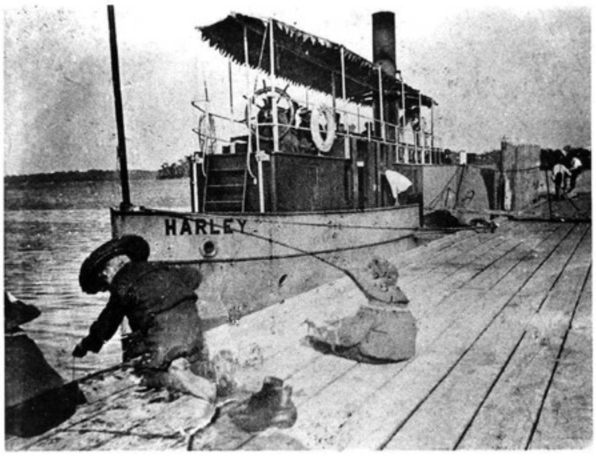

Figure 6. Historic photograph entitled 'Children fishing' from State Library of Western Australia ref. 85840P.

Technology

When smartphones first started, an expert IT programmer needed to write a separate program for each type of phone as they all used different languages and different ways of doing things; as new innovations emerged, a change in the code required a new version to be written and submitted to the app stores for users to update their phones to the latest version.

There have been so many changes and upgrades with mobile phones and now with a major Apple upgrade expected in late 2017 it is expected that a major re-write will be required. The rewrite project has been made much easier with new software available that can write in a common computer language and then have three versions exported out for each of the smartphone app systems. This will also make any changes much easier to make in the future with just one program holding the master project. This does mean that we will have a new stable platform with a common language and design that can be amended and tailored to suit another Australian state or any country.

The future?

- To work on projects which can record and expand our knowledge of shipwrecks and maritime history in Western Australia.
- Gain assistance from the public to find more old photographs and stories of the people involved—owners, ship captains and their families.
- In conjunction with the Western Australian Museum, involve schools and community groups in researching and developing resources relating to shipwrecks found in their local area, to be included in the database.

- Include new technologies such as 3D modelling and videos of important shipwrecks.
- Design the project for later expansion around the coast of Australia, or any country in the world.

Conclusion

A smartphone application is a complicated project to commence from an idea; development takes a significant amount of time, money and persistence. Sponsorship of other resources is essential to complete the project including volunteers willing to provide the extensive time to research and interpret all the data and process all the photographic images. Help from professional app developers is usually required as well.

Acknowledgements

Help and encouragement from WA Museum staff and members of MAAWA. Sponsorship from WA Lotterywest and the Australian National Maritime Museum made the project possible to complete.

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Android Google Play store:<https://play.google.com/store/apps/details?id=hyperionstudios.com.au.shipwreckswa&hl=en>.

Appendices

'Young people are now more likely to prefer to read on a computer screen rather than a printed book or magazine.'

Of the survey 52% preferred to read on screen compared to 32% who preferred print.<http://www.literacytrust.org.uk/assets/0002/6896/Children_and_Young_People_s_Reading_in_2014.pdf>.

'Just 28% of young people read either online or conventional newspapers each day' Sciencedaily, 10 December 2012. <www.sciencedaily.com/release/2012/12/121210080736.htm>.

A Sub-Bottom Profiler and Multibeam Echo Sounder Integrated Approach as a Preventive Archaeological Diagnosis Prior to Harbour Extensions

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Abstract

Before excavations were carried out of the rocks and dredging spoils for extension of the Porto-Vecchio marina in Corsica, France, an investigation was carried out by the Subaquatic Office of the French National Institute for Preventive Archaeological Research. SHOM (Service Hydrographique et Océanographique de la Marine, Ministry of Defence in France), who specialised in Hydrographic and Oceanographic services, recommended that the project team couple the sub-bottom profiler with a multibeam echo sounder.

In preventive archaeology, time pressure is a significant factor in your need to compile a large volume of data. Archives such as archival maps, old spatial data and data from more recent surveys including meta-data from a sub-bottom profiler and multibeam echo sounder, can be superimposed on the dataset of current marine maps after which all statistics can be integrated in a Geographical Information System (GIS).

All of the processed data were exported in QGIS®™. The GIS allowed us to subdivide or categorise the abnormalities according to different parameters. GIS is a meta-data compilation tool—a guide for archaeologists to strategically choose what to excavate.

Keywords

Sub-bottom profiler, multibeam echo sounder, GIS, harbour

Introduction

This investigation was carried out in France, more specifically at Corsica in the Mediterranean, between September 2015 and June 2016, at one end of the bay of Porto-Vecchio including a part of the maritime public domain (Figure 1). The Subaquatic Bureau of the French National Institute for Preventive Archaeological Research carried out the investigation, at the request of the Department of Submarine and Subaquatic Research of the Ministry of Culture. It was carried out before excavation of the rock and dredging spoils in order to extend the marina in Porto-Vecchio. According to Pelgas (2015b: 338), a similar survey was conducted in 2013 in the commercial port at Porto-Vecchio with superposition of different data.

Methodology

With preventive archaeology, limited time is a key factor in the compilation of large volumes of data, so how can this be best organised? Most of the old spatial data could be superimposed onto the dataset of the current marine map and survey, superimposed onto the architect's project plan, and then all could be integrated in a Geographical Information System (GIS, cf. Figure 2). In general, for old maps, transferring them into a GIS is not easy, potentially resulting in significant distortions in measurements due to incompatibilities. In this example of an eighteenth-century map, we already see the Porto-Vecchio harbour; however, the data is more qualitative than quantitative.

The old postcards also provide useful information, showing: a two-masted schooner and an anchored four-masted boat in this part of the bay in shallow waters, dated to the beginning of the last century, probably in the 1920s. This data could be associated only with a reference to the area (raster grid with web link) with the zoom in scale minimal and maximal visibility. Historical data studies including maps can provide information about marine deposits or erosion. Data was compiled and superimposed onto the current marine maps.

Different plotting was incorporated in the GIS using lead lines (fat covered) between 1884 and 1891 by SHOM, in the harbour and the gulf (Figure 3). It provides us with data relating to the seabed's evolution. These bathymetric figures have respectively provided 1291 and 1017 measurements. With the time constraints faced, measurements were of utmost importance using monobeam in 1979 and 1987, with the vertical sounder

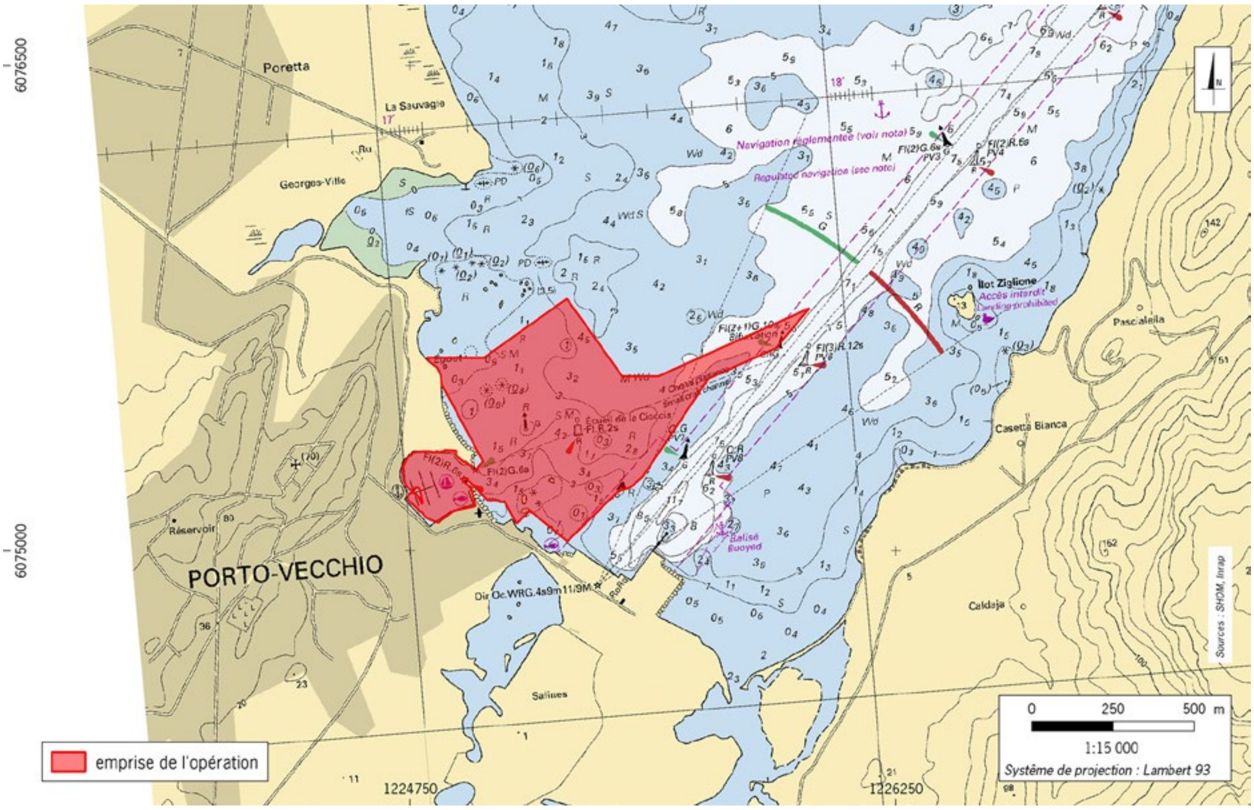

Figure 1. Area under investigation.

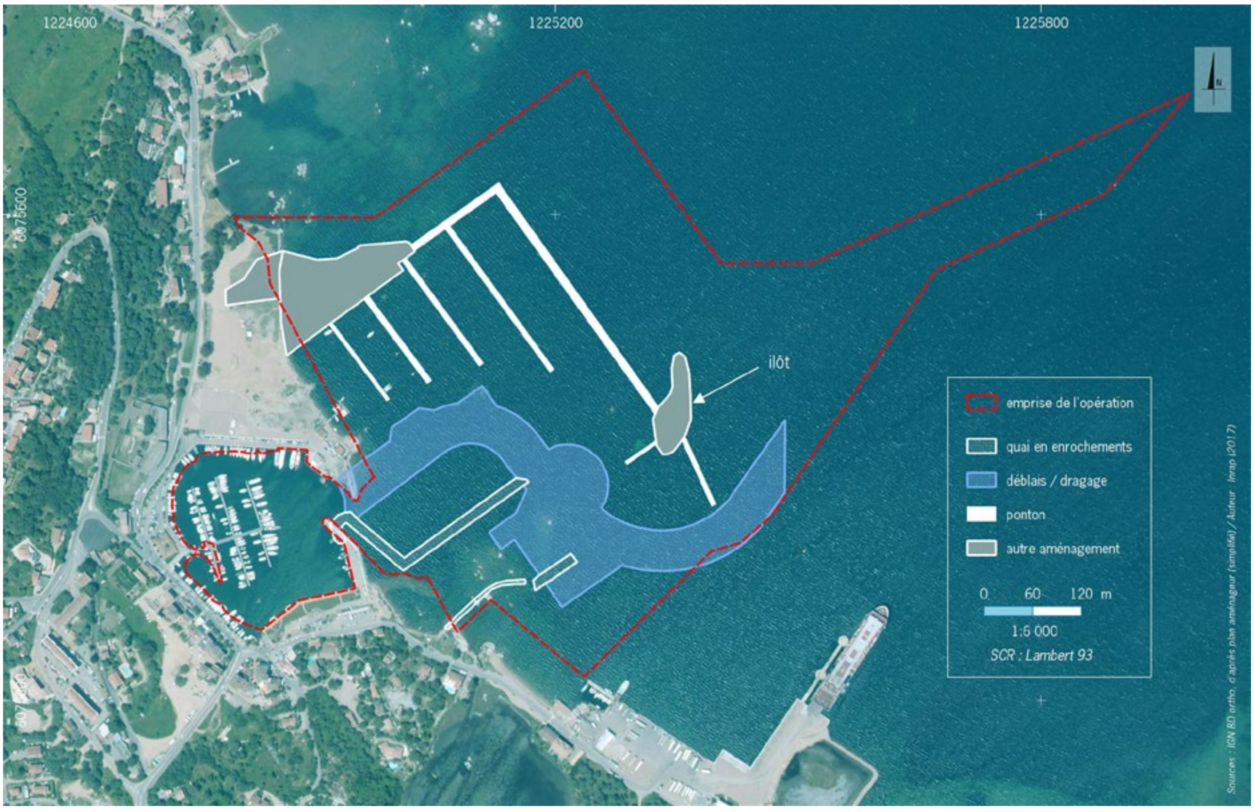

Figure 2. Results of the investigation superimposed onto the harbour development plan.

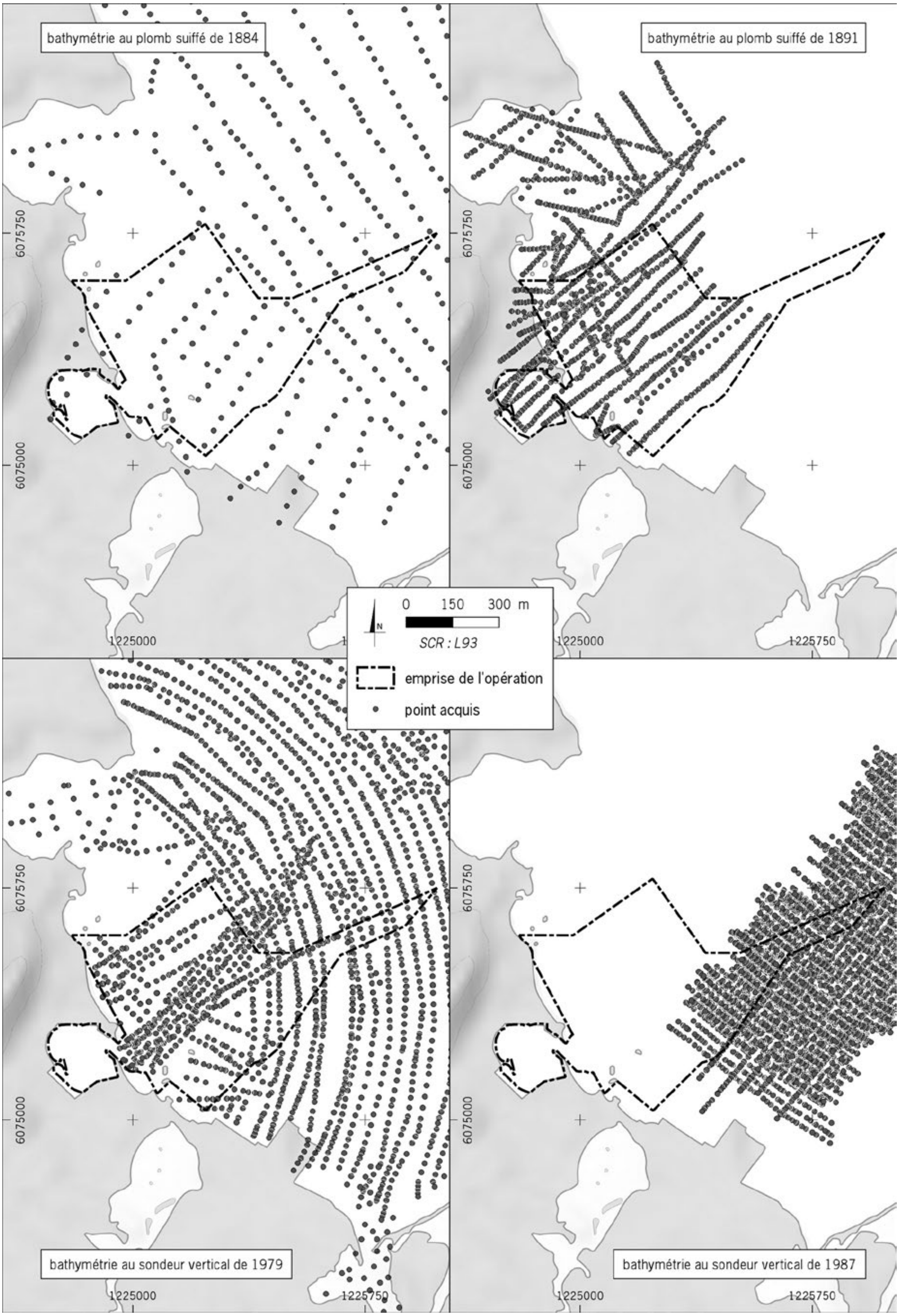

Figure 3. Lead lines (fat covered) between 1884 and 1891, SHOM data.

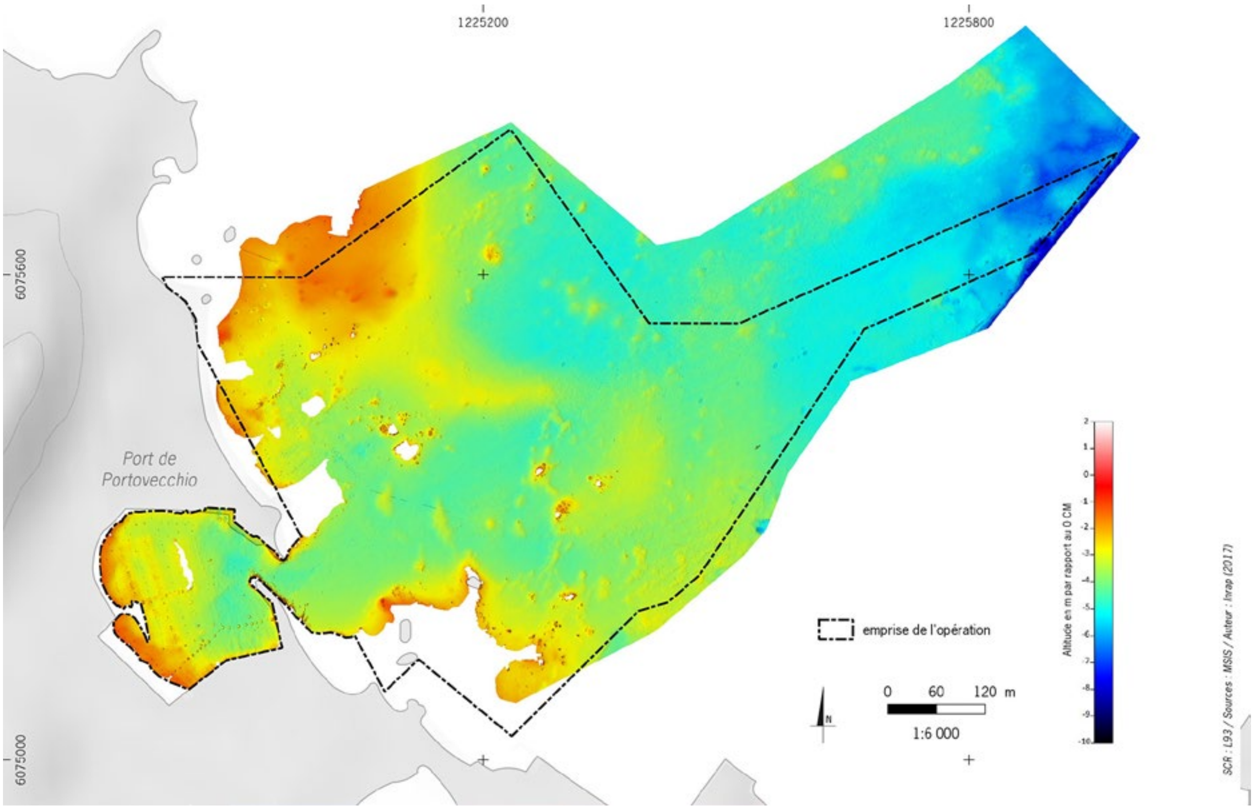

Figure 4. 2015 Mesuris bathymetric map.

DESO20, with 6060 and 9676 measurements within the same area.

One step that produced a significant volume of data was the sub-bottom profiler survey, which has been requested by DRASSM of the Ministry of Culture. However, before this step, according to Pelgas *et al.* (2015a: 89), in order to carry out an effective sub-bottom echo-sounder survey, it is very important to construct a very good quality bathymetric Digital Elevation Model of the area. It is an important preliminary step (Figure 4). Caiti (2009: 149) has already indicated that multibeam allows us to carry out a very accurate plan of an archaeological area.

The metadata files include:

- Position of the different seismic emissions;
- Speed of the vessel;
- The name of each acoustic profiling; and,
- The number of ping emissions.

SHOM, who specialises in Hydrographic and Oceanographic services, recommended coupling the sub-bottom profiler with a multibeam echo sounder. We have used the seabat® 7125 with Teledyne Reson (511 beams on an angle of 160° with a cadence of 40 measurements per second). Data acquisition allows us in this case to obtain up to 25 probe spots per square metre. A reference station was established on land with global system for Mobile Communication 'GSM' liaison with the Global Positioning System 'GPS' on the boat. INRAP collaborated with Mesuris Company to implement an underwater survey using the multibeam echo sounder and the sub-bottom profiler.

The use of the multibeam echo sounder has the advantage of reliable positioning; and, is vertically accurate to +/– 10cm, and horizontally accurate to +/– 2cm. Another advantage is that should the abnormality be covered with sediment after the survey, the reliability of the positioning will increase the likelihood of relocating the anomaly. In the boat, the team has a real-time follow-up of the survey on the screens; and, under the hull, there were tools (multibeam and sub-bottom connected to the inertial central). It is also important to measure the velocity of the acoustic wave in the water, according to the temperature and the salinity.

The seabed detection is carried out by analysis of the beams dispersed in all directions. The reception aerial is made up of transductors that digitise the echoes reflected from the seabed and its features (seabed profile, rocks, etc.). We obtain a matrix containing the depth measurements of the seabed on the acoustic signal received. It is the reflectivity of the samplings, which

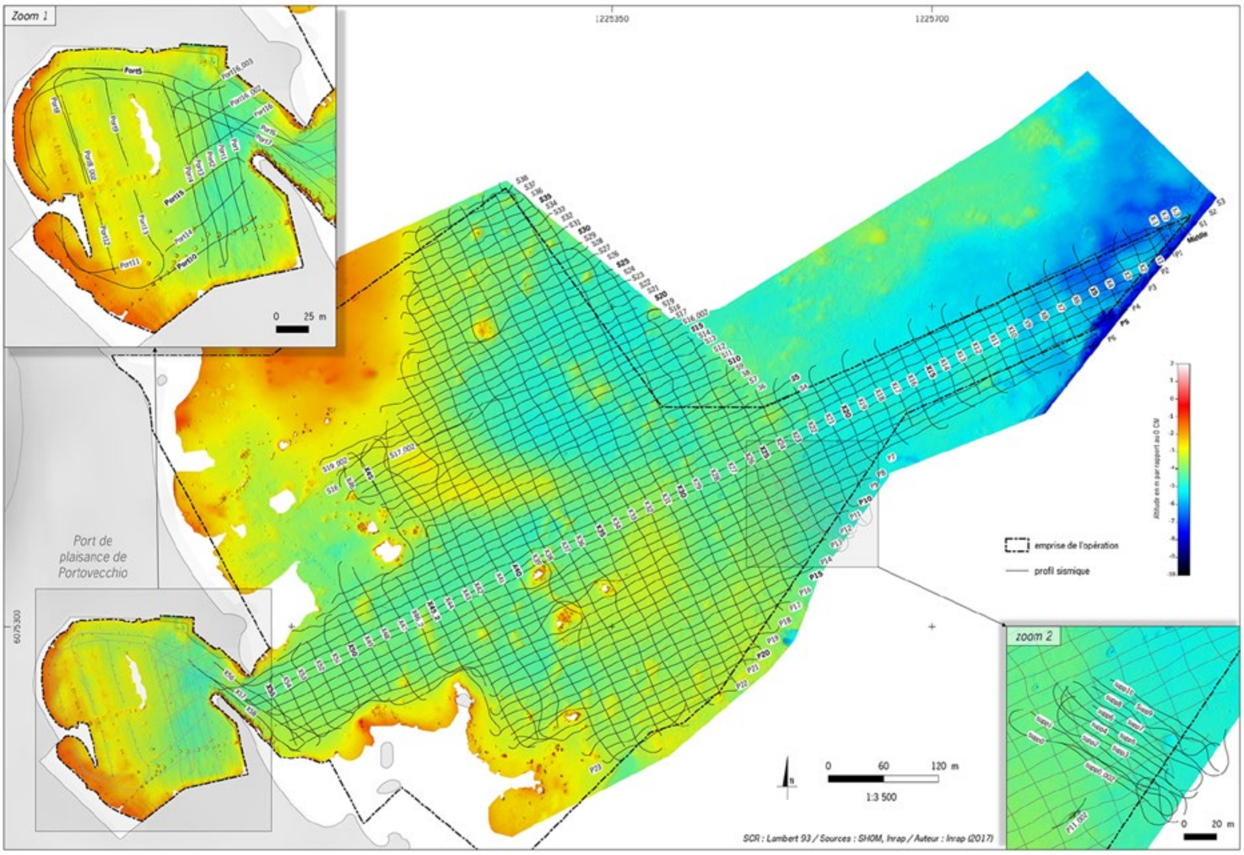

Figure 5. Sub-bottom profiles.

create an acoustic imaging. In the QINSy software™, the probe reserved is an average of the probe data. The bit map density gives us a Digital Elevation Model with centimetric accuracy. The multibeam is connected to the inertial unit, and the GPS (Real Time Kinematic) is connected with the shipping package software QINSy™.

The high definition is obtained by other captors and sensors of the inertial unit, to compensate for the rolling motion, pitching and heaving, and the change of course, in order to ensure the continuity of the direction and position when the GPS signal is temporarily lost. To realise the Digital Elevation Model, we programmed the software package based on the required parameters. In the treatment phase, the QINSy Cloud software™ sorts the valid data and eliminates false data. For each depth range, a colour is associated to enable visualising of the 3D map.

The primary data is presented in .kml and .xtf files, and transformed into ASCII data. The 3D georeferencing carried out with the Fledermaus™ software allows us to analyse the seabed as needed. An open source viewer tool allows us to visualise the 3D map. We can represent the isobaths or not, to appreciate the depths. A geological company, which carried out the seismic refraction survey a few years ago, provided the data, which give us the area and altitude where the rock appears. It also gave us the thickness of the sediment.

The second main step of this survey was the use of the sub-bottom profiler. It is a tool to gain time and to detect what is undetectable by the multibeam. A sub-bottom profile was carried out every 7 to 10m, giving us 163 profiles with redundancy profiles established along different acquisition axes (Figure 5). It is necessary to multiply profiles with different acquisition axes to increase the chance of discovering abnormalities.

This survey was made with the slowest acquisition speed (2 knots), a necessary positioning to superimpose the survey onto the bathymetric DTM. A system attached to the vessel is preferred to a towed system. The sub-bottom raster profiles are represented on the bathymetry. Each profile is named. The superimposing of the echo sounder profiles on the bathymetric data allows setting the reading of the echo sounder profiles. The transducers are electronically controlled by Delph Seismic Acquisition software ™ and read using Delph Seismic Interpretation software ™. Delph Interpretation exported the native data to XTF to SEG-Y file. The frequency of the sub-bottom profiler is between 5 and

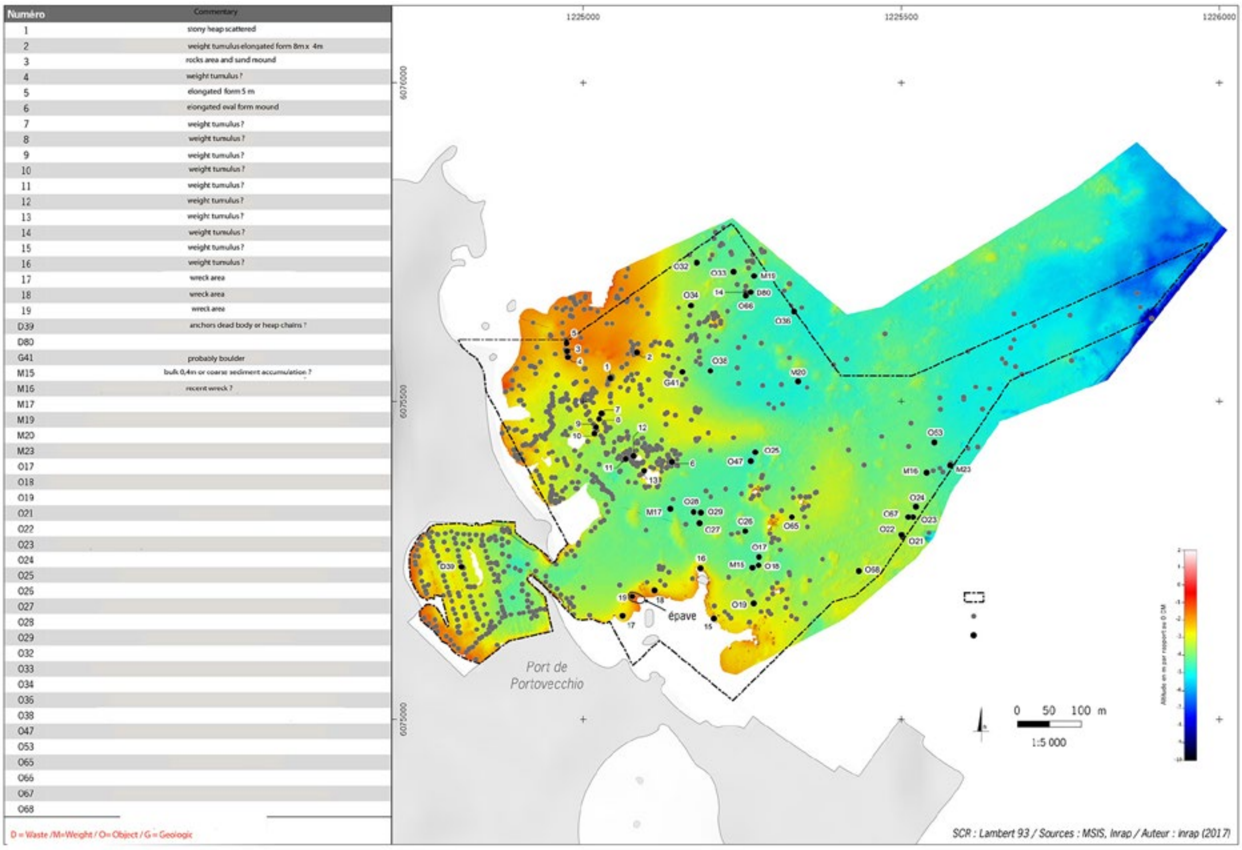

Figure 6. Selected abnormalities.

15kHz for a vertical resolution of less than 10cm and a maximum directivity of 20 degrees. It is readable with other seismic scoring software (Kogeo, an open source software), or in Kingdom seismic and geological interpretation of HIS Kingdom® (purchased software).

The importation of the navigation data in Shape file corresponding to each profile is carried out.

A selected profile can be read, and we can see where the other perpendicular profiles are; and, we can determine the burial depth of abnormalities. All the processed data (Shape file) can then be exported in QGIS®™ (an open source GIS software). We have for each data, the .dbf, .prj, .sbn, sbx, shpp, and .shx files.

Analysis

The GIS allows us to subdivide or categorise the abnormalities according to different parameters. The depth of burial and depth to the water surface will be recorded for each abnormality. The advantage of carrying out the preliminary DTM is to compare some abnormalities and their positioning (Figure 6). The GIS allows us to see structures as a pipe sometimes on the bathymetry, and on the sub-bottom profiles the continuity of the burial pipe.

Abnormalities were selected and sorted in order to be verified soundings (concrete mooring) with water dredge. We have seen vertical positioning 'ultra-accuracy' with a vertical resolution of 7cm and horizontal resolution between 15 and 25cm with 3 knots.

Results

One of the abnormalities was a stone 5cm above the bedrock —a wreck was discovered in an area covered by multibeams: some frames, wooden hull lining girders and metal remains, which possibly covered the hull (unknown today) as well as nineteenth-century artefacts (roof tiles with printed dates). The multibeam picture indicated rock or anthropic abnormality. All the others have given geological results or layers of hardened shells. All information could be exported in the GIS.

Conclusion

GIS is a meta-data compilation tool, but it requires a significant amount of time (several months, in this case, to analyse all files, compile and select). It is a guide for archaeologists in the strategic selection of where to conduct excavation.

Acknowlegements

Simon Ichstchenko, Mesuris.
Philippe Raja, INRAP.
Emmanuelle Miejac, INRAP.

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Seventeenth-Century 'Glass Wreck' Research Using Photogrammetric 3d Documentation—the 'Virtual Open-Air Museum of Wrecks in the Gulf of Gdańsk' Project

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Abstract

In 2015 archaeological excavations including 3D documentation were carried out by the National Maritime Museum (NMM) on the 17th century 'Glass Wreck' in the bay of Gdańsk. The site lies at a depth of 20m, 5Nm from the coast of Gdynia. During work on the wreck it was determined to be 25m in length and almost 8m wide. The keel of the vessel is aligned east–west. Structural elements of the vessel, which are of oak, include fragments of both sides and a section of the bottom. Oak used to build the vessel was gathered in the second decade of the 17th century.

The vessel sank carrying iron guns and a cargo of casks containing iron bars and glass bottles of various sizes and shapes. The bottle's tin caps are stamped with the 17th century marks of the Gdańsk tinsmiths. In addition, three lead ingots with merchant and producer's marks were discovered. The lead came from deposits in southern Poland. The wreck showed significant evidence of burning.

In 2015 NMM launched the 'Virtual Open-Air Museum of Wrecks in the Gulf of Gdańsk'. The website contains thirteen 3D models of wrecks with their descriptions, photo and video documentation. One of them is the 'Glass Wreck'. By the end of 2018, NMM had plans to post on the website www.wsw.nmm.pl eight more wrecks from the Gulf of Gdańsk.

Keywords

Underwater archaeology, photogrammetry, glass wreck, 3D model

The F53.30 *Glass Wreck* was discovered in 2012 by the Maritime Office in Gdynia. Sonar images identified large parts of a wooden ship buried in the sandy seabed with casks protruding from the seafloor. The vessel lies at a depth of 20m, 9.3km (*c.* 5 nautical miles) to the east of the seashore in Gdynia Orłowo area (Figure1).

Figure 1. Location of the F53.30, Glass Wreck (Archive NMM).

Archaeological fieldwork was conducted in 2015 as a part of the 'Virtual Open-Air Museum of Wrecks in the Gulf of Gdańsk: Documentation and cataloguing of underwater archaeological heritage' scientific research project. The work aims to catalogue four wooden vessels in the Gulf of Gdańsk, which date back to a period between the 17th and 19th centuries, such as W-6 *Solen*, W-23 *Loreley*, W-21 wreck and F53.30 'Glass Wreck'. Drawings, photographs, video and photogrammetric recordings used to create a photo-mosaic and 3D models of the sites were compiled during fieldwork. Additionally, samples for dendrochronological analysis were collected, and consequently physical as well as chemical analyses were conducted on the wood samples from the wrecks (Bednarz 2015: 3–5).

The fieldwork was carried out on the F53.30 wreck over 15 days in June 2015. The work was conducted from the ship *Hestia* with the participation of four underwater archaeologists from the NMM in Gdańsk, supported by a team of six volunteer divers.

The wreck occupies an area of $200m^2$, and is 25m in length and almost 8m in width. The keel of the vessel is aligned east–west. Structural elements of the vessel, which are of oak, include fragments of both sides and a section of the bottom. The wreck is tilted to the starboard side where a significant part of the cargo is located. The identified structural parts include a partially visible keel at least 10m long; floor timbers, frames, 10–12cm thick and 15–22cm wide; 8cm thick wooden staves; staves of inside panelling, 3cm thick and up to 22cm wide; a section of a mast 2m long; a part of a bilge pump 2.3m long; and a section of a sternpost 3.8m long. Structural elements are fastened with treenails of 3–4cm in diameter. The preserved part of the structure is occupied by the cargo, which is mainly represented by wooden casks loaded with iron bars and glass bottles (Bednarz 2015: 5–6).

Figure 2. Glass bottles with tin cups in wood barrel on the site F53.30 (J. Szymonik).

As a result of a completed dendrochronological analysis, it was determined that the wood used for construction of the hull was brought from the western Baltic Sea area. Absolute dating was achieved for 15 wood samples out of the total number of 28 collected for analysis. None of the dated samples had sapwood. The earliest preserved rings in the analysed samples indicate that construction of the ship was conducted no earlier than after the year 1614 (Bednarz 2015: 10).

Figure 3. Tin cup made by Salomon Gieseler from Gdańsk (T. Bednarz).

During fieldwork, a total of 650 artefacts were recovered from the F53.30 wreck. Glass bottles of different sizes and shapes with tin caps constitute the most interesting assembly of artefacts (Figure 2). Ninety-four bottles, ranging from 105 to 245mm in height, were recovered along with over 300 fragments of glass bottles. The majority of recovered artefacts included rectangular bottles in cross-section, although there were also 12 smaller hexagonal bottles in cross-section, with their heights ranging from 105 to 120mm. The discoveries included the total of 329 tin caps of several different sizes and shapes, ranging from 19 to 70mm in diameter. Most were stamped with tinsmith's escutcheons. The hexagonal bottles have caps of 19mm diameter. The bottles with tin caps were transported in 795mm high casks; straw was used inside as additional protection to prevent them breaking. The glass bottles and tin caps are currently being subjected to functional and typological laboratory studies.

Three tin caps are stamped with an escutcheon with a characteristic merchant's mark and Gdańsk coat of arms. The escutcheon has been identified as the mark of Salomon Gieseler who was granted the master's rights in 1655 (Tuchołka-Włodarska 1978a: 83) (Figure 3). The Gieseler's family was a well-known Gdańsk manufacturer of tin goods including monumental sarcophaguses. Most of the escutcheons visible on the caps bear the image of a five-petal rose under a crown with letters 'SG' on both sides, which identifies Salomon Gieseler as their manufacturer. Another discovery on the wreck is a cap with a tinsmith's escutcheon bearing the Gdańsk coat of arms. The marking of this escutcheon has never been recorded before in any sources and has not as yet been published. It is a characteristic merchant's mark with letters 'PS'. The mark has been identified as an escutcheon of Paul Schedelook who was granted the master's rights as a guild tinsmith in Gdańsk in 1657 (Hintze 1923: 51) (Figure 4).

Figure 4. Tin cup made by Paul Schedelook from Gdańsk (T. Bednarz).

In addition, one recovered cap is stamped with an escutcheon bearing an image of a five-petal rose under a crown with a date, which possibly is '1635', written on two of the lower rose petals. In the 17th century, Gdańsk was a well-known centre for Polish goods such as grain, wood and forest goods, which were transported from here to western Europe. Manufactured in Gdańsk, glass bottles with tin caps were also transported goods, and some of them contained alcohol and pharmaceutical products (Tuchołka-Włodarska 1978b: 72; Bogucka 1962: 223). The above findings indicate that the freight or part of it was loaded in Gdańsk's harbour.

Besides the above-mentioned artefacts, two wooden casks, 23 and 28cm in height, loaded with iron bars, staves and casks heads, as well as three iron cannons (1.4m, 1.5m and 2m in length), were raised from the wreck. Two large wooden casks filled with glass bottles with tin tops were also recovered. Some of the collected cask heads remain unidentified in terms of the merchant's marks stamped on them. Moreover, three lead ingots ranging from 87 to 95cm in length and bearing characteristic merchant's marks were discovered at the site. The ingots most likely came from the Olkusz-Kraków deposits in the south of Poland which, until the end of the 17th century, were known as one of the leading European centres of exploitation of lead ore deposits and exported this metal to the whole of Europe. A considerable part of this export was conducted through Gdańsk's harbour after the goods had been transported along the Vistula River. One of the merchant's marks identified on the casts bears legible letters 'PM' arranged in a characteristic way, which initially can be related to Matis Przykelmajer, a merchant operating in the 2nd half of the 17th century, located in Olkusz – Kraków, trading lead along the Vistula route to Gdańsk (Molenda 2001: 124).

Small amounts of grains of rye were discovered in the wreck's keelson area. Another discovery included numerous burning traces visible on some of detached artefacts, such as melted glass, burnt grain and some structural elements.

A total of 166 inventoried and recorded artefacts were recovered, which made it possible to determine a chronology of the object and a provenance of the cargo transported by the vessel. Not all mobile artefacts identified at the site were recovered. At least 30 wooden casks filled with iron bars and at least three iron cannons remain *in situ*.

Analysis of the data collected during fieldwork led researchers to determine that the wreck is a merchant ship from the 2nd half of the 17th century, which sank after the year 1657 following its departure from Gdańsk's harbour with a cargo of casks loaded with iron bars and glass bottles of various sizes and shapes. A fire or an explosion most likely caused the sinking.

In terms of the transported cargo, the 'Glass Wreck' shows certain similarities with the *Aanloop Molengat* wreck from the 1st half of the 17th century, which was found in the area of Texel Island (Holland) and researched in the 1980s (Maarleveld and Overmeer 2012: 119). Considerable numbers of lead ingots from Olkusz deposits in the south of Poland were discovered at this site. Other elements such as tin rolls were traced to an area in Slovakia. The goods, similar to those found at the 'Glass Wreck', were initially transported down the Vistula to Gdańsk where they were loaded onto the ship for transport to one of the western European ports. Both ships never reached their destinations.

In 2017, the NMM research team planned to continue underwater fieldwork on the F53.30 'Glass Wreck'. A period of at least fifteen research days are planned to be spent at the site. The aim is to perform an additional examination of the area surrounding the wreck's structure and also to create another comparative 3D model of the object.

3D Model of the F53.30 'Glass Wreck'

In the course of the fieldwork on the F53.30 'Glass Wreck', detailed photographic recordings were compiled for the creation of a photogrammetric 3D model of the site. Over 18,000 serial photographs were taken, covering the area of the entire site. Each subsequent photo covered 60–80% of the area covered by the preceding photo. The photographs were made from the distance

Figure 5. Ortho-photo plan of the site F53.30. Besides the wood construction, various casks and iron cannons are visible (Archive NMM).

of approximately 1m from the object by moving along and across the site in order to acquire a full coverage of the object. The horizontal visibility underwater did not exceed 1.5m. The photographic recordings were conducted using a Nikon D7000 camera with a Nikkor 10–24 lens in an Ikelite waterproof housing fitted with two Big Blue VL15000PM continuous light lamps, of 15,000 lumens power each. Before conducting the recording, five reference (benchmark) points, with accurately measured distances between them, were placed at the site, which enabled determining their geographic positions in the WGS 84 system.

The photogrammetric 3D model was created by using the Agisoft PhotoScan Professional software, with application of average settings in the subsequent processes to create the Align Photo and Dense Cloud models. Due to a considerable volume of data used for creating the model, it was required to use a desktop computer with specific parameters. The final selection was a computer with two 8-core Xeon processors and 256 GB of RAM.

The PhotoScan software is used to export georeferencing data in the form of a numeric model of the terrain (Digital Elevation Model (DEM)), which makes it possible to create bathymetric plans of wrecks, as well as GeoTiff photo mosaics. This data can be used in the GIS software, such as Global Mapper or Site Recorder, and due to the information contained in the software it is possible to conduct precise measurements, as well as create cross-sections and projections of the site (Bednarz and Różycki, in print). Based on the 3D model of the F53.30 'Glass Wreck', a precise bathymetric plan of the site was created by using the Global Mapper software.

The 3D model of the 'Glass Wreck' provides information regarding precise positions of individual objects on the site, such as cannons, casks and structural elements and equipment of the vessel (Figure 5). A characteristic arrangement of casks and iron cannons is visible at one place. It may be assumed that this arrangement is similar to the original one when the ship was sailing with a stowed cargo. In such a case, it should be assumed that the two cannons between the three casks loaded with glass bottles constituted a part of the cargo (Figs. 6 and 7). The entire space between the casks and the cannons, as determined during fieldwork, was filled with straw in order to secure the cargo. These objects lie directly on the inside panelling of the ship, i.e. on the bottom of the cargo hold. An interesting fact is that the casks visible on the model are half-casks with intentionally hemmed edges of staves. This probably was the condition in which they were loaded onto the ship. To a certain extent, the original arrangement of the goods can be restored by analysing the arrangement of the cargo visible on the 3D model. Small casks filled with iron bars were placed in the keelson area while large casks filled with glass bottles (visible on the model) were placed closer to the sides. Half or full casks alternated with a few iron cannons were used for transporting bottles. The entire cargo had a compact form in which each and every element provided security and stowing for other elements.

Virtual Open-Air Museum of Wrecks in the Gulf of Gdańsk

Since 2013, the NMM in Gdańsk has been developing an innovative method for underwater documentation creating photogrammetric 3D model wrecks from the Bay of Gdańsk. Using that new documentation

Figure 6. Casks with the glass bottles on the two iron cannons—ortho-photo plan of the site F53.30 (Archive NMM).

technique, the *in-situ* archaeological research and recording of three wrecks were accomplished so far.

Photogrammetry has already become a long-standing tradition in the history of underwater research conducted by the NMM in Gdańsk. In the 1980s, photogrammetric recording was used during research of the W-6 *Solen* wreck to create a photo mosaic of the site. Drawings of the *Solen*, which sank in 1627 during the Battle of Oliwa, were then made based on the compiled projection of the site.

The first site recorded with photogrammetry was F53.27 'Porcelanowiec' (porcelain-carrier), which is the remnant of the 20m-long sailing boat made of spruce wood and pine in the first half of the 19th century, which sank after 1853. Fragments of English earthenware vessels, and a brass snuffbox produced in Sweden were discovered on the archaeological site (Bednarz, 2016: 232–33).

In 2014 two successive underwater archaeological recordings were accomplished using innovative methods of documentation. The first was the 30m-long shipwreck F53.14 in the area of the entrance to the port of Gdańsk, the relics of a sailing vessel built of oak. The vessel was made probably in the first decade of the 19th

Figure 7. 3D model showing part of the site—two iron guns visible after removing the casks with glass bottles. The same area of the site as in Fig.6 (Archive NMM).

Figure 8. 3D model of the site available in the 'Virtual Open-Air Museum of Wrecks in the Gulf of Gdańsk' (www.wsw.nmm.pl) and sketchfab.com (Archive NMM).

century, and the wood used in its construction came from eastern Pomerania (Bednarz 2014: 9).

The second of the wrecks documented using the photogrammetric 3D models was wreck F53.31 'Głazik' (stone-carrier) representing the remains of a 15–16m length small sailing vessel with a transom stern, and clinker-built after 1831. To construct the unit, oak growing in Gdańsk Pomerania was used. The ship sank in the area of Gdynia Redłowo, 2.5km from the coast, with a cargo of stones of up to 1m in diameter (Bednarz 2014: 3, 11).

The advantages of 3D photogrammetric documentation of underwater archaeological sites since 2013 in the NMM are:

- Rapidity in underwater photography compared to the traditional method of underwater manual recording;
- High accuracy and details for mapping individual elements;
- The possibility to create models in low water clarity, even below 1m visibility;
- Ability to perform throws, cross and longitudinal sections and create drawings as well as documentation at any point or object;
- Models are currently a form of backup data and can be used to monitor the state of preservation of underwater objects and the changes taking place. The impact of changes from both the environment and human activities can be monitored; and
- Creating visually stunning animations and presentations for exhibitions and educational purposes.

In 2015, NMM has launched the 'Virtual Open-Air Museum of Wrecks in the Gulf of Gdańsk' project, funded by the Ministry of Culture and National Heritage and the museum. This website presents photogrammetric 3D models of wrecks from the Gulf of Gdańsk created in the NMM since 2013. Due to application of specific computer programs of the SfM (Structure from Motion) category, we have developed an effective system aimed at compiling records on this website of underwater objects for which it has been possible to create 3D models. In addition to constituting visually attractive presentations, the models of wrecks, and this is their most significant feature, serve as universal and precise measurement tool used in the field of underwater archaeology. Apart from their aesthetic qualities, the featured 3D models of wrecks constitute careful copies of the objects and make it possible to create sections, projections and animations of any kind. Moreover, the models serve as an effective tool for monitoring and protection of underwater cultural heritage. In the nearest future, we have an ambition to compile archaeological records of all wrecks, both wooden and metal, found on the Gulf of Gdańsk seabed, under the 'Virtual Open-Air Museum of Wrecks in the Gulf of Gdańsk' project (Bednarz, in print).

This website with 3D models of wrecks from the Gulf of Gdańsk, accompanied by their descriptions, constitutes one of the achievements of the project. The models represent careful copies of the actual appearance of the wrecks lying on the bottom of the Gulf of Gdańsk. This is how underwater archaeologists see them in the course of their work, except that the visibility underwater is most often limited to 2–3m, while the 'Virtual Open-Air Museum of Wrecks' website provides a full view for each wreck.

The website now contains thirteen 3D models of wrecks with their descriptions, photo and video documentation. One of them is the 'Glass Wreck' (Figure 8). The objects come from the 15th to the 19th centuries. All wrecks were excavated by the NMM and the artefacts from them now are in the Museum's exhibitions. The website is available in Polish and English. The wrecks can be viewed in three dimensions using virtual reality googles like Google Cardboard or Oculus DK1 or DK2.

By the end of 2018, NMM has plans to post on the website www.wsw.nmm.pl eight more wrecks from the Gulf of Gdańsk and more wrecks in the following years.

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High-resolution Digital Recording Techniques and Taphonomic Trajectories: Multi-image Photogrammetry Applied to a Drowned Late Pleistocene Site in Central Chile (32°s)

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Abstract

Late Pleistocene sites in the Americas provide relevant data for modelling paleolandscapes, studying paleohabitats and available resources, as well as discussing possible migration routes for the peopling of the Americas. However, interpretation of these sites is often hindered by the nature of the evidence recovered—primarily animal bones that are subject to complex formation processes, with no—or extremely discrete—signs of human modification. With the exception of the GNL Quintero 1 site (GNLQ1), evidence of late Pleistocene drowned terrestrial sites dated after the Last Glacial Maximum is very scarce along the Pacific coasts of both North and South America. The site studied herein is located in central Chile (Quintero Bay), where a well-preserved continental fauna bone assemblage was recovered (*c.* 24,800–21,600 BP) with a high taxonomic diversity that includes extinct fauna but also small mammals (Camelidae, Cervidae, Xenarthra, Mylodontidae, Canidae, Rodentia and Myocastoridae). Recently, a 3D mesh model of a section of the site was obtained through diver multi-image underwater high-resolution photogrammetry. These 3D images were used for bone refitting, modification identification, and location within the depositional matrix. Photogrammetry provided a rapid and precise mapping method for *in situ* recording and when coupled with 3D modelling proved to be a powerful tool for interpreting taphonomic trajectories of the bone assemblage. Although 3D models are commonly useful for interpreting wreck sites and other complex structures and artefacts, they can also be successfully applied to the study of drowned Late Pleistocene sites with few visible features.

Keywords

Late Pleistocene, drowned terrestrial site, extinct fauna, 3D mesh model, taphonomy, central Chile

Introduction

While underwater and maritime archaeology has traditionally emphasised the study of historic contexts, work in prehistoric sites are becoming increasingly frequent, and have been referred to in studies of the use of coastal routes in the initial peopling, the use of ancient seagoing vessels, among others (Blanton 1996; Dunbar *et al.* 1992; Faught 2004a, 2004b; Faught and Donoghue 1997; Fedje and Christensen 1999; Fedje *et al.* 2004, 2011; Flemming 2004; Gusick and Faught 2011; Mackie *et al.* 2013).

The difficulties encountered in working in a medium entirely different from any land-based one, combined with formation processes unlike those encountered within traditional sites, has led underwater archaeology practitioners to formulate their own theoretical and methodological frameworks and adapt other techniques on the basis of classic field archaeology. Nevertheless, the excavation of an underwater context is not extremely different from those conducted on dry land; the similarities include the visual record, excavation techniques, sample collection, and planimetric recording, although the limitations of the underwater medium do affect conditions and timeframes of the work undertaken.

One of the main goals of underwater archaeology is to develop a rapid and accurate method for recording drowned archaeological sites using standards similar to those used for terrestrial sites (McCarthy and Benjamin 2014). In this context, multi-image photogrammetry is one of the most effective and cost-efficient methods of 3D documentation in underwater archaeology, as McCarthy and Benjamin (2014) have shown abundantly. Underwater photogrammetry has been used primarily for documenting ancient shipwrecks (Demesticha *et al.* 2014; Diamanti and Vlachak 2015; Drap *et al.* 2015; Erič *et al.* 2015; Yamafune *et al.* 2015; among others), sites with visible features, and objects (Henderson *et al.* 2012; Skarlatos *et al.* 2012).

Nevertheless, in the case of prehistoric sites, it is much less used. However, the technique has been successfully applied at the Mesolithic site of Ertebølle at Faldsled on the south coast of the Danish island of Fyn. There, 3D models were created of a trench located 3m below the surface. The level of detail led to the recording of a 15cm-long Ertebølle hand axe that was lying on the seabed. Indeed, the 3D model provided enough detail to allow specialists to analyse the artefact virtually (McCarthy and Benjamin 2014: figs 3 and 4).

Meanwhile in the Americas, a growing number of studies undertaken in the Canadian province of British Columbia have demonstrated that the exposed continental shelf would have been available for human occupation and may have served as a migration route when sea levels were lower—between 13,500 and 9500 BP (Fedje and Johsenhans 2000; Josenhans *et al.* 1997; Mackie *et al.* 2013). Furthermore, Late Pleistocene to Mid-Holocene human occupations have been confirmed at drowned sites located in Florida (Dunbar *et al.*1992; Faught 2004b; Faught and Gusik 2011; Halligan *et al.* 2016). However, the only site documented by means of multi-image photogrammetry and 3D reconstruction is Hoyo Negro, a large, submerged underground chamber of Outland Cave, located in the Yucatan Peninsula (south-east Mexico), where the paleontological record consists of plant macrofossils and bones (large mammals, bats and fish). Among the animal remains, investigators recovered a variety of taxa, including tapir, puma, ground sloth and gomphotere—the last of which was dated to between 36,000 and 33,000 years BP. Still, the most relevant find corresponds to a female skeleton dated at *c.* 11,000 BP (Chatters *et al.* 2014; González *et al.* 2014). The depth and remoteness of that site meant that specialised documentation techniques had to be employed to achieve a 3D model. Among those recording techniques, divers took photos that were used to create 3D structure-from-motion (SfM) models of the cave, and those 3D digital models have been used for anatomical and taphonomic analyses, as many of the bones have not been removed from the cave (Nava *et al.* 2015).

The GNL Quintero 1 site (GNLQ 1) is the only documented Late Pleistocene drowned terrestrial site along the Pacific Coast of South America (Figure 1). Located in central Chile (Quintero Bay), the site yielded a well-preserved continental fauna bone assemblage (*c.* 24,800–21,600 BP) with a high taxonomic diversity that included not only extinct fauna but also small mammals (Camelidae, Cervidae, Xenarthra, Mylodontidae, Canidae, Rodentia and Myocastoridae) (Carabias *et al.* 2014; Cartajena *et al.* 2013; López *et al.* 2016a and b). The site has a high degree of integrity and provides high-resolution contexts. In this paper we present the results of the first 3D mesh model achieved through a diver-based multi-image underwater high-resolution photogrammetry applied to a drowned Pleistocene site. Open-air Late Pleistocene sites generally do not exhibit visible structures and are primarily composed of scattered bone and lithic assemblages. The interpretation of these sites is often difficult due to complex formation processes affecting site integrity and associations, the sampling and quality of the data, and the frequent absence or discreteness of signs of human modification. In this context, the taphonomic studies are crucial for interpretation when the agents and/or processes affecting sites are difficult to identify (Bonnichsen 1982; Borrero 2015, 2016; Dillehay 2009; Stewart 1999).

Multi-image photogrammetry is a very versatile tool and can be used to take measurements, create traditional plans and sections of underwater archaeological sites, employ surface analysis techniques that allow details to be enhanced, perform virtual fly-throughs, site reconstructions, and undertake dissemination and artefact analyses (Demesticha *et al.* 2014; Drap *et al.* 2015; McCarthy and Benjamin 2014; Yamafune *et al.* 2016; among others). For the GNLQ1 case in particular, multi-image photogrammetry was used for detailed micro scale analysis, in which we explored this tool's potential for interpreting taphonomic trajectories of the bone assemblage by using 3D images for bone refitting, identification of modifications, orientation, and location within the depositional matrix.

Site GNL Quintero 1 (GNLQ1)

Quintero Bay (32° S, central Chile) is an active harbour with major energy, mining and industrial infrastructure. The site is located *c.* 650m offshore and 13m underwater and yielded a well preserved continental fauna bone assemblage. The bones identified show a high taxonomic diversity of extinct

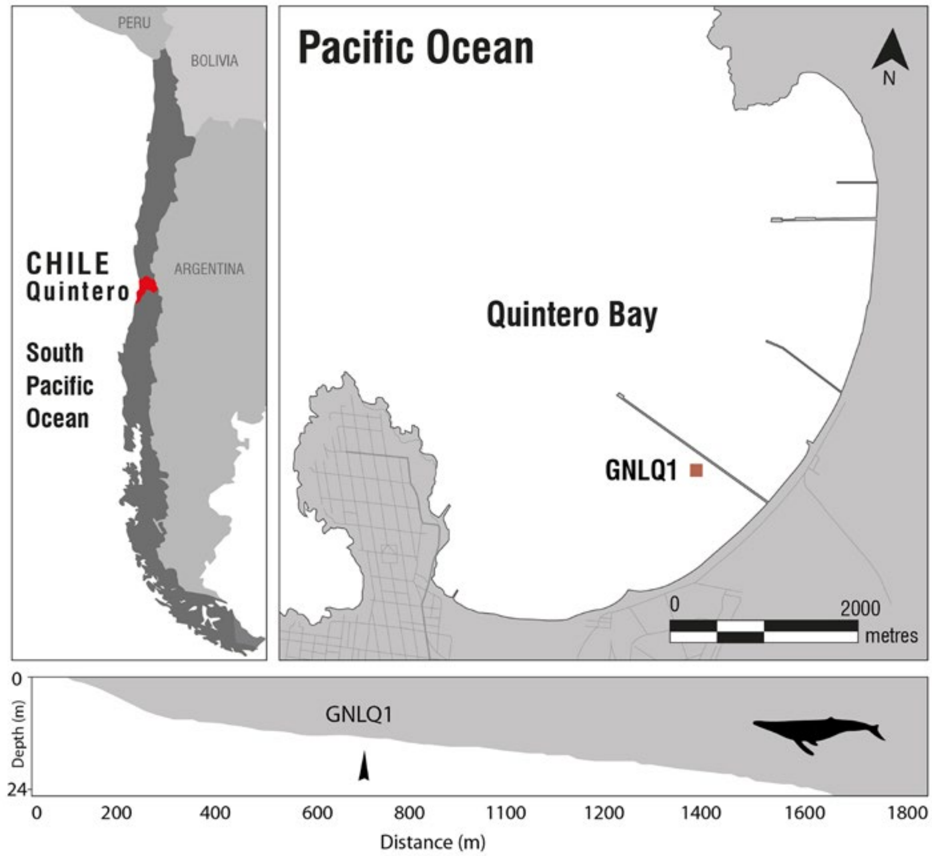

Figure 1. Location map of the study area in Quintero Bay, central coast of Chile. Bathymetric profile of the area with site GNLQ1.

terrestrial megafauna, including Camelidae (cf. *Palaeolama* sp. and cf. *Lama gracilis*), Cervidae, Equidae (*Equus [Amerhippus]* sp.) , and Xenarthra; but also included smaller animals such as a red-fox , (*Lycalopex culpaeus*), coypus (*Myocastor coypus*), rodents, fish, and birds. The minimal number of individuals is 26, with a high representation of megafauna but also small fauna (López *et al.* 2016a). Originally, the site would have been situated several kilometres inland, as the paleoshoreline was farther out on the continental shelf, close to the 90m isobath (≤ 5km). This hypothesis is consistent with the taxonomically homogenous composition of the assemblage of vertebrate fossils and the absence of marine resources in the record (Carabias *et al.* 2014; López *et al.* 2016a and b). The bones are embedded in a clast-supported clayey gravel matrix characterised by gravel-sized highly resistant rounded masses (composed of fine sand and clay in a sandy to clayey matrix). The sedimentary matrix and geomorphological analyses suggest that the site developed in a low energy fluvial continental environment, possibly a floodplain. Nineteen skeletal elements and molars of various taxa were directly dated by AMS-radiocarbon using the bioapatite fraction, reporting ^{14}C ages between 19,280 ± 40 and 24,890 ± 70 BP. The organic fraction of the sedimentary matrix containing the bones was also 14C dated at 13,640 ± 40 BP López *et al.* 2016b: table 1). Ongoing sedimentary analyses and new dating were performed in order to understand this chronological gap between the sedimentary matrix and the bones.

Methodology

The specific bathymetric position of site GNLQ1 on the upper shore-face under the influence of wave action would have prevented sediment deposition. Today, the site is located in a transitional area between the tidal (9m) and normal (12m) climate wave zones. The upper shore-face environment is under the continuous influence of wave action and experiences predominantly south-westerly winds. This medium to high energy environment enables a thin protective layer of modern sand to exist and occasionally exposes the Late Pleistocene deposits during storms. This in turn facilitates site visibility and identification through diver-based operations and remote sensing.

The excavation covers a surface of 13m^2 representing nearly 20% of the estimated surface of the site (64m^2). The excavation was carried out using a 3” induction

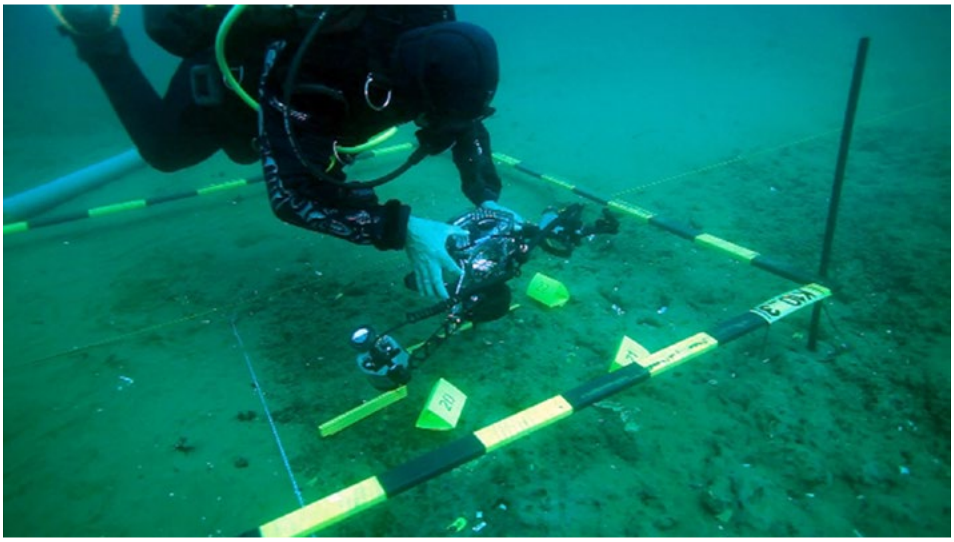

Figure 2. Diver performing targeted photo coverage of individual bone assemblages. These have been previously discriminated and tagged within the excavation unit (2x2 m) by quadrants (R. Paredes-Rosales).

water dredge and the material excavated was deposited first in a 6.5mm holding basket underwater. Skeletal remains were exposed by careful excavation using *in situ decapage* techniques and recovered with their sedimentary matrix in order to be microexcavated in the laboratory.

The surface layer of unconsolidated modern sands was removed and the sedimentary matrix containing the bones exposed. A pre-disturbance 3D model of a section of the site was generated through diver multi-image underwater high-resolution photogrammetry. Photogrammetry provided a rapid, accurate mapping method for recording *in situ* the faunal assemblage distribution and its depositional context. The discrete concentrations of bones were numbered as assemblages No.1 to 33.

For the photogrammetry process two recording levels were applied. A general aerial survey along parallel strips with high overlaps (~ 70% in both axis), and an individual bone assemblage aerial survey, around each bone discrete concentrations. For coverage of both, a Canon EOS 5D Mark II camera housed in an IKELITE housing was used with tow sub strobes Inon Z240 Type IV with a diffuser. A 20mm Standard lens and a 50mm Macro lens were used, respectively (Figure 2).

The general survey covered an area of 13.2m^2 using nine marked parallel baselines, from a height of *c*. 1.45m, applying a shutter speed of 1/100$_{th}$ of a second, at F/9 aperture and ISO 400. The individual bone assemblages survey was performed from a height of *c*. 0.5m all around the finds, applying a shutter speed of 1/125$_{th}$ of a second, at F/18 aperture and ISO 400.

Trilateration of a network of control points was achieved using Site Recorder 4 (SR4). The three-dimensional models were developed using Agisoft PhotoScann 1.2.6 and Acad Map 3D 2014 was used to enhance bone assemblage recording. The 3D dense point cloud was covered with texture from the original photographs for analytical purposes.

Even though the use of strobe or flash can cast shadows and these will be different in each image and therefore could affect feature matching and model texture (McCarthy and Benjamin 2014), these outputs will depend on site conditions. GNLQ1 has a very homogeneous topography, and good visibility conditions are not extremely rare. These two factors combined with an experienced underwater photographer, familiar with the use of strobe and divergent underwater lighting, enable the use of strobe, minimising shadows and the backscatter, without losing sharpness and colours in the result.

In previous works, different taphonomic modifications were taken into account, affirming that the total assemblage is slightly to moderately abraded according to the stages proposed by Cook and Trueman (2009). Although the bones are not heavily abraded, abrasion covers both surfaces, suggesting long-term *in situ* abrasion, which probably resulted from low-energy water flowing through the sediments during the continental phase (terrestrial-based processes occurring in a probable floodplain environment during the Last Glacial Maximum). However, abrasion could be also attributable to the action of abrasive marine sediments during the marine phase (maritime-based processes occurring in a shallow water environment

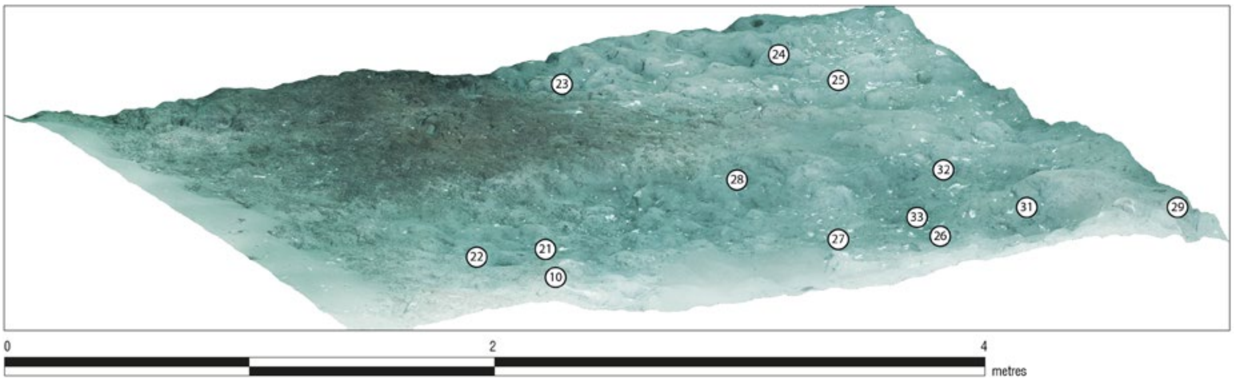

Figure 3. 3D mesh model of a section of the site generated through photogrammetry with the position of bone several assemblages.

subsequent to sea-level transgression during early post-glacial times) (López *et al.* 2016a).

In this study, we address abrasion using the indicators proposed by Fernández-Jalvo and Andrews (2003), who provide guidelines for interpreting abraded bones. Those authors maintain that characteristic differences can be identified in abrasion caused by several types of sediment (coarse to fine) and involving different types of bone (fresh, dry, weathered or fossil). To this end, we chose bone remains whose exact position in the 3D model plan was known. These nineteen samples were analysed on two faces—the one exposed to wave action and the other in contact with the sedimentary matrix. Scanning electron microscopy images (300x and 400x) were taken, and compared with the abrasion patterns proposed by Fernandez-Jalvo and Andrews (2003), in order to determine the possible differences related to their location in the matrix, potential abrasive agents, and modifications caused by the abrasion.

Mechanical refitting of fragmentary bones and anatomical refitting of skeletal segments (mechanical, bilateral and intermembral) (Waguespack 2002) was undertaken using non-metric attributes for the most common taxa (Pavéz 2017). Mechanical refitting consists of connecting two or more fragments of the same element or skeletal part, which involves joining two fracture planes or connecting a positive and negative in the case of medullar and/or cortical detachments (Fernández-Laso 2010). It is therefore important to identify fractures caused to fresh, dry bones, as the fractured surfaces display different features (Johnson 1985). In the case of bilateral correspondence, left and right elements were identified based on the principle of bilateral symmetry (Lyman 2008). Finally, intermembral union consists of refitting contiguous joints from the same individual (Fernández-Laso 2010). Bone refitting was divided into two stages (Morin *et al.* 2005); the first was refitting of specimens within each assemblage, while the second involved refitting bone specimens among different assemblages and excavation units (López *et al.* 2016a; Pavéz 2017). During refitting, the 3D models of both the site itself and specific bone assemblages were used, thereby allowing the individual bones to be identified in their original depositional context prior to excavation, especially when the remains were highly fragmented.

Results

The high resolution of the photogrammetry and the resulting 3D models allowed us to describe the micro topography of the sedimentary matrix. The micro topography consists of an irregular surface with multiple depressions, characterised by a sandy to clay matrix with agglomerates visible on the plan (Figure 3). It can be observed that the matrix is not homogenous, and is intercalated with gravel-sized highly resistant rounded masses composed of fine sand and clay with evidence of oxidation and carbon residue (Carabias *et al.* 2014). The bulk of the bones show iron oxide staining (Cartajena *et a*l. 2013; López *et al.* 2016a). As the figures show, the red-orange stains observed on the bones are directly related to the reddish agglomerates within the sedimentary matrix in contact with the bones. Further analysis is needed to confirm whether or not the high percentage of oxidative staining can be explained by the interaction of the bones with the sedimentary matrix, notably its ferrous elements.

A complete mandible of a now-extinct Cervidae was recovered (Figure 4) as well as a metapodial diaphysis from a small-sized camelid (Figure 5). Despite being completely fractured, these items were very well preserved in the sedimentary matrix. Their edges were moderately rounded but could be refitted, suggesting that the bones were only slightly weathered, as rounding is much more prevalent among heavily weathered bones (Fernández Jalvo and Andrews 2003).

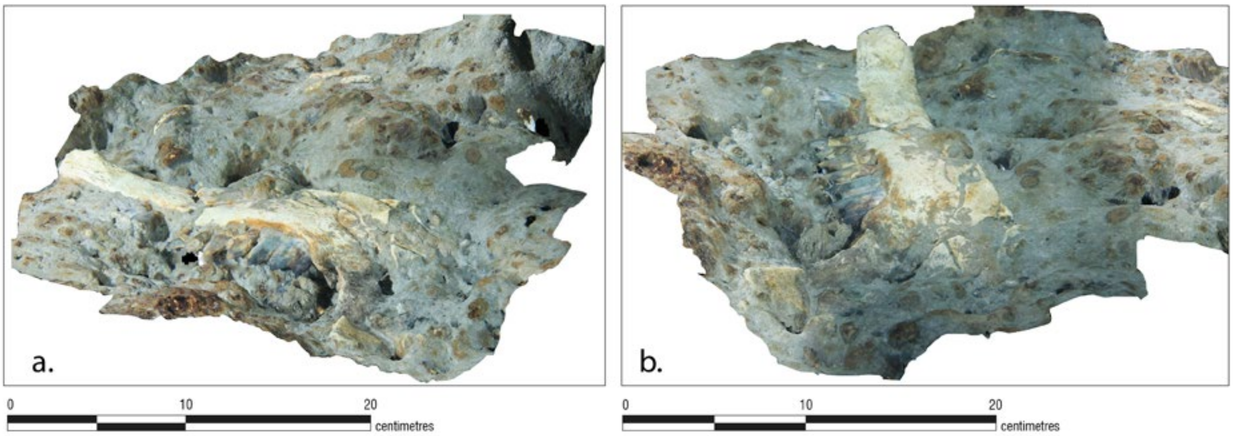

Figure 4. 3D models of assemblage No. 10: an extinct deer mandible. a) The image is realistic and visually appealing. b). The depositional context of the bone embedded in the matrix is apparent.

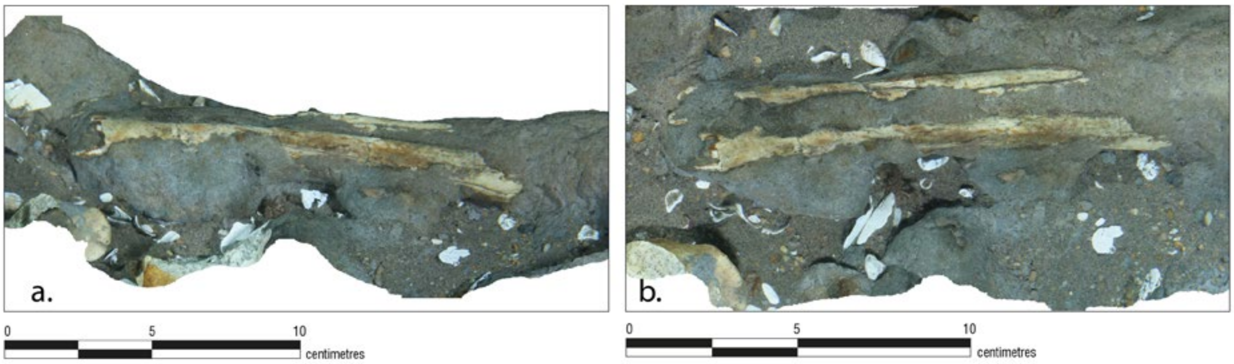

Figure 5. 3D models of assemblage No. 26: a small size camelid diaphysis; a) Axonometric view; b) Horizontal plane view.

The fragments embedded in the matrix had remained *in situ*, suggesting that the depositional environment was stable. However, as soon as the bones were exposed to hydrodynamic activity, the fragments became detached from the matrix.

SEM images acquired do not feature a single apparent pattern. Instead, some display a coarse sand pattern that is probably more connected with the effects of marine abrasion on bones, once they become exposed (Figure 6c). Others, however, display isolated polished and flattened patches—both on the face of bones found in contact with the matrix and on the exposed surfaces of weathered bones (Figure 6b)—that are consistent with the pattern produced by fine sands and silts and the composition of the sedimentary matrix. This kind of abrasion is more likely related with long term *in situ* abrasion during the terrestrial phase, as noted above.

On the exposed sides of the bones fewer marks or modifications are preserved, as prolonged abrasion and/or exposure tends to rub out those marks. As in the case of the deer mandible, marks can be observed right at the edge of the two faces, and are sharper toward the bone's zone of contact with the matrix (to the right) (Figure 6d). This can also be observed on the contact face of a distal humerus (cf. Palaeolama), where a group of marks can be easily identified. But the nature of those marks and the agents that produced them are still being analysed.

The refitting at the intra-assemblage level yielded a total of 1059 mechanical refits and four intra-membral joints. An example of this stage was the mechanical refitting of a highly fragmented metapodium of cf. *Lama gracilis*, which was refitted using the photographs of the bone on the plan, as well as the 3D model of the site. Fifty-two inter-assemblage refits were also performed, five of which correspond to intermembral joints and 47 to mechanical refittings, in which the Autocad 3D Map site plan was very useful for identifying the position of the fragments to be refitted and for measuring the

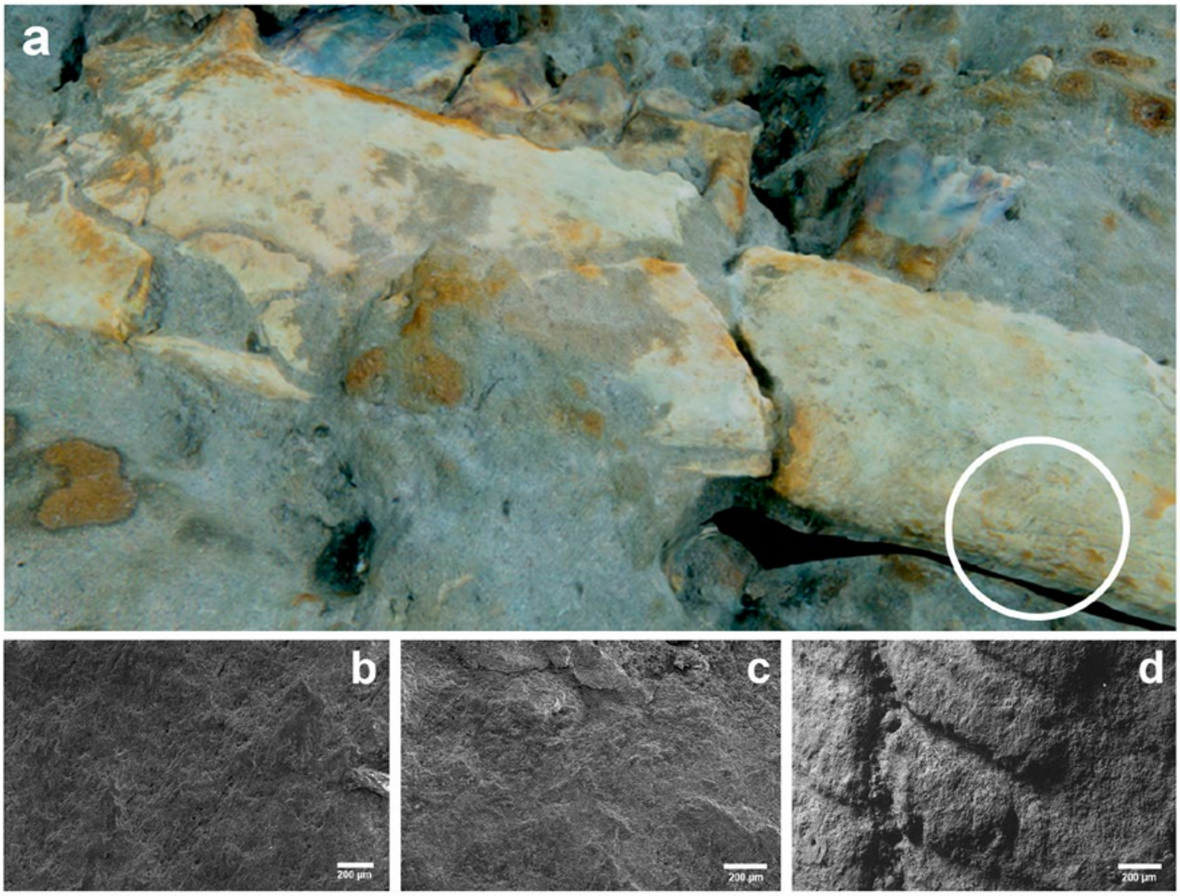

Figure 6. Partial 3D model of an extinct deer mandible; a) The circle encloses marks located on the edge; b) SEM image depicting smaller polished and flattened patches (x 400); c) SEM image depicting larger polished and flattened patches (x 400); d) SEM images detailing sharper marks (x 250).

distances among them. The use of high resolution digital recording techniques contributed to the identification of the specific position of bone remains at the site, even of very small specimens; it was also instrumental in reconstructing anatomical elements by means of bone refitting, as the 3D model of the site facilitated the search for fragments of the same bone element based on such aspects as morphology and colour changes in the cortical surface of the bone.

Conclusions

The use of high-resolution digital recording techniques enabled the first-ever documentation of the plan of a Late Pleistocene site drowned after the LGM and containing animal bone remains but no visible structures or other features. The multiple fly-throughs employed allowed the site to be virtually analysed, while the assemblages identified could be virtually rotated, which allowed in-depth analysis of the location of the remains in the sedimentary matrix.

On the one hand, while most of the remains are fragmented, many of them could be reassembled, which suggests that the matrix was stable. However, once exposed to hydrodynamic and wave actions, the loss of detached material increases considerably. These accelerated deterioration processes are indirectly attributable to human activity, particularly the modification of the depositional environment due to industrial activities taking place in the nearby harbour. The 3D recording of the site plan enabled us to monitor the long-term effect on the exposed matrix, while also taking into account seasonal variations in wave action and their impact on the site. Once uncovered, the bones were rapidly subject to physical, chemical and biogenic alterations including abrasion, which was observed in some of the exposed faces and was linked to marine abrasion and coarse sand particles. Furthermore, the greater the abrasion, the more likely it was that any marks on the bone fragments were erased over time. This was demonstrated by comparing marks found on exposed faces with those found on faces still embedded in the sedimentary matrix.

Multi-image photogrammetry provides an opportunity for accurate, multi-scale analysis. At the micro scale, these tools proved especially adequate for investigating

Late Pleistocene contexts when combined with other techniques. Further applications might include micro-stratigraphy analyses to address complex site formation scenarios, differentiate depositional events and contribute to understanding processes such as re-sedimentation, which could explain the chronological differences between the sedimentary matrix and the dates obtained for the bone remains.

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The Role of 3D Representations in the Interpretation and *in Situ* Preservation of Archaeological Heritage: The Case of the Building with Porticoed Courtyard of the Portus Iulius in Submerged Baiae (Pozzuoli, Naples)

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Abstract

Archaeologists and conservators have always largely relied on visual spatial representation in the process of recording, analysing and interpreting archaeological evidence and in assessing archaeological heritage. Site plans, artefact drawings and other visual aids have always assisted the analysis of archaeological sites and artefacts.

The innovations in computer vision and optics are offering archaeologists and conservators new and empowering tools for recording the submerged resource. Such tools possess a large potential for acquiring information about sites and artefacts, which help with planning activities, interpreting the archaeological evidence, monitoring site deterioration, as well as planning conservation and preservation programmes for the underwater archaeological heritage. Since 2009, the Italian *Istituto Superiore per la Conservazione e il Restauro* (now Istituto Centrale per il restauro (ICR)) in the frame of the project '*Restaurare sott'acqua*—Restoring Underwater'—has invested resources in the development of three-dimensional underwater scanning systems to plan and document conservation works on underwater archaeological structures. A trial of Computer Vision Photogrammetry (CVP) and Underwater Laser Scanning (ULS) on a portion of the Building with porticoed courtyard of the Portus Iulius in the archaeological submerged site of Roman Baiae (Pozzuoli, Naples), funded by ISCR and supported by the Honor Frost Foundation 2015 Grant Award, offered the opportunity to advance some ideas on the potentials of these recording techniques in attempting to incorporate such tools within the interpretive and *in situ* preservation analysis processes of a submerged archaeological site.

Keywords

three-dimensional model, archaeological interpretation, *in situ* preservation, submerged Baiae

Introduction

Archaeology largely relies on visual spatial representations in the process of recording, analysing and interpreting the archaeological evidence (for a critique, see Thomas, Oliveira Jorge 2008; Thomas 2008). Also, archaeology growingly relies on computing technology to acquire, process, manage and share both raw data and their interpretations (for a critique, see Dallas 2007, 2015a, b; Huggett 1995, 2004, 2012). The typology and quality of technological devices available for recording on land and underwater have increased significantly in recent years. Due to constraints of the physical environment and the economies of the underwater work, underwater archaeology has always welcomed technological innovations. In this process of technological acquisition, the innovations in computer vision and optics are now offering underwater archaeologists and conservators new and empowering tools for imaging and recording archaeological remains, to assess the state of preservation and document conservation activities. While the potential of these recording devices and techniques is unquestionable, there is a continuous need to assess and validate devices and procedures in order to understand their more suitable use and limitations more fully (Chrysanthi *et al.* 2012 a, b; Dallas 2015 a, b).

It is accepted that archaeology is a destructive activity, particularly where excavation is concerned. From this very observation derives the inescapable requirement for thorough documentation of the archaeological record as well as of the archaeological process itself. Time and spatial information are essential for the interpretation of the preserved archaeological record. In addition, the spatial relations between individual components of an archaeological site and between the site and its surroundings—its 'context'—are essential to enable archaeologists to reconstruct the significance of the site itself, understand the state of preservation and retrace the site formation processes, including the processes and social actions represented by the archaeological remains (Barceló 2002). Moreover, all the conservation process phases (analysis, first aid interventions, restoration works, etc.) demand high precision of documentation and recording results. Therefore, the ability to acquire three-dimensional models of archaeological structures is paramount for *in situ* preservation, as it enables conservators to monitor changes in the structural remains and processes affecting the archaeological evidence. Furthermore, there is a necessity to limit costs for the documentation, which, in the past, have frequently consumed a significant portion of the time and budget of an underwater excavation or conservation/restoration project.

Since 2009 the Italian ISCR, within the framework of the '*Restaurare sott'acqua*—Restoring Underwater' Project (Petriaggi 2005, 2008), has variously tested photogrammetry for the documentation processes of the *San Pietro in Bevagna* shipwreck (Petriaggi and Davidde 2010), a bath of the *Villa con Ingresso a Protiro*, a portion of the wall from the *viridarium* of the *Villa dei Pisoni* in Baiae in collaboration with the University of Calabria and (Gallo *et al.* 2012) to document and monitor the experimental cleaning operations in submerged Baiae (Bruno *et al.* 2013) . Moreover, since 2011, the ISCR has invested resources in the development of three-dimensional underwater scanning systems to plan and document conservation works on underwater archaeological structures (Davidde Petriaggi *et al*. 2014; Davidde Petriaggi and Gomez De Ayala 2015). Within the frame of this technological acquisition process, a collaboration between the ISCR and the Università degli Studi di Sassari—supported by the Honor Frost Foundation 2015 Grant Award—also allowed the production of a series of recording tests, employing a combination of Computer Vision Photogrammetry (CVP) and Global Positioning System/Global Navigation Satellite System (GPS/GNSS), in order to record a portion of the Building with porticoed courtyard of the Portus Iulius in the submerged site of Roman Baiae (Pozzuoli, Naples). This paper will present the experience developed by the ISCR over the years, including the above-mentioned trials of photogrammetry and laser scanning applied to a shallow water site.

Historical and archaeological background

Located at the northern end of the wide Naples' Bay, Baiae was a famous seaside town much prized in antiquity for its temperate climate, beautiful setting and the properties of its mineral waters, which have been exploited at least since the 2nd century BC. It was one of the most popular resorts among the Roman aristocracy and the Imperial family (such as Pompeius the Great, Marcus Antonius, Julius Caesar, Augustus, Caligula, Nero, Hadrian, Septimius Severus and the list goes on) up until the end of the 4th century AD, when several geological phenomena—particularly bradyseisms — caused the submersion of some areas of the city. A steady settlement of the area is testified in 770 BC, with Pithecusa (modern Ischia) as a port of call, and by the foundation of Kyme (present day Cuma), the first Greek colony in the western Mediterranean. During the 6th century BC, Cuma confronted the Etruscans, while in 194 BC the Romans founded the city of Puteoli (present day Pozzuoli) in the area of the Greek site of Kyme. In the wide territory of the Campi Flegrei (Phlegrean Fields), ancient Baiae represented for centuries the holiday and recreation centre for the Roman aristocracy, thanks to its mild climate, healthy air and the existence of a rich system of thermal waters. Since the 1st century BC, the Roman Republican aristocracy and then the élites related to the Imperial court (Tocco Sciarelli 1993: 18) started building sumptuous maritime villas, often supplied with fishponds for breeding fish (Benini 2004), while the beginning of the crisis of the Roman Empire around the 3rd century AD brought the abandonment of the area. A series of natural and cultural contributory causes led to the decline of Baiae, namely the decline of the empire together with the effects of bradyseismic phenomena leading to the submergence of large portions of the inhabited area, at least since the end of the 3rd century AD (Benini 2004: 36; Zevi 1983: 13).

Through the millennia, the original archaeological complex has been submerged and a great part of the archaeological remains of Roman Baiae are presently underwater. The archaeological remains lay underwater along the current coastline, while the Roman coastline is today submerged at a distance of around 400 to 500m from the modern one. The submerged portion of the archaeological site of Baiae extends from the modern residential area of Pozzuoli to the south, to Capo Miseno to the north, where numerous remains of structures representing thermal baths, maritime villas, fishponds, and the renowned nymphaeum of Emperor Claudius are preserved.

The first underwater archaeological research programmes were developed in 1959 by Italian archaeologists Nino Lamboglia and Amedeo Maiuri, with the ambitious plan to thoroughly investigate the area of *Punta dell'Epitaffio*. Unfortunately, the lack of funding and bureaucratic hurdles brought the project to an untimely abandonment. More than twenty years later (1981–1982), the site was investigated by archaeologists Piero Alfredo Gianfrotta, Bernard Andreae and Fausto Zevi in collaboration with the *Soprintendenza Archeologica per le Provincie di Napoli e Caserta* and the collaboration of the *Centro Studi Subacquei* in Naples (Andreae 1983a, b; Gianfrotta 1983; Tocco Sciarelli 1983). The archaeological excavation of the nymphaeum of Punta dell'Epitaffio uncovered the entire structure of the Claudian nymphaeum and several statues (Gianfrotta 1983; Andrae 1983b). In the second half of the 1980s, the commendable commitment of a group of volunteers produced the extended survey and mapping of the archaeological remains of submerged Baiae (Di Fraia 1993; Lombardo 1993a, b; Scognamiglio 1993, 1997, 2002, 2006). Finally, an important step towards studying, understanding and protecting the archaeological site was achieved at the dawn of the new millennium. On 7 August 2002, a joint effort between the Ministry of Environment and Land Conservation, the Ministry of Cultural Heritage (now Ministry of Cultural Heritage and Activities and Tourism – MiBACT), the Ministry of Transport, the Ministry of Agricultural Policies and the Regione Campania, enacted an *ad hoc* legislation (D.M., 7 August 2002) establishing the Marine Protected Area-Underwater Park (MPA-UP) of Baiae.

The involvement of four Ministries and a Regional Government represented an important step towards safeguarding a highly significant archaeological site. The MPA-UP is today located off the north-western coasts of the bay of Puteoli (Naples), in the littoral zone between the southern limit of the port of Baiae and the dock of Lido Augusto.

The MPA-UP has an area of about 176.6 hectares and works to protect not only the archaeological remains of the Roman city and the infrastructures of the Roman harbour known as Portus Iulius, but also represents an underwater area of great environmental value. Environmental aspects of this area are related to a peculiar volcanic and deformational history. As we said above, since antiquity this coastal region has been subject to bradyseismic phenomena, both positive and negative. Due to these geological effects, the remains of the Roman period are now submerged to a depth ranging between 1 and 14/15m below the sea level, acting as an artificial reef for sea life.

Over recent years, the *Soprintendenza Archeologia di Napoli* has been the responsible authority of the MPA-UP, although in 2018 this responsibility has moved to the *Parco Archeologico dei Campi Flegrei* acting as the new *Autorità di Gestione* (Managing Authority, MA). The MPA-UP of Baiae has today at least five archaeological-environmental itineraries, which are open to a diversified public of divers and non-divers, thanks to glass-bottomed vessels. The MA authorises local diving clubs to bring underwater divers to the submerged city. The currently open underwater itineraries are 1) the *nymphaeum* of *Punta dell'Epitaffio*; 2) the *Villa con Ingresso a Protiro*—Villa with vestibule; and, 3) the Villa dei Pisoni, 4) Portus Iulius, and 5) the '*Secca Fumosa*'.

Within the project 'Restoring Underwater', the ICR has over the years focused interventions on few specific areas (Petriaggi 2005, 2008). The reason for a selection appears obvious: in the first place, the area is so vast that a thorough commitment would have been impossible in both economical as well as human resources terms; in the second instance, the ICR decided to focus on those areas that had already been open to the public, in order to counter-balance eventual stresses caused by visits and continuously monitor the state of preservation of the remains, as well as to enhance the appeal of the underwater trails while experimenting with conservation techniques and materials (Petriaggi and Mancinelli 2004; Petriaggi 2005, 2008; Petriaggi and Davidde, 2005, 2007, 2008, 2010). Among these was the area of the Portus Iulius, the harbour commissioned by Marcus Vipsanius Agrippa from the architect Lucius Cocceius Auctus in honour of Gaius Julius Caesar Augustus, during the civil war between Octavian and Sextus Pompey (37 BC). The port was intended to host the Roman fleet, while its construction assured the connection between the sea, Lake Lucrine and Lake Avernus via a navigable channel and to Cumae by a 1km-long underground tunnel through which chariots could pass. Nonetheless, the military life of Portus Iulius was short due to the silting of the basin and in the year 12 BC the imperial fleet was moved to the nearby natural harbour of Miseno, while Portus Iulius was converted to a commercial harbour (Gianfrotta 2012a, b) (Figure 1).

As previously mentioned, since 2009, the ISCR, within the framework of the project 'Restaurare sott'acqua—Restoring Underwater', has invested resources in

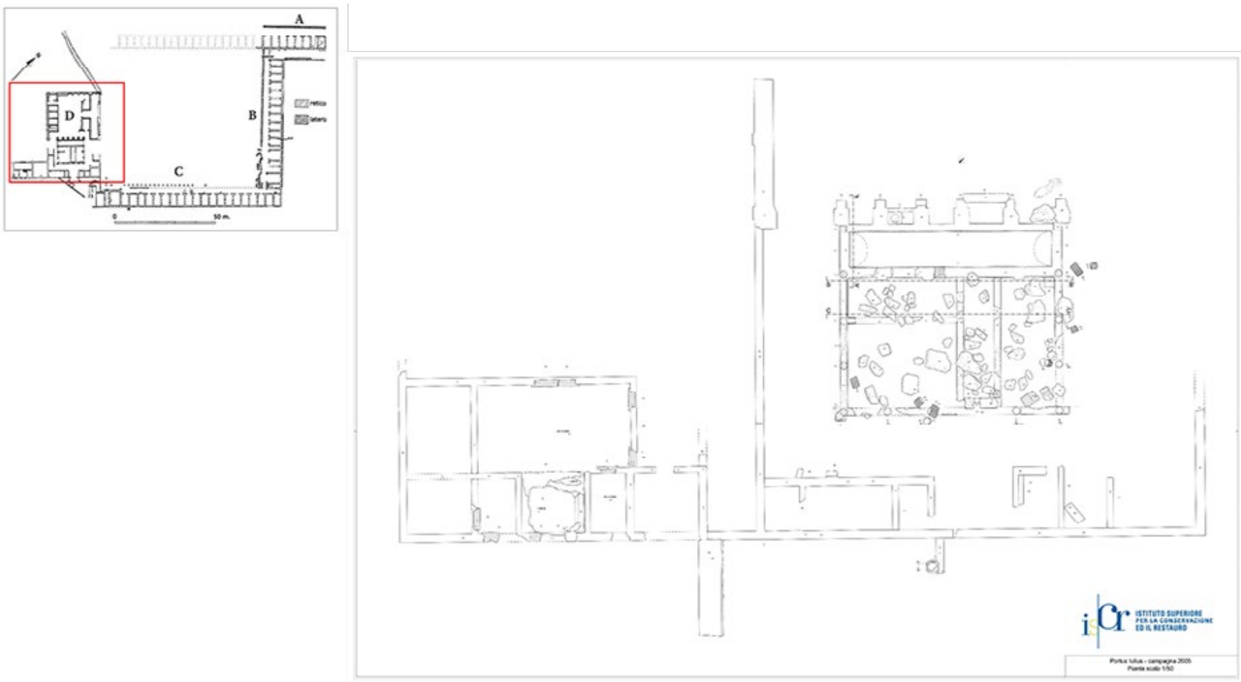

Figure 1. Submerged Baiae (Pozzuoli, Naples). Left: area of Portus Iulius with the Building with porticoed courtyard (D) in (Gianfrotta 2012b, p. 3 fig. 2). Right: drawing of a portion of the Building with porticoed courtyard as documented in 2005 during the ICR restorations works directed by Roberto Petriaggi (© ICR).

the development of three-dimensional underwater survey and scanning systems to plan and document conservation works on underwater archaeological structures (Davidde Petriaggi *et al.* 2014; Davidde Petriaggi and Gomez De Ayala 2015). A major part of the ISCR Project is devoted to the development of a documentation system of the restoration works with the realisation of SAMAS documentation system and the GIS *Baia sommersa* (Petriaggi and Davidde 2005).

Three-dimensional techniques applied: case study the Building with porticoed courtyard (domus?) of the Portus Iulius in submerged Baiae (Pozzuoli, NA)

It has been suggested that submerged Baiae could become a training and testing ground in underwater archaeology for local and international participants, similar to what has been happening in Pompeii (Stefanile 2014: 218–19). This is in fact already happening in Baiae. The commitment of the ISCR to experimentation in technologies, techniques and methods for the survey and conservation of underwater cultural heritage in the submerged Roman town makes the site an outstanding case study. Due to the specific requirements of *in situ* conservation interventions in the underwater environment (the need to precisely plan activities in advance to optimise time spent underwater and reduce costs, acquire precise understanding of the site's extent, geometry and characteristics), implementation of tools and techniques that can ensure a metrical accuracy coherent with the objectives of the conservation activities are required. The same considerations apply to the phases of the underwater archaeological investigation (i.e. assessment and recording surveys). In order to investigate and validate three-dimensional recording of *in situ* underwater cultural heritage, the ISCR has committed to experimenting 3D tools and techniques. This paper attempts to present the experimentations produced with underwater photogrammetry connected with a GPS/GNSS survey and the underwater laser scanning survey conducted with the Naumacos WIRscann, a device developed by the Naumacos Company.

A grant from the Honor Frost Foundation enabled the appointment of Massimiliano Secci, whereby the collaboration between the latter and Barbara Davidde, director of the *Nucleo per gli Interventi di Archeologia Subacquea* (Underwater Archaeology Unit) at the ISCR, under the surveillance of the *Soprintendenza Archeologia di Napoli* and the collaboration with the *Parco Archeologico dei Campi Flegrei*, allowed us to conduct a preliminary survey testing implementing a connection of underwater close-range, multi-image photogrammetry and a GPS/GNSS survey. The area chosen for the test is represented by a portion of the Building with porticoed courtyard (domus?) of the Portus Iulius, where the ICR over the years has conducted several restoration

Figure 2. The photogrammetric model of the portion of the Portus Iulius produced with Agisoft® LLC PhotoScan (Data capture and elaboration Massimiliano Secci).

campaigns. The site is characterised by several adjacent rooms enclosed by walls in *opus reticulatum*, some of which are still standing, while others have collapsed.

Prior to recording the area, it was imperative to create a set of relevant points on the seafloor that would be successively recorded by means of both photogrammetry and GPS/GNSS. The specifics and considerations related to establishing a set of control points have been thoroughly described by Kotaro Yamafune, Rodrigo Torres and Filipe Castro (2016) in a recent publication. In Baiae, a set of nine Ground Control Points (GCPs) were positioned around and within the site to act as reference points for both the photogrammetric and the GPS surveys.

Following the establishment of a network of GCP, the points were recorded with both the GPS/GNSS (a GeoMax Zenith 10, 72 channels) mounted on a custom-built fiberglass floating raft (see Secci *et al*. 2017), which allowed moving of the rover antenna of the GPS/GNSS system over the site and on the vertical position of the point to be recorded. As the floating raft's working principles have been described elsewhere (Secci *et al.* 2017) we refer readers to that publication for further information. In brief, the system allows projecting the points recorded on the seafloor on their zenithal position on the sea surface, where the GPS/GNSS rover antenna is positioned on the floating raft. The GCPs were then recorded by means of GPS and Direct Survey Method (DSM), in order to be able to confront the two recording systems. The chosen portion of the site was then thoroughly photographed with a Sony® Alpha 57 SLR camera with a Tokina® AT-X 116 Pro DX AF 11–16mm f/2.8 lens, in an Ikelite® underwater housing with an eight-inch Dome Port.

The photographic data has been elaborated within the proprietary software Agisoft® LLC PhotoScan in order to produce a series of deliverables useful to further representations and analysis (Figure 2). The analytical results of the experimentation with photogrammetry and GPS/GNSS survey have been preliminarily analysed elsewhere (Secci *et al.* 2017). This paper focuses on a series of hermeneutical considerations regarding the implementation of three-dimensional techniques for acquiring spatial data and visual representations of *in situ* underwater cultural heritage. Before attempting to present these considerations, we would also like to briefly present a series of tests carried out by the ISCR with a three-dimensional underwater laser scanning system.

The underwater laser scanner was developed in 2007 by researcher Gabriele Gomez de Ayala, optimised over time and first employed by the ISCR in 2009. In 2011 the ISCR underwater archaeology operation Unit tested the Naumacos L1 scanning system to document a room, paved in *opus sectile*, from the bath in *Punta dell'Epitaffio* MPA-UP of Baiae in order to plan the restoration works. The L1 system is a light and compact 3D scan system (15 x 16 x 10cm, 4kg) in a specifically designed waterproof case and is based on the emission of structured laser light which records three-dimensional coordinates in

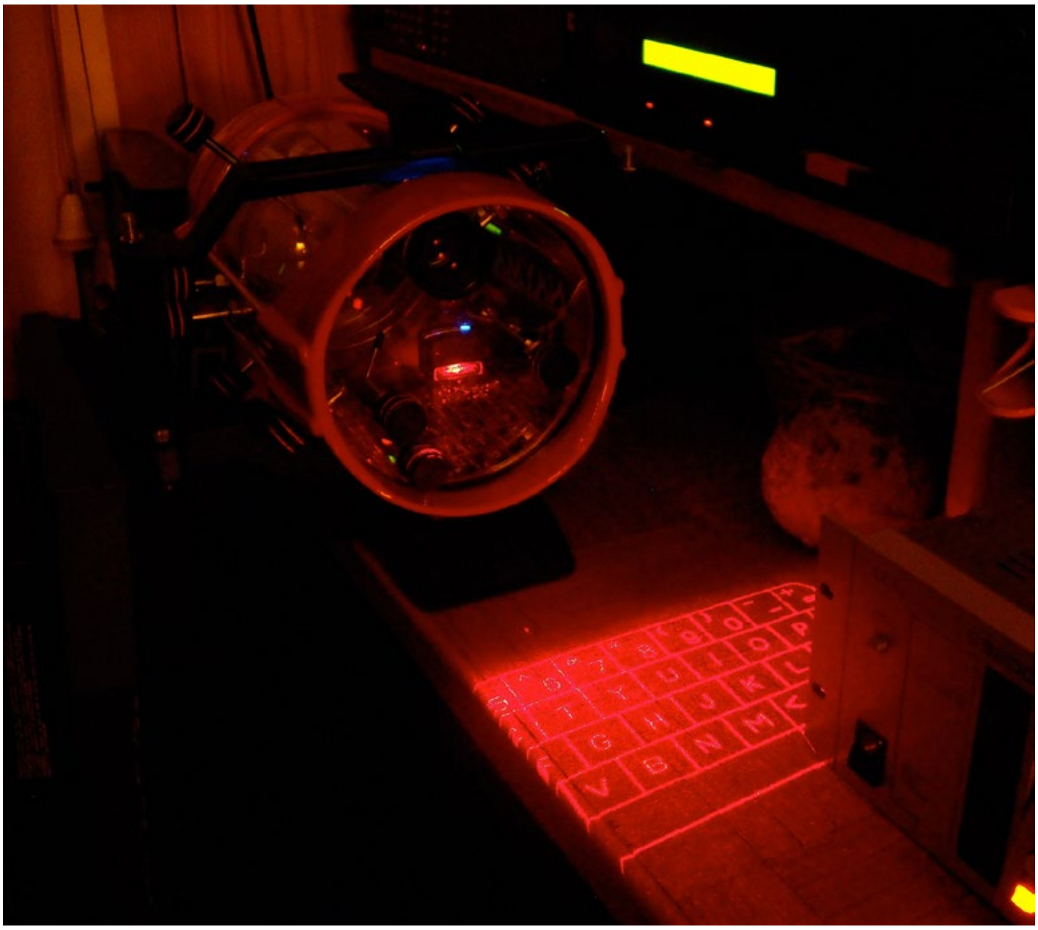

Figure 3. The WIRscann device developed by independent researcher Gabriele Gomez de Ayala. (© ISCR).

the 3D space. The device acquires a cloud of points, each of them having the associated RGB colour values.

During the following years (2012–2013–2015) the natural evolution of the L1 system—the L2–L4 systems—were employed to document the archaeological structures and a black and white mosaic from the *Villa con ingresso a protiro* as well as the floors of a Republican villa and structures of a building with a portico in the area of the Portus Iulius (Baiae).

The L2–L4 scanning systems consist of a 3D Real Time Moving Scanner based on structured infra-red laser light which acquires a point cloud of the scanned area in real time, while being deployed and moved over the site. The system has an accuracy of 0.05mm and can scan up to several square meters in one go. Unlike its terrestrial counterpart, the Naumacos L2–L4 systems can scan moving objects as well as scan objects while being on the move, not requiring prior calibration or the existence of GCPs in the area to be scanned.

The scanning system follows two main optical principles: the infra-red rays (IR) and the laser light. The system allows large areas to be covered in a short time, while acquiring information on the relative position of each point. The system is therefore based on natural infra-red emissions and produces a grey scale high definition 3D depth map of the scanned area. As for the L2–L4 systems, WIRscann (Figure 3) can be operated on the move and reaches a resolution which can range between millimeters to centimeters depending on the job requirements and the available time underwater, where the level of resolution is a function of the time spent underwater.

The scanner has the dimensions of a digital camera. Hence, it can be conveniently carried on fieldwork. Once in the field and deployed in the water, the device produces an auto-calibration to set temperature and other geo-physical parameters. When ready to scan, the underwater scanner will display the optimal distance from the object to be scanned: the distance being calculated on the well-received infra-red emission.

During the recording phase, the scanner will find common points between each single scan (1 up to 60 per second) and give information on the successful

Figure 4. A point cloud of the black and white mosaic located within the *Villa con ingresso a protiro* (Data capture and elaboration Gabriele Gomez de Ayala) (© ICR).

accomplishment of the task, as well as the speed and the distance from the object being scanned. Every 300 scans, the scanner elaborates the data, produces a points cloud and stores it.

The ICR produced a survey of the black and white mosaic located within the *Villa con ingresso a protiro* (submerged Baiae) which took place over one hour of optimal weather and sea conditions. In particular, the work surveyed an area of 49sqm, and detected an area of 54sqm including high structures, generating a point cloud of 15,010,242 points (Figure 4). The detailed three-dimensional model of the mosaic allowed conservators at the ICR to plan and design the conservation intervention. The model was key in understanding the diving time required to accomplish single tasks, and the amount of material required for the divers to accomplish their individual tasks.

It was this need to scan very large areas of the seafloor that encouraged the development of the WIRscann system, which can effectively scan areas up to 1000sqm. Therefore, in 2015, the ICR decided to test a new underwater laser scanner called WIRscann–Warm Infra-Red scanner–to document a large area of the Portus Iulius. For this site, the ICR surveyed an area of 2340sqm and an area of high structures equal to 2896sqm was detected over a period of five hours, with optimal weather and sea conditions, producing a point cloud composed of 440,064,684 points (Figure 5). The surveys produced with the L4 and WIRscann laser scanners have proven extremely useful for planning restoration works, allowing the mapping of the structure's state of decay and documenting the results at the end of the intervention. The final products have also proven very useful for disseminating the results from both a scientific point of view and from a more popular perspective.

In the case of the Building with porticoed courtyard of the Portus Iulius, the area to be scanned totalled around 1000sqm, in this case, first, we scan a number of cross-points like a grid including external perimeter; this gives the scanner a chance to completely cover the required area. A different approach was taken in the recording of a brick column requiring consolidation works.

In this case, changing settings to high resolution switches the scanner to small area mode, with up to 60 scans per second being produced. As we have said above, the highest resolution of the acquired model is a function of the time spent, and the distance to the recorded object (Figure 5). Once the underwater operations are completed, the result is a single point cloud of the complete area and numerous single point clouds (300 scans each).

If required, the post-processing phase is similar to terrestrial laser scanning systems: point clouds can be cleaned, polygonal models can be created, texture can be extrapolated from vertex colours and more

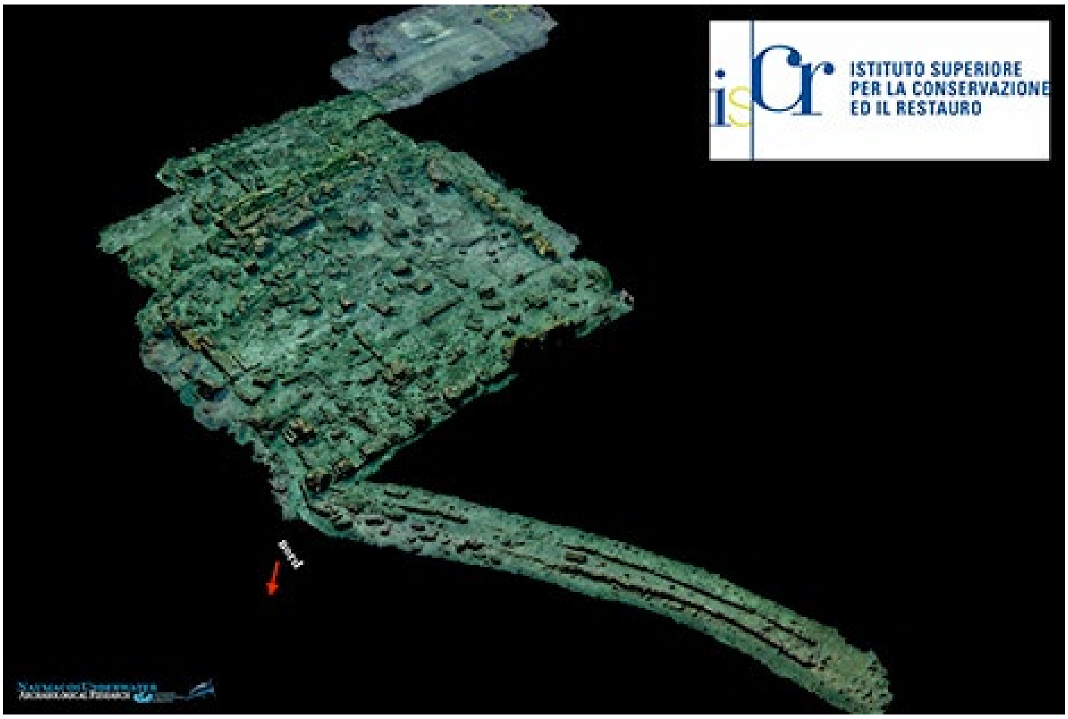

Figure 5. A point cloud of the building with porticoed courtyard of the Portus Iulius acquired with the WIRscann system (Data capture and elaboration Gabriele Gomez de Ayala) (© ISCR).

traditional representation deliverables created for archaeological or conservation purposes.

Discussion

The surveys made with the laser scanners have proven very useful in designing and planning conservation activities, as well as in mapping the state of decay and degradation of the archaeological structures. The L4 laser scanner was particularly helpful for the documentation of bioerosion on the mosaic tesserae, due to the ability to produce short-range measurement, being therefore ideal for capturing high-detail measurements (within millimetres). In the field of conservation studies and marine biology, the laser scanner is useful for defining the colonisation dynamics of the surfaces exposed to the marine environment (and consequently to biodeteriogens) and for studying the type and extent of degradation. This technique has been specifically used by the ISCR to document a peculiar differential degradation detected on the bi-chrome mosaic of the *Villa con ingresso a protiro* in submerged Baiae. The tool allowed the obtainment of data providing a reference point for the state of conservation of the architectural remains. An important application was the ability to monitor over time the state of preservation of submerged artefacts. The processed images provide an accurate three-dimensional reconstruction of a portion of the mosaic characterised by this type of degradation with a sub-millimetric precision (Ricci *et al.* 2015) . The state of conservation has been well documented by this laser scanner, offering high level details and the ability to recognise type and extent of colonizing agents.

From an archaeological point of view, assessment surveys or more detailed recording using these techniques surveys can be advantageous for the ability of photogrammetry and laser scanning techniques to acquire significant volumes of data in a relatively short time. The achievable level of detail offers the opportunity to employ three-dimensional models during the design phase as well as for the full recording of the site. Three-dimensional models also empower archaeological interpretation, offering a contextual visual representation of the site and related artefact, in their spatial relation and visual characteristics, often lacking in more traditional 2D representations (i.e. site plans, section profiles etc.). As it has been recently proven by Kotaro Yamafune, Rodrigo Torres and Filipe Castro (2016), starting from photogrammetric models, further data analysis and elaborations can add to the interpretation of the archaeological remains found *in situ*.

Moreover, three-dimensional digital models represent a very suitable tool for the dissemination of archaeological information on both a scientific and a more popular level. Laser scanned and photogrammetric models are now commonly exploited by the cultural heritage sector to allow the general public to know and appreciate the underwater cultural heritage. Three-dimensional models allow the general public to visualise and, sometimes, virtually visit sites difficult to reach by non-diving (and often even diving) people, or to 'bring back to life' excavated sites that are no longer visible. Virtual Reality (VR) and Augmented Reality (AR) are becoming familiar tools to archaeologists, while low-cost, user-friendly game engines are enabling archaeologists to produce entertaining whilst educational virtual reality environments (i.e. serious games). As the VR/AR revolution appears to be approaching the digital world, VR and AR tools, devices and experiences will become more common, representing irreplaceable opportunities to share the knowledge of the past with the lay person and to convey an understanding of the values of our disciplines and the history we attempt to uncover and outline.

Conclusions

Often defined as the underwater Pompeii, submerged Baiae represents an extraordinary underwater archaeological site shedding light on the life of the late Republican and Imperial Roman aristocracy.

The area also represents an outstanding location for trialling new technologies and approaches, while allowing advanced techniques and methodologies for underwater archaeological research and *in situ* conservation. The ISCR has already exploited this potentiality of the submerged site in relation to its duties to *in situ* conservation of the underwater cultural heritage.

Three-dimensional tools and techniques are allowing underwater archaeologists and conservators to acquire useful data for the interpretation of the archaeological remains, in order to plan both archaeological and conservation works. The potential of these techniques is undoubted, as the many case studies around the world have demonstrated. While a strictly and thoroughly technical comparison of the point clouds deriving from the two techniques (i.e. photogrammetry and WIRscann) is still in the process of being published, the present paper aimed to focus attention on a series of hermeneutical considerations regarding the role played by and the effects, and value of the implementation of these techniques in underwater archaeological and *in situ* conservation fieldworks. To conclude, in a pre-informatics and pre-computational environment, Lewis Mumford (1934: 3) stressed how technological progresses do not simply represent a mere technical matter, or better, their full implementation and eventual success do not solely depend on the related technical aspects; conversely, a mental change is required. Hence, the consolidation of a new technological paradigm is not just a technical matter, but rather a convergence of technical wherewithal and human willpower. While the implementation of these techniques in underwater archaeology is still in its infancy, and more experiments and case studies are required, the understanding of the tools needs to go through both technical and a more human analysis of the results and effectiveness of their employment.

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The Influence of the Point Cloud Comparison Methods on the Verification of Point Clouds Using the Batavia Reconstruction as a Case Study

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Abstract

During the excavation of the *Batavia* shipwreck in the 1970s part of the wooden hull and additional artefacts were excavated and conserved. In the course of the excavation over 3500 underwater images were captured to document the expedition. These images have allowed for the digital 3D reconstruction of the *Batavia* as it was found on the sea floor. The physical shipwreck timbers were reconstructed and are now located in the Fremantle Shipwrecks Museum. In 2014, a Terrestrial Laser Scanner (Leica C10) was utilised to capture the shipwreck as displayed in the museum. This resulted in two different point clouds of the vessel: a) based on the images captured underwater and, b) based on laser scan data captured in the museum. The case study will focus on two different sections of the vessel with different complexity, and has two aims. Firstly, the goal is to compare the 3D reconstructions from the underwater archival photography with the laser scans and 3D reconstruction of the *Batavia* hull currently on display to verify if the *Batavia* as displayed today has the same configuration as the original wreck. The results show that while the difference between both datasets is often minimal, some differences are visible because the excavation took place over a long period. Secondly, the paper will evaluate the influence of different methods for point cloud comparison. The methods are namely point-to-point and point-to-model and are used to quantify the differences of the shipwreck's point clouds. Even though the same input point clouds were utilised, the paper will show that the results of the comparison were influenced by the point-cloud-comparison method used.

Keywords

Photogrammetry, laser scanning, verification, underwater archaeology, point cloud, comparison, 3D reconstruction

Introduction

Over the last few decades, photogrammetry has become a powerful tool for the recording of archaeology and significant heritage sites due to the relatively simple process of data capturing and image processing to generate 3D maps and models. While the use of underwater photography for site recordings is well established (a historical overview is given in Drap 2012), there have been recent advances in image processing technology that allow fast 3D mapping of sites utilising a high level of automation. These improved methods can be utilised for a wide range of different image data, and importantly for archaeology allows the 3D capturing of sites. This has included both land-based (Martorelli *et al.* 2014) and underwater recordings in seas (among others Balletti *et al.* 2015; Bandiera *et al.* 2015) and lakes (Bucci 2015). It has also allowed for the joint processing of in-air and underwater projects (Menna *et al.* 2015).

Nevertheless, not only has the advanced automatic processing of the images contributed to the current uptake in the use of photogrammetry for underwater archaeology, it has also seen an increase due to advances in digital cameras that are light, highly light-sensitive, wide-aperture, compact user friendly and low cost (McCarthy and Benjamin 2014). Hence, photogrammetry is used for small (McCarthy and Benjamin 2014) and medium-scale projects (Diamanti and Vlachaki 2015), as well as for large-scale projects in combination with bathymetry (Bruno *et al.* 2015). However, processing using photogrammetry is not limited to images from current projects; it can also be performed based on archival materials of objects of interest (Metres *et al.* 2014). Nevertheless, alternative capturing methods exist in order to create 3D models of objects underwater. Some of these include structured light sensors (Bräuer-Burchardt *et al.* 2015), multibeam sonar (Bruno *et al.* 2015), airborne laser scanning (Doneus *et al.* 2015), triangulation sensors (Ekkel *et al.* 2015) and underwater laser scanning (Davidde Petriaggia and Gomez de Ayalab 2015). All of those methods create a 3D point cloud with varying accuracy, precision and point spacing.

So far, one of the large advantages of the derived 3D models is the possibility to visualise complex sites (Repola *et al.* 2015), and to create fly-through videos (McCarthy and Benjamin 2014). These methods of visualisation, as well as the production of 3D prints, help with communicating the findings to a large audience. This benefits projects, as the products can be made available within publications, exhibitions, web pages and more. On the other hand, the derived models also allow further analysis in respect to mapping of sites and creating a GIS representation (Drap 2012), performing surface analysis of artefacts (McCarthy and Benjamin 2014), providing a reference for restoration and renovation processes through the creation of 3D CAD models (Martorelli *et al.* 2014), and for the verification of theoretical models of artefacts (Drap 2012). Within the photogrammetric processing the most prominent software solutions used for underwater projects are Agisoft's PhotoScan (McCarthy and Benjamin 2014; Metres *et al.* 2014; Van Damme 2015), Autodesk's 123D Catch (D'Amelio *et al.* 2015; McCarthy and Benjamin 2014), PhotoModeler (Green *et al.* 2002) and VirtualMapper (Green *et al.* 2002). Alternative solutions also exist such as VisualSFM (Hollick *et al.* 2013; Wu 2013;), and it can be predicted that the number of software solutions will grow in the future.

However, underwater photogrammetry does face challenges. One example is the effect of moving objects such as seagrass (McCathy and Benjamin 2014). The constant movement of seagrass potentially disrupts the matching process within the software leading to an inability to create sparse and the following dense point clouds on those regions. Further challenges for photogrammetry are the reduced light at greater depths (Van Damme 2015), sufficient light creation at deep-water sites using ROVs (Drap *et al.* 2015) and reduced visibility (Van Damme 2015).

Nevertheless, when using new technologies one important aspect is to verify the accuracy of the captured and derived data. A number of different ways of assessing the accuracy were applied in the past and can be categorised as follows. The first is the use of single measurements of objects of interest (McCarthy and Benjamin 2014; Metres *et al.* 2014) or the comparison of control point observations (Green *et al.* 2002). Another is to use graphical representations of the scenes to examine the results (D'Amelio *et al.* 2015). The final group of methods is to perform point cloud comparison (D'Amelio *et al.* 2015; Martorelli *et al.* 2014; Troisi *et al.* 2015).

The main issue with evaluating the accuracy based on single measurements or control points, is that only a limited number of discrete observations are utilised while the majority of the derived 3D information is not considered. Furthermore, by comparing only discrete measurements systematic error influences, e.g. based on the location of the objects of interest (in the centre of the survey area or the outside), its orientation (pointing in a specific direction) as well as their dimension (smaller objects vs larger objects) is difficult to detect. For instance, McCarthy and Benjamin (2014) focussed on two shipwrecks—one in shallow water (3m) and one in deeper water (13–16m). The accuracy of the derived models was verified by comparing its measurements with measurements of the objects of interest taken on the sea floor. The results are summarised with a usual high level of accuracy, however, some artefacts in the dense point cloud based on miss-matches in the dense matching process are clearly visible in the derived models, but were not considered in the accuracy assessment. A similar assessment of the accuracy was done in Metres *et al.* (2014) where the derived 3D models based on archived video material are compared to the hand survey measurements with ranged errors between 18% (for smaller objects of 0.37m dimension) and 0.56% (for larger objects of 4.21m dimension). Green *et al.* (2002) used control points and grids to check the precision of photogrammetric site survey as well as tape measure trilateration. Control points and points on the grid were observed and adjusted in order to check their precision, i.e. the agreement of the observations to each other. However, a cross-comparison is missing.

For practical aspects of archaeological documentation, the accuracy of discrete points is often not relevant. Instead, in many cases the focus is to describe the geometrical aspects of objects in order to allow an identification and classification of those objects. For this purpose, D'Amelio *et al.* (2015) created 2D profiles of amphorae and inspected them visually. However, the profiles were created based on 3D point clouds. Hence, instead of comparing the whole object with all given information (points in the point cloud), a reduction of information is produced and used.

It is possible to compare actual point clouds with each other so that no reduction of information is necessary. Within the point cloud the comparison can be limited to small objects (D'Amelio *et al.* 2015, compares amphora) or medium to large-scale projects (Martorelli *et al.* 2014, examines ship hulls). To provide a more detailed example, Martorelli *et al.* (2014) used a laser scanner to compare the results of a 3D point cloud derived based on images of a ship hull, and found that the average deviation of 1.25mm based on the Euclidian methods. However, the provided heat map shows much higher maximal values (up to 15 mm), and a clear systematic trend (larger positive values are located on the outside, and larger negative values in the inside of the compared hull face). Therefore, an important aspect when comparing point clouds is to consider how they are compared, as there are a number of different ways. In this publication, we will show that by comparing the same point clouds the results can be quite different only depending on how the point clouds are compared.

However, before introducing two methods for point cloud comparison and the analysis of their results, it is important to understand the data involved in the comparison. In the majority of publications related to archaeology where point clouds are derived from photogrammetry, a comparison is performed against point clouds captured with a laser scanner, with the laser scanner point cloud usually used as the reference.

Therefore, the structure of this paper is as follows: in the next section we will introduce our case study site, the *Batavia* shipwreck, focusing especially on the point clouds derived from underwater images and those captured using a laser scanner of the vessel's physical reconstruction in Western Australia's Shipwrecks Museum in Fremantle. Not only are the data capture and the best practice of processing the data briefly outlined in this section, but we also discuss the data sources with respect to accuracy, precision and point spacing. Afterwards, two selected methods for the point cloud comparison are introduced in detail (namely point-to-point and point-to-model) including the prediction of their results. Finally, we compare the two point clouds—photogrammetry based on underwater images and laser scanner data based on the data captured at the shipwreck 'recovered and reconstructed' at the WA Shipwrecks Museum. The evaluation will discuss two aspects. Firstly, how accurate the reconstructed shipwreck in the museum is compared to its state underwater when it was discovered. Secondly, the impact of using different point cloud comparison methods will be evaluated.

Case study—data

During the excavation of the *Batavia* in the 1970s, the remaining wooden hull was excavated and conserved, along with additional artefacts. In the course of the excavation over 3500 underwater images were captured to document the expedition. These images have allowed the digital 3D reconstruction of the *Batavia* as it was found on the sea floor (Woods *et al.* 2016). The physical shipwreck timbers were physically reconstructed and are now located in the WA Shipwrecks Museum. In 2014, the shipwreck as displayed in the museum was surveyed using a Terrestrial Laser Scanner (Leica C10), which allowed the production of two different point clouds of the vessel—a) based on images captured underwater, and b) based on laser scan data captured in the museum. This case study will focus on comparing the different point clouds with respect to two different sections of the vessel with different complexity and properties.

Laser scanning

When capturing the data of the *Batavia* shipwreck as presented in the WA Shipwrecks Museum a surveying grade Terrestrial Laser Scanner system was used, namely the Leica C10 scanner (Annesley 2014). The distance measurement accuracy of this scanner is 6mm, the angle accuracy (vertical) is 12", the angle accuracy (horizontal) is 12" and the model surface precision is 2mm (Leica Geosystems 2016). A total of four different scans were captured spaced around the shipwreck with three being captured on the ground floor and one being captured from the mezzanine walk-way. The scans of all four stations were registered together to form a point cloud with 4,370,279 points covering the inside as well as the outside of the hull.

The scanning results from the inside of the hull are shown in Figure 1, and represent the primary focus of the comparison in this paper. Due to laser scanning being an active system (emits its own light source) the scanner also captures returned intensity information, which is a function of the scanner geometry to the surface and the surface properties such as reflectance and texture in relation to the laser wavelength. Instead of a coloured point cloud, the values shown in Figure 1 represent intensity information only. Based on the metric point cloud it is easy to derive profiles and perform a range of measurements (distances, profiles, volumes, etc.) as given in Figure 1. In order to derive accurate measurements it is required that the scanner operates within the specifications, i.e. that the scanner is calibrated. A calibration of the used scanner passed the required specifications.

Laser scanner data is often used as the reference dataset, as its errors and error models for correction are well studied. Point clouds derived from laser scanners are accurate (globally) but can contain some noise/lower precision (locally) (Figure 1, bottom left). The noise is due to the integration time of the return signal and includes noise in the return signal, as well as

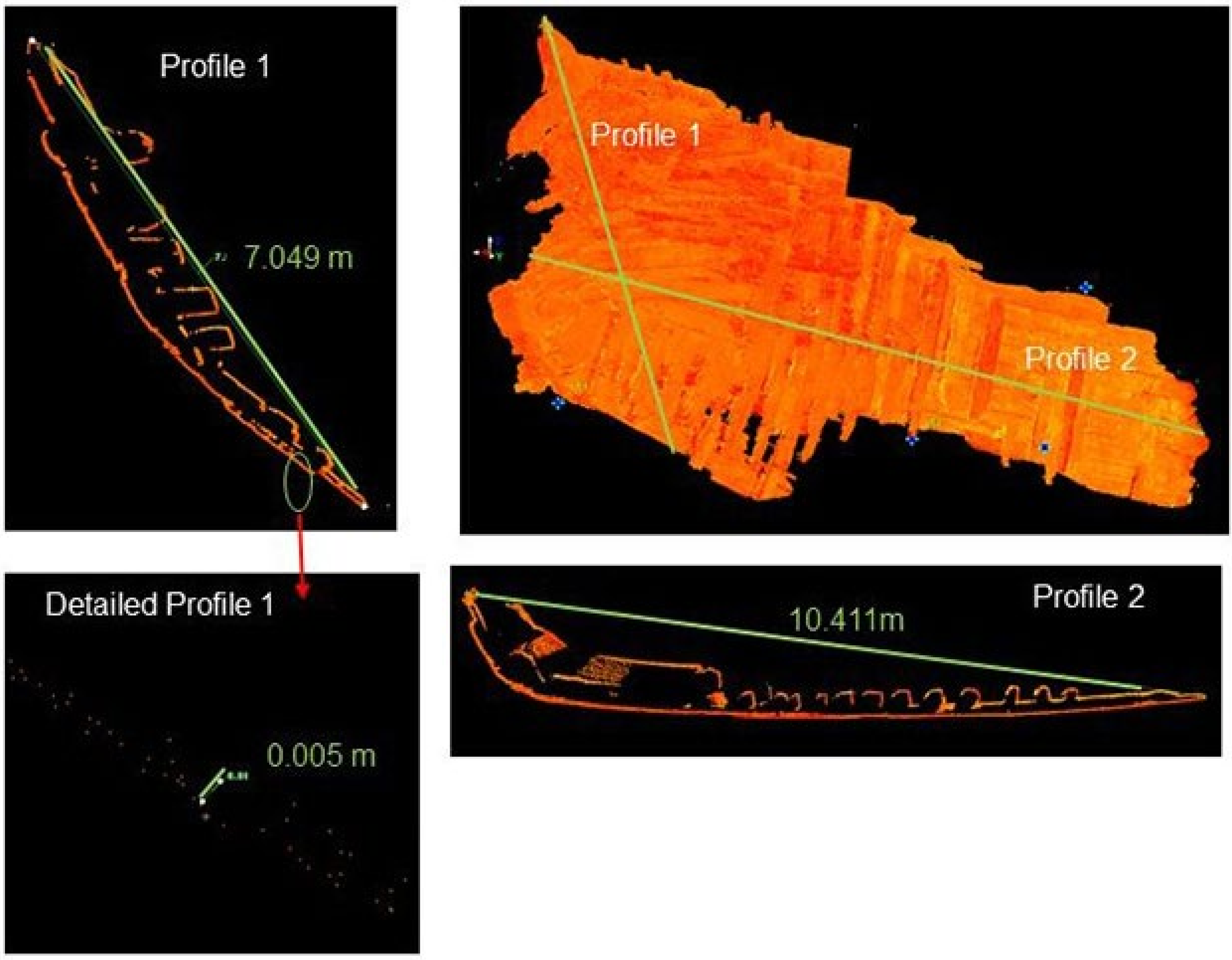

Figure 1. Point Cloud of the *Batavia* shipwreck captured with the Leica C10 laser scanner at the museum (top right) as well as two selected profiles (top left and bottom right) with a detailed section (bottom left).

noise from the beam interaction over the surface. If the distribution follows a Gaussian distribution then local interpolation should smooth out the noise and preserve the trend. The spacing of the points depends on the scanner resolution and the number of captured scans.

Photogrammetry

Based on the underwater images a number of digital 3D reconstructions of the *Batavia* have been created (Woods *et al*. 2016). To be able to extract precise measurements, the geometry in which the images are captured, the quality of the cameras and lenses used and the *in situ* calibration of the camera are all important. Sufficient and homogenous illumination was present when the underwater images were taken without any shadow areas.

From the overlapping images of the object of interest, the position of the camera can be determined. For this process Agisoft's PhotoScan was used. The metrics related to these 3D measurements were added using the known dimension of grids placed in the field of view of the camera. The generated point clouds were further processed to produce a textured meshed surface. Figure 2 shows the two selected image-based point clouds (MF1 and MF37) and their location relative to the laser scanning point cloud data.

The errors in image-derived point clouds are a function of: a) the calibration quality of the camera (interior orientation), b) the accuracy of the image alignment (exterior orientation), and c) the quality of the dense image matching procedure. The dense matching (point cloud creation) works well if the object is smooth and without sharp changes in the topography as well as having a well-textured surface. Occlusions and surfaces lacking sufficient texture often lead to mismatches (Figure 2, profile). Models derived from images usually have the characteristic of being precise but may be less accurate compared to laser scanning point clouds (Figure 2, right detailed plots), i.e. while small details

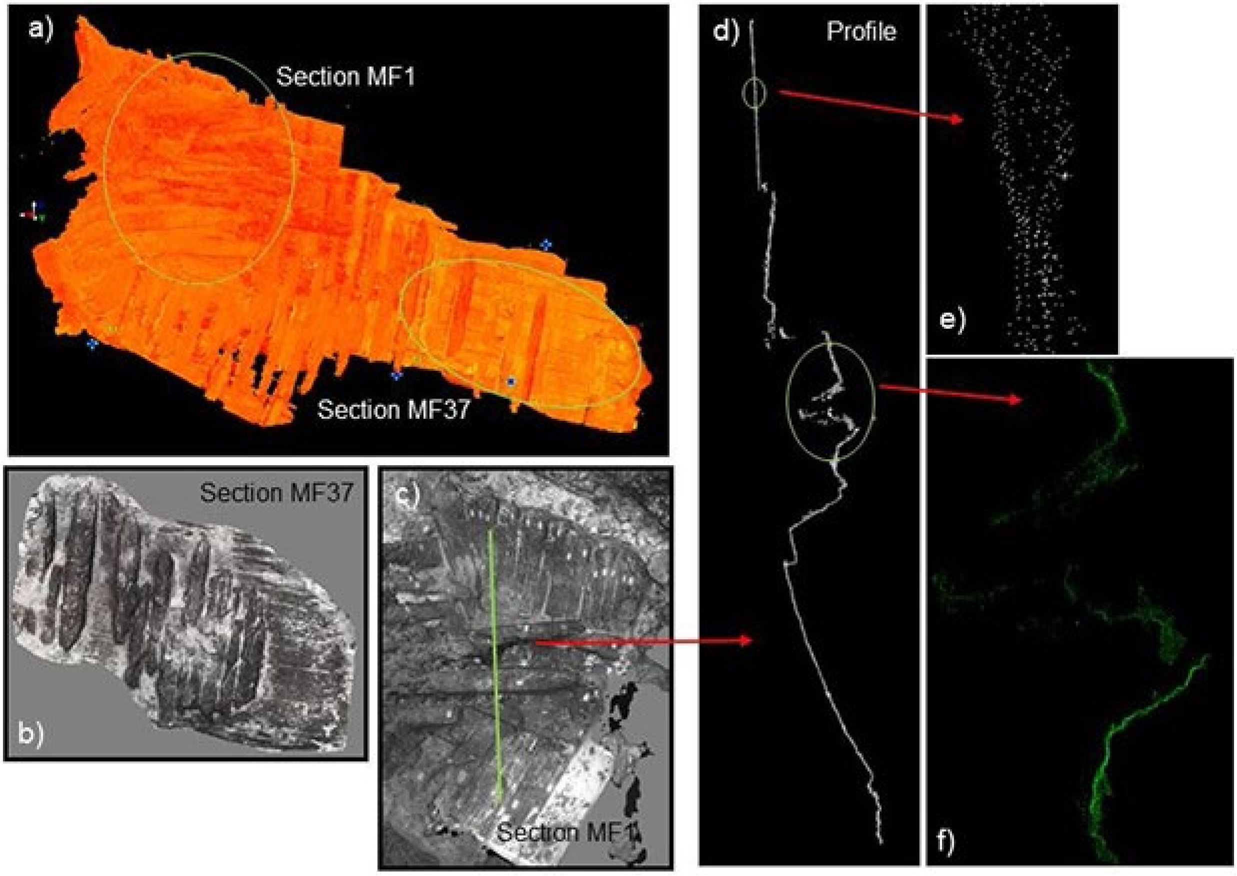

Figure 2. Intensity point cloud of the ship wreck at the museum (a), rendered 3D point clouds based on the underwater images captured of the *Batavia* – Section M37 (b) and section MF1 (c), selected profile of MF1 (d) and its detailed views 1 (e) and (f).

are usually reconstructed well, the point cloud itself can show inaccuracy globally (e.g. a surface warping effect).

Methodology

The comparison of the underwater image-derived point cloud with the laser scanning point cloud will use three different methods: visual inspection, point-to-point (P2P) comparison, and point-to-model (P2M) comparison. Through visual inspection, it should be possible to detect larger differences between the point clouds such as missing timbers. However, differences within cm or mm range will not be as easily detected using this approach. On the other hand, it should be possible using the P2P and the P2M method to detect these smaller differences. While there are a number of other methods, this paper will focus only on these two.

Point-to-Point (P2P) comparison

If it can be assumed that the density of the two point clouds is high, or the point sampling between the two are similar, then the distance between the nearest neighbouring points is close to the true distance between the point clouds (Figure 3, top). This is the basis of the point-to-point method. However, there is the issue of no 'real' correspondence between points as would be the case if control points or markers were utilised. This results in a bias ε_1 dependent on the sampling distance [Figure 3, top right]. The average distance is the maximum between the sampling distance and the point cloud separation. Hence, when using this method there will be no distance value of '0' (because 'real' correspondence do not exist), and the mean distance may be slightly larger than the true average surface separation.

Point-to-Model (P2M) comparison

Using the P2M comparison, the surface of one point cloud is locally modelled using a Least Square Plane fitting method, taking into consideration the k nearest neighbouring points (kNN). Then, the distance between this model and the closest point in the other point cloud is calculated as the projected distance between the points onto the normal vector of the modelled surface (Figure 3, bottom). While this eliminates the errors

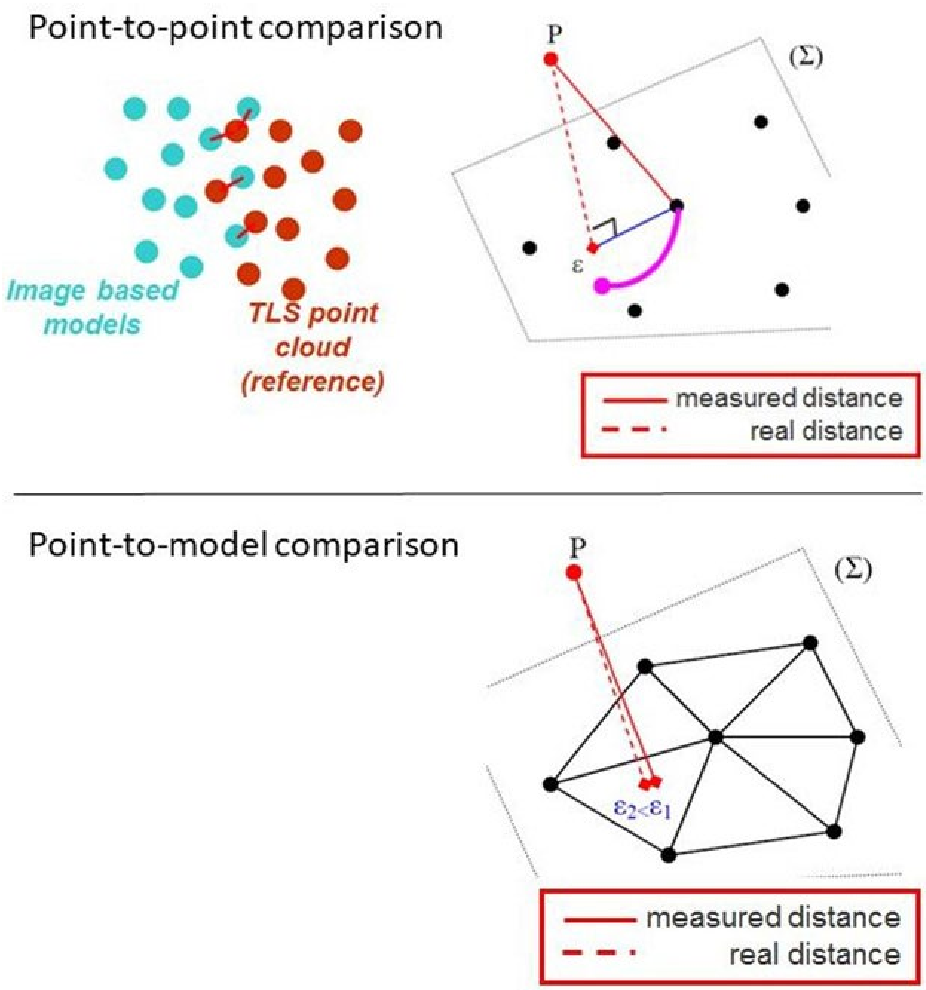

Figure 3. Point-to-point comparison (top) and point-to-model comparison (bottom) (adopted from CloudCompare, 2017.)

due to missing corresponding points, there are still the remaining issues of the model resolution, which will introduce a bias ε_2. This is due to noise in the points to the surface and slight errors in the surface normal approximation to the true surface normal. However, this bias is much smaller than those that are exhibited when using the P2P method.

Data processing

The data processing can be separated in three steps:

a. Alignment of the point clouds;
b. Application of the comparison methods; and
c. The analysis of the comparison.

In order to align the point clouds a rough alignment is the initial step. This alignment is usually done picking a number of identical points (at least four) in the two point clouds and applying a seven parameter Helmert transformation based on the corresponding points. The Helmert transformation will rotate (three degrees of freedom), translate (three degrees of freedom) and scale (usually one degree of freedom) the sample point cloud onto the position of the reference point cloud. It is recommended to apply a scaling factor. Scaling errors can have a number of different reasons such as incorrect camera calibration, layout of the control points (e.g. extrapolation effects) or simple imprecise measurements within the image processing workflow. After the two point clouds are roughly aligned, the method of 'iterative closest point' (ICP) (Besl and McKay 1992) can be applied, and both point clouds aligned precisely. The result is that the reference point cloud and the underwater-derived point cloud are comparable.

Then the three proposed comparison methods (visual inspection, P2P and P2M) are applied. Output is a) a heat map on which the distances between the point clouds are colour mapped, b) statistical information such as the 95% significance level, minimum distance, maximum distance, distance with the most counts and c) a histogram plotting the distances. Beside a visual inspection of the histogram, it is possible to determine the Weibull distribution parameters, i.e. the shift parameter D (offset from 0), the shape parameter a (larger values means the distribution is moved away from zero), and the scale parameter b (assumed to be between $0 < b < 1$, larger values means the distribution is more stretched out).

Results

Visual Inspection

The hull timbers of the shipwreck were removed from the sea floor over a series of several expeditions in the 1970s (Green 1989). As this process was undertaken, underwater images were captured and a hand-drawn site diagram was developed over the period (Van Duivenvoorde 2015). The digital 3D model generated from the underwater images helps represent the state of the ship at this time; however, it was impossible to capture the detail in one period. As such, the full model had to be built from groups of images collected over successive periods as the excavation progressed. In contrast, the laser scan of the ship in the museum could be captured in a single instance. While the two models should essentially be the same, readily apparent differences can be seen. When looking at Figure 4 showing site MF37, it becomes clear that the opposite is the case, e.g. timber parts are missing in the museum model (Figure 4, bottom, yellow arrows). These are due to the condition of the timbers—not all timbers could be restored and, therefore, are not present in the museum display.

While the excavation of site MF37 was done in one excavation period (December 1972 to May 1973), the excavation period for ME1 took place over two periods within January and December 1974. More time was required to excavate the more complex structure of this site. When looking at Figure 4 it becomes clear that the matching of the three different information sets (excavation site diagram, image-based point cloud, and a photo of the *Batavia* in the museum) is also more challenging due to the complexity of the hull. However, for this site, it is true that the processed underwater model, representing just a snapshot of the nearly year-long excavation of this site, does not contain all the recovered timber pieces.

Point-to-Point comparison

The results of the point-to-point comparison of MF 1 and MF37 are presented in Figure 5. The missing timbers in MF37 are easily recognisable in the figure due to their detected differences being in the order of 0.015m and higher. The colours mapping the differences are consistent with those shown in the histogram to highlight the distribution of distances in the comparisons. Beside the missing timbers, the figure shows that the differences between the reconstruction in the museum compare well with the captured underwater model, and is within 0.01m. However, after closer examination of the histogram, a clear bias away from zero (also indicated by the Weibull shift parameter D of 0.000116m) is visible. This bias confirms the issue with point correspondences as discussed in the previous section. In addition, the histogram shows a strong peak in the 0.005m to 0.01m interval range. This bias, and the peak, would not be easily observable from just the raw statistical results. Ninety-five percent of all distances are within the 0.071m range, the mean difference is 0.031m, and the standard deviation 0.021m. All values are within the expected range, it can be seen that they are biased away from zero by the missing elements and the comparison method.

The results of the P2P comparison of site ME1 confirms the results of site ME37. Again, the missing timbers are easily recognisable in the figure indicated by large differences (the regions in yellow and red that are more distinct). Please note that the same colour scale for visualising the distances between the point clouds was used in Figures 9–12. This histogram also exhibits a similar response to the previous site, showing the same bias (shift parameter is 0.000115m). Again, statistical values are within the expected range but with higher values due to the higher number of missing timbers in the underwater model and the complexity of the site. 95% of all distances are within the 0.130 m range, the mean difference is 0.058 m and the standard deviation is 0.038 m.

Point-to-Model comparison

Figure 6 presents the results of the P2M comparison. When only inspecting the distances displayed in the figure, the difference to the P2P comparison result is minimal. Visually, it is difficult to identify any differences between both methods. The differences become more apparent when inspecting the statistical values. Ninety-five percent of all distances for MF37 are within the 0.075 m (instead of 0.071 m) range, the mean difference is 0.029 m (instead of 0.031 m), and the standard deviation is 0.022 m (instead of 0.021 m) and therefore apparently producing a better result. Even though the differences are small, it is recognisable that when using the same point clouds the comparison result changes due to using a different comparison method. The differences between the P2P and P2M statistical values are small due to this site not being overly complex. Therefore, the impact of the missing timbers is small. However, a significant difference

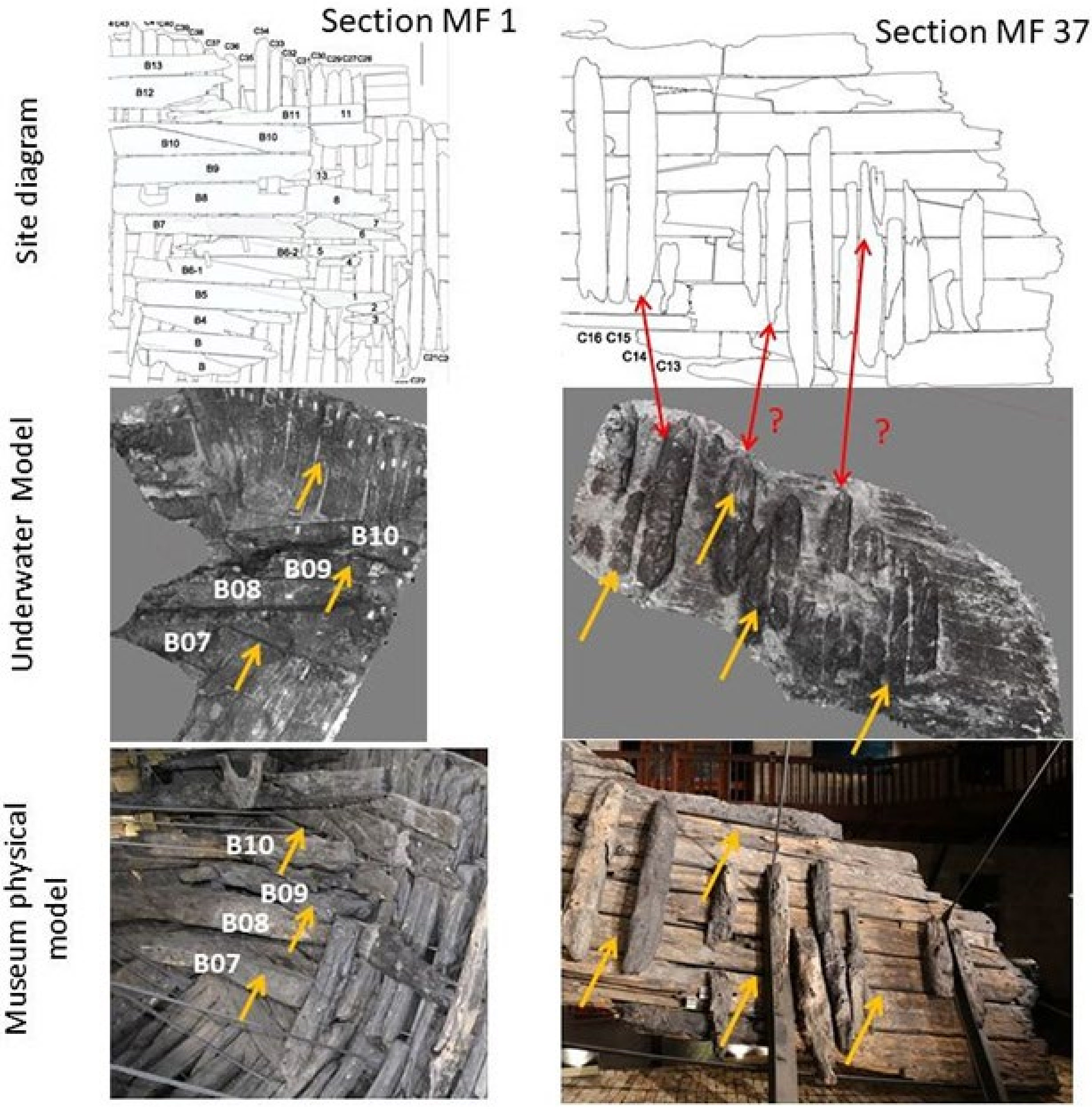

Figure 4. Results of the visual inspection of the point clouds of site MF1 (left) and MF37 (right). The top row shows the site diagrams of each site, the middle row the underwater model, and the bottom row the physical model in the museum. The red arrows indicate matching positions, yellow arrows indicating missing timbers in either the underwater model or the reconstruction at the museum. The location of the yellow arrows match. Site diagram from (W. van Duivenvoorde, 2015).

is visible when looking at the histogram. The bias away from zero has also been resolved as predicted in previous section. Furthermore, the peak of differences in the green area disappears, too. The histogram looks more balanced and closer to the expected trend.

Finally, in Figure 6 (top), the results of the more complex scene MF1 using the point-to-model comparison method are shown. Due to the complexity of this scene the differences of this heat map compared to the one presented MF37 become visible. For instance, the gaps in blue in the image point cloud due to missing timber parts (yellow and red areas) are more visible. Those areas also influence the statistical values, i.e. 95% of all distances are within the 0.119m (instead of 0.130m) range; the mean difference is 0.048m (instead of 0.058m); and, the standard deviation is 0.037m (instead of 0.038m) and again producing apparently better results. From comparing these statistical values, a clear improvement is visible when using the P2M comparison method. The improvement in the histogram of site MF1 is similar to the improvement seen in the histogram of site MF37 using the same comparison method confirming the previous findings.

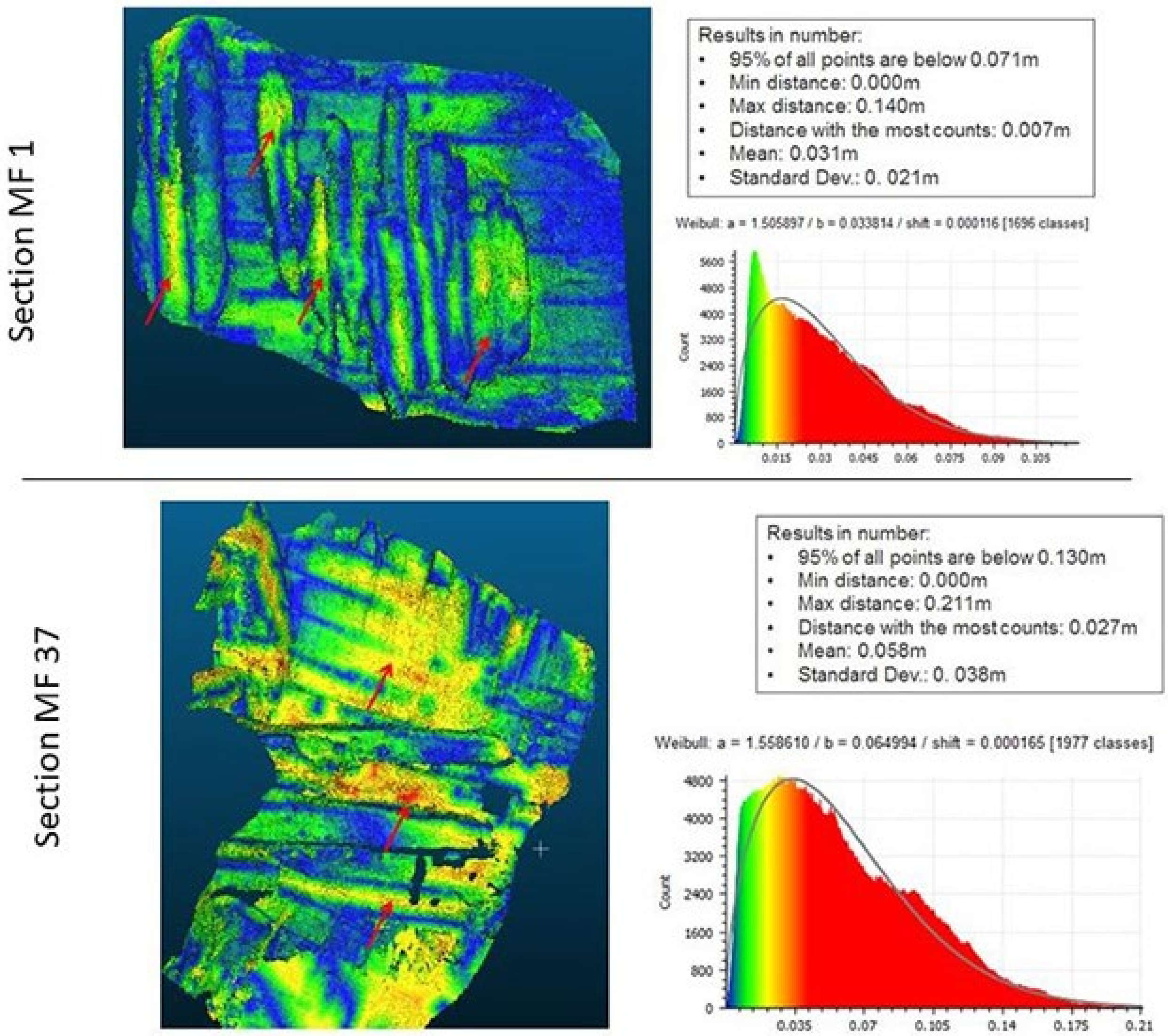

Figure 5. Results of the point-to-point comparison of the point clouds of site MF 1 (top) and MF37 (bottom). On the left: heat map, top right: summary of the statistic information, lower right: histogram with Weibull parameters. The red arrows indicate the areas with the largest differences between the point clouds.

Conclusion

The primary conclusion regarding the physical reconstruction of the *Batavia* hull in the WA Shipwrecks Museum compared to the underwater digital 3D models is that the overall reconstruction is observed to be close to the original, besides the detection of some missing timbers. Reasons for missing timber in the digital 3D underwater model are that the excavation took place over a long period, so underwater 3D models only present a snapshot in time, but not the overall extent. In order to make a more complete conclusion the different underwater models should be merged before comparing them to the point cloud of the physical model of the vessel. The reasons for the missing timbers in the physical reconstruction are due to the fact that not all timbers could be restored and, therefore, are not present in the museum display.

It needs to be highlighted that the goal of the comparison in this paper was to show that different comparison methods can create different results, even when the same point clouds are used for the comparison. In order to compare the underwater point cloud with the physical model, a scaling correction was performed to make the two point clouds comparable. Therefore, scaling differences (e.g. due to the exposure of the timber to the atmosphere in the museum) could not be detected. If scaling differences are the focus of the study, the scale must be calculated independently of the model. However, this was outside of the scope of this work.

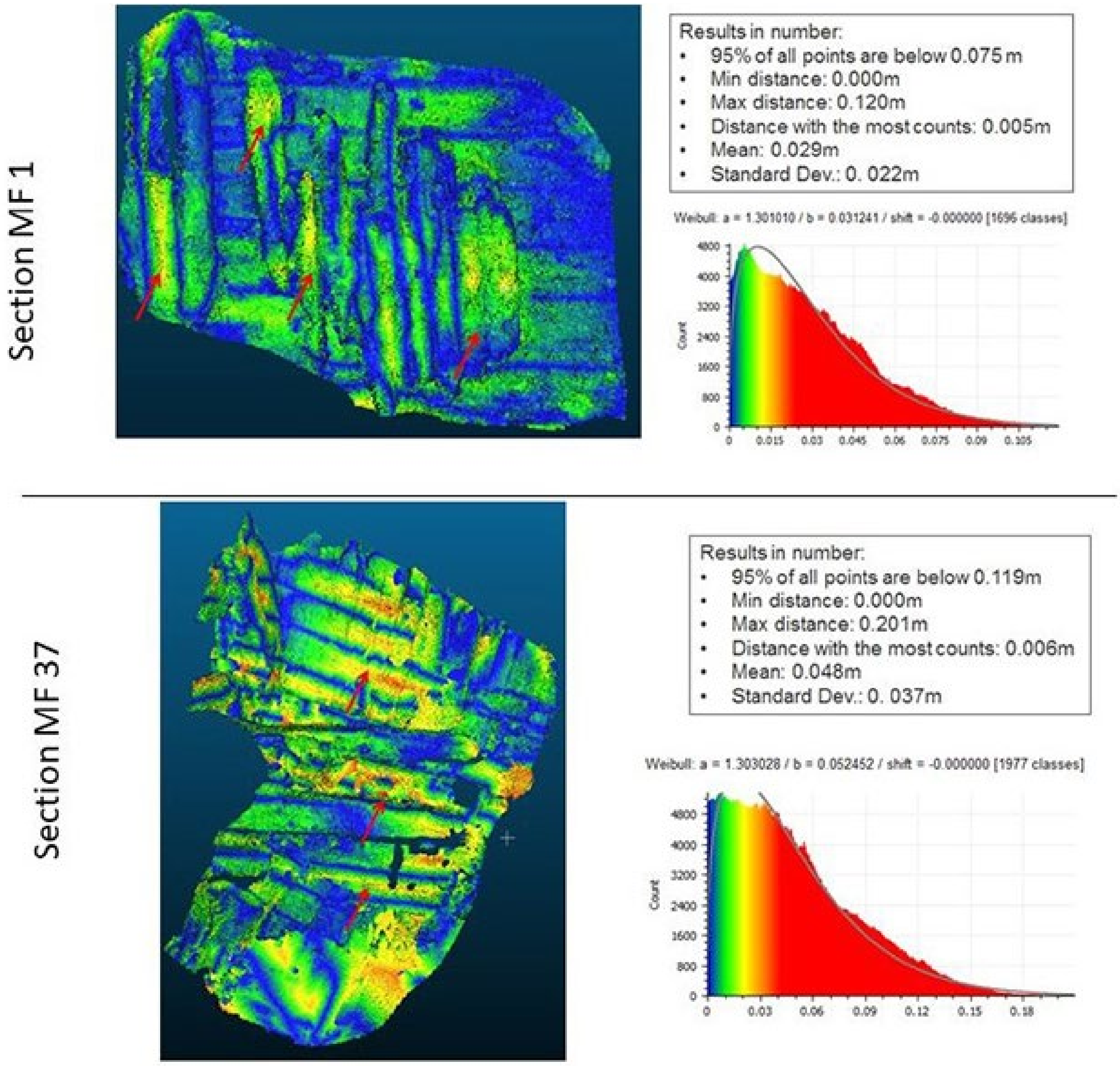

Figure 6. Results of the point-to-model comparison of the point clouds of site MF1 (top) and MF37 (bottom). On the left: heat map, top right: statistical information, lower right: histogram with Weibull parameters. The red arrows indicate the areas with the largest differences between the point clouds.

The method used in comparing point clouds is important and depends on three main factors: the density, accuracy and the precision of the point clouds compared. While the influence of the comparison method can be different for different complex scenes, a comparison using the P2M method over the P2P method is preferable. It can deal with differences in densities of point clouds, as well as lower accuracy and precision.

During this work, it could be demonstrated that the choice of the comparison method has an impact on the comparison results. This means that even though the same point clouds for the comparison were used, the results are different. The choice of the comparison method has a lower impact when dealing with less complex scenes and higher sampling densities, i.e. the results are 'more similar'. This conclusion is made based on the similar statistical values (mean, standard deviation, max and most common difference) of the P2P and P2M comparison of site ME 37 in Table 1 (column 2 and 3). However, if the scene is more complex and the two point clouds compared have higher differences this is not true anymore. In Table 1 (column 4 and 5) a clear 'improvement' of the values are visible when using the P2M over the P2P comparison method.

Paying special attention to the shift parameter (*D*) of the histogram a bias away from '0' can be observed in the P2P comparison, but not in the P2M comparison. In general, while it can be observed that the shape parameter (*a*) is larger for the P2P comparison and smaller for the P2M. The shape parameter (*b*) is similar

Table 1: Comparison of the statistical values and the histogram-derived values for ME37 and ME1 using the point-to-point (P2P) and the point-to-model (P2M) method.

	ME 37 – P2P	ME 37 – P2M	ME 1 – P2P	ME 1 – P2M
95% of the values are within [m]	0.071	0.075	0.130	0.119
Max [m]	0.140	0.140	0.211	0.201
Distance with the most counts [m]	0.007	0.005	0.027	0.006
Mean [m]	0.031	0.029	0.058	0.048
Standard Dev. [m]	0.021	0.022	0.038	0.037
Weibull shape a	1.505897	1.301010	1.558815	1.303028
Weibull scale b	0.033814	0.031241	0.064994	0.052452
Weibull shift	0.000116	0	0.000165	0

for ME37, so it does not matter which comparison method was used, however this parameter is shown to be significantly higher for ME1. This means that the ME1 histograms are more stretched (due to more missing timber elements). Within the ME1 site the value for *b* is slightly lower when using the P2M method compared to the P2P method.

Nevertheless, even though there are differences in the comparison results using the different methods, the comparison of the derived point clouds is preferable over comparison of just a few discrete measurements, as it shows missing elements and systematic trends more significantly.

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3D Reconstruction of the *Batavia* (1629) Wreck Site from Historical (1970s) Photography

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Abstract

The wreck of the VOC ship Batavia (1629) was discovered in 1963 on Morning Reef, in the Wallabi Group of the Houtman Abrolhos Islands. The site was excavated over four seasons in the 1970s. During these seasons, over 3500 underwater photographs were taken of the site by Green and Baker (Green 1989). The project team scanned all of the original 35mm photographs of the Batavia wreck site and applied photogrammetric 3D reconstruction techniques to generate a large selection of detailed 3D models of the in situ ship's timbers (prior to and during excavation) and the surrounding site. These 3D models provide a realistic depiction of the 3D shape and layout of the site, which can be visualised in full-scale in a virtual environment display such as at the Curtin HIVE (Woods *et al.* 2020) or a head-mounted display (HMD). Some of the historical photosets had been captured for the purpose of generating a relatively successful 2D hard-copy photomosaic of the area, the only option available at the time. However, photogrammetric 3D reconstruction techniques have allowed a much more detailed and realistic 3D rendering of the area to be generated. A 2D photomosaic assumes a flat site and, therefore, imposes significant distortions on the mosaic, whereas 3D reconstruction produces 3D models, which can allow accurate site measurements to be obtained. This paper discusses the 3D reconstruction processes used, details of a new 'expanded' 3D reconstruction technique, and discusses the results concerning the processing of this significant legacy dataset.

Keywords

Photogrammetric 3D reconstruction, photogrammetry, VOC, Batavia, Morning Reef, Houtman Abrolhos islands, Beacon Island, ship timbers, digital 3D models

Introduction

On the morning of the 4th of June, 1629, the VOC ship Batavia was wrecked on Morning Reef, close to Beacon Island (named by the survivors as Batavia's Graveyard), Wallabi Group of the Houtman Abrolhos islands, approximately 55km from the coast of the Western Australia mainland. In modern times, the wreck site was discovered in 1963, and during the 1970s, it was surveyed, catalogued and excavated over a series of four expedition periods in the Australian summers of 1972/73, 1973/74, 1974/75 and 1976 (Green 1989). During the first three of these expeditions, the site was photographed, surveyed and mapped. As the ship's hull timbers were gradually uncovered from underneath the coral and concretion, they were labelled, photographed, plans drawn, and then removed for conservation. This was so that the timbers could eventually be reassembled, and displayed in the WA Shipwrecks Museum of the Western Australian Museum, Fremantle. Over 3500 photographs were taken during the expeditions, for the multiple purposes of creating 2D photo-mosaics to visualise large sections of the wreck site, to allow contemporary photogrammetry measurements, to allow stereoscopic interpretation and analysis, and also for general site documentation. These legacy site-recording photographs have now been reused with modern photogrammetric 3D reconstruction techniques to create digital 3D models of portions of the wreck and wreck site. This article discusses the process used to create these models from the historical photographs, and outlines a new technique to develop 'expanded' 3D models that are more extensive than 3D models developed using common photogrammetric 3D reconstruction techniques.

The challenges of this project were that there was a very large set of photographs to work from, the photographs were not taken with modern 3D reconstruction in mind, and there was no way of knowing which groups of photographs would have good matches for creating 3D models.

Background

Photogrammetric 3D reconstruction

Photogrammetric 3D reconstruction is an algorithmic process, which allows digital 3D models of objects to be generated from a series of photographs captured of, and around, that object. The technique is also known by a few different names including 'Structure from Motion' (SfM), '3D reconstruction', and also simply 'photogrammetry'. The term 'photogrammetry' is currently being used very widely in maritime archaeology circles to refer to what we, in this paper, are calling 'photogrammetric 3D reconstruction'; however, we have avoided using that term to avoid confusion with traditional photogrammetry. The term 'photogrammetry' traditionally refers to the science of making measurements from photographs and although that occurs at a very high-density in photogrammetric 3D reconstruction, the later stages of generating a digital 3D model is beyond the scope of traditional photogrammetry. We have used the term 'photogrammetric' in front of '3D reconstruction' to avoid confusion with other forms of 3D reconstruction, such as laser scanning, manual modelling or specifically the physical reconstruction of the Batavia hull in the WA Museum Shipwreck Galleries. After initial usage of the 'photogrammetric 3D reconstruction' term, we will drop the term 'photogrammetric' and just use '3D reconstruction' through the rest of the discussion unless there is ambiguity.

Photogrammetric 3D reconstruction is a multi-stage process. In summary, the stages are: (a) feature points are identified in the photographs (Lowe 2004); (b) feature matching is performed to find matching features between photographs; (c) the relative position, orientation and lens parameters of the camera(s) used to capture the images, as well as the 3D coordinates of the feature match points are estimated using a bundle adjustment algorithm resulting in a sparse point cloud (Wu *et al.* 2011); (d) a dense point cloud is calculated; (e) a mesh is laid over the dense point cloud to generate an un-textured 3D model of the object; and, (f) the original photographs are projected onto the mesh to generate a textured 3D model of the object. The end result, if the process has completed successfully, is a photorealistic digital 3D model of the original object. The accuracy of the model will depend upon a range of factors.

Typically, photographs for 3D reconstruction purposes are captured in a methodical manner that captures all surfaces using overlapping imagery, and ensures all areas are imaged by at least two camera angles, if not more. Examples of work using photogrammetry techniques to create underwater 3D reconstructions include: Balletti *et al.* (2016), Edwards *et al.* (2017), McCarthy and Benjamin (2014), and The Thistlegorm Project (2017). All of these projects intentionally captured images for the purposes of photogrammetry and, hence, the images were captured to optimise image overlap and coverage. However, in some cases large reconstructions can be created from datasets that were not originally intended for photogrammetric 3D reconstruction (Hollick *et al.* 2013, Helmholz et al. 2020) but this is dependent on the actual structure of the captured imagery. Our goal with this project was to determine if the historical 1970s photographs of the Batavia wreck site could be used to create 3D models of the wreck as it existed underwater before excavation, using these 3D reconstruction techniques.

Some of the underwater photographs of the Batavia wreck site were captured for the purpose of generating a 2D photomosaic of the wreck site areas. A 2D photomosaic is usually photographed by swimming the camera over the desired area, maintaining the camera to always point in the same direction (e.g. directly down), and taking photos with approximately 20% to 50% overlap between adjacent images. A successful 2D photomosaic can be generated with as little as 5% overlap (or perhaps 1% overlap in exceptional circumstances) but more overlap makes the stitching process easier. A 2D photomosaic will have more coverage of an area than a 3D reconstructed model from the same image set because a 2D photomosaic can still be created in single photo coverage areas whereas a 3D model can only be reconstructed in areas of image overlap. However, a 2D photomosaic assumes a flat site, which can impose significant distortions on the imagery if the area is not flat.

The 3D reconstruction process can generate digital 3D models of areas and objects, which are not flat, and also allow site measurements to be obtained. The 3D reconstruction techniques also allow much more detailed and realistic 3D rendering of an area than can be generated with 2D photomosaic techniques; however, it requires a higher density of images.

The photography

In the 1970s, just over 3500 images were captured of the Batavia underwater wreck site by Jeremy Green and Patrick Baker (Baker and Green 1976). The photos were captured using Nikonos underwater 35mm film cameras fitted with water-corrected uw-Nikkor lenses. The 28mm lens (59° diagonal coverage) was used for the entire photo-mosaic recording, with a 15mm lens (94° diagonal coverage) used from 1974 onwards for all other underwater photography. Most of the site-recording photography was obtained using black-and-white film, and colour film was widely used for general photography. Some stereoscopic 3D photography was also produced for both photogrammetry and stereoscopic viewing purposes.

The first step in the project was digitising all of the underwater photographs from the Batavia excavations. At the commencement of the digitisation process, three different scanning solutions were tested and compared: an Epson 1000XL flatbed scanner with transparency capability, a DSLR camera with film holder attachment, and a Nikon Super CoolScan 4000 film scanner. The Nikon film scanner was found to offer the best resolution and least noise of the three systems tested. The Nikon film scanner was used to digitise the photographic negatives and save them as lossless compressed TIFF files. Some of the photographs had already been digitised as either TIFFs or JPEGs prior to the start of this project (van Duivenvoorde 2015), however, a large quantity of images had not been scanned, and some rolls were rescanned. The photograph collection was organised into numbered rolls of film, ordered by the date they were taken. Each image file was named by the initials ‘MA’ (Maritime Archaeology), film number and image number—e.g. ‘MA104_13’.

The film collection also includes many images captured above-water, for example of objects and timbers as they were recovered from the sea floor—these were not scanned for this particular project.

Another aspect of the image collection is that the images were collected over several seasons. At the beginning of the project a large series of photographs were taken for the purposes of creating a 2D photo-mosaic of the whole wreck site prior to excavation commencing. As excavation progressed, frequent small-area 2D photo-mosaics were created to produce a detailed record of the newly revealed layers.

As mentioned previously, some of the underwater photographs were captured for the purpose of generating a 2D photomosaic. The intention was to capture images with 50% overlap but due to the difficulty of swimming a turbulent site, the extent of overlap varied considerably.

Applying 3D reconstruction processing to a legacy dataset offers many challenges. In the days of film, there was an inherent reluctance to take any more photographs of an object than were absolutely necessary. Apart from the relatively high cost of film and processing, there was a maximum of 36 shots on a single roll of film. Once the last shot was reached a new roll could be loaded, but in underwater photography this would require a return to the surface and a complicated and delicate process of opening the watertight camera, changing the roll and re-closing the camera whilst maintaining the integrity of the important watertight O-ring seal. Additionally, there was then the lengthy developing and processing time involved in producing a print. All of these factors would normally act to reduce the number of photographs captured.

It has been generally considered that there would be limited scope for 3D reconstruction processing of a random legacy dataset from the days of photographic film. In this particular instance, some of the photography was captured for the purposes of generating a 2D photomosaic with an intended 50% overlap; hence, the potential for success in 3D reconstruction processing is likely to be higher. The question remained as to how successful 3D reconstruction processing of this dataset would be and this would depend upon the actual extent of overlap, the actual quantity of images captured, and the complexity of the site. Would it work?

Methodology

Data processing

Currently one of the most commonly used software solutions for photogrammetric 3D reconstruction is Agisoft PhotoScan (Edwards *et al.* 2017; McCarthy and Benjamin 2014; PhotoScan 2017) (recently renamed Agisoft Metashape), and this was our first step with this dataset. One of the challenges of this particular dataset is that although the images are from one site, the images show several different areas of the site and the images are not all joined. While there were some early successes with building 3D models using PhotoScan, it was found that PhotoScan would often only align a fraction of the images it was provided from this collection.

The problem appears to be that PhotoScan is optimised to assume all photographs are of a single subject and will only try to build a single model from the dataset. In the case of this dataset, the photographs covered many different areas from which we would expect lots of different, non-connected, models to be generated. When PhotoScan processed the dataset, it appeared to select a starting point in the image set, and build the 3D model from there. If there were additional 3D models, which did not connect to this starting point, it would not process them. Therefore, in order to generate multiple 3D models it would be necessary to import subsets of images (not the full dataset) and commence processing on those images one subset at a time. While there were some ways we could attempt this manually, such as using the dates the photographs were taken to divide them into likely matches, we wanted an automated process to save time, to be repeatable if more photographs were scanned, and to catch any unexpected matches between photographs.

A solution we found to overcome this problem was to use another program to segment the dataset into groups of images which were likely to generate separate models—this program we used for this step was VisualSFM (VisualSFM 2015). VisualSFM was one of the early programs available for photogrammetric 3D reconstruction, is freeware, but is now fairly dated (the latest version 0.5.26 was released February 2015). When VisualSFM works through a set of photographs it will identify and process multiple groups of images to generate multiple 3D models. These groups do not need to have any common features between each other. We used VisualSFM to feature match the entire image dataset, which identified a large number of possible models. VisualSFM is also able to generate 3D models from these groups; however, perhaps due to its age, does not perform as good a job at generating visually appealing 3D models as PhotoScan does. The groups of images identified by VisualSFM were imported into PhotoScan and processed to firstly align the photographs and, if possible, build a 3D model.

In addition, another set of image groups were run through PhotoScan, using VisualSFM's matches as a guide. This new group was a copy of the previous groups, but the photographs included in each group were expanded by adding the remaining photographs from any roll that was in the build. That is, if a group included the photograph MA104_27, then all the photographs from roll MA104 were added to that group. If the group also included images from MA106 and MA108 then the expanded group would comprise all the photographs in MA104, MA106 and MA108. This approach was to test whether PhotoScan could match more images than VisualSFM once it had a narrower image set to focus on than the entire photograph collection.

Broadly both sets of image groups (original and expanded) were successful, producing models from across the entire photograph collection. In several cases photographs were aligned but no useful model was produced, indicating an erroneous alignment. One set was not more useful than the other, as they had different successes.

Model review process

Once the processing of the two sets of images was complete, which generated many 3D models, there were some duplicates of the same areas and some malformed models due to poor camera alignment. To reduce work for the following steps, a master build set was created for selected builds to be copied into and worked on further. To create this master build set, a spreadsheet of the 3D model builds was compiled, organised by the photograph rolls used to build them. This allowed us to clearly see which 3D models came from the same rolls, and was likely to be of the same area and time. By working through the spreadsheet it was possible to select 3D models of unique portions of the wreck site. Where multiple models showed the same area, the largest and clearest of them was selected. Models, which had poor photograph alignment, were discarded.

Figure 1a shows a 2D photomosaic of the Batavia debris field created using analogue methods by Green and Baker in the 1970s (Baker and Green 1976), and Figure 1b shows the 3D model (bordered in blue) generated during this project from the same images using the photogrammetric 3D reconstruction method, laid over the top of the photomosaic. As can be seen from this figure, the 3D model has significant gaps and is not as extensive as the 2D photomosaic.

It is common for reconstructed 3D models to have gaps or voids and this can occur when a portion of the object or area is not photographed by at least two camera angles, or not photographed at all. For example, the underside of a cannon might not appear in any photographs and would simply not be created. It might also occur if there was insufficient overlap between successive images. Fortunately, filling the gaps or voids was fairly straightforward as PhotoScan has an option when building the model's mesh to 'extrapolate' the mesh, which fills gaps.

The 3D model is not as extensive as the 2D photomosaic for two reasons:

a. The first reason is that in the right-hand side of the photomosaic, successive images had only a small amount of overlap—sometimes as little as 20%. Although the aim on site was to photograph the area with at least 50% overlap, the reality after a challenging day in the field can be quite different. The 3D reconstruction process cannot generate 3D models from images, which only have a small amount of overlap, hence, the software was not able to generate a 3D model in areas on the right hand side. At present, there is no way to overcome this limitation.

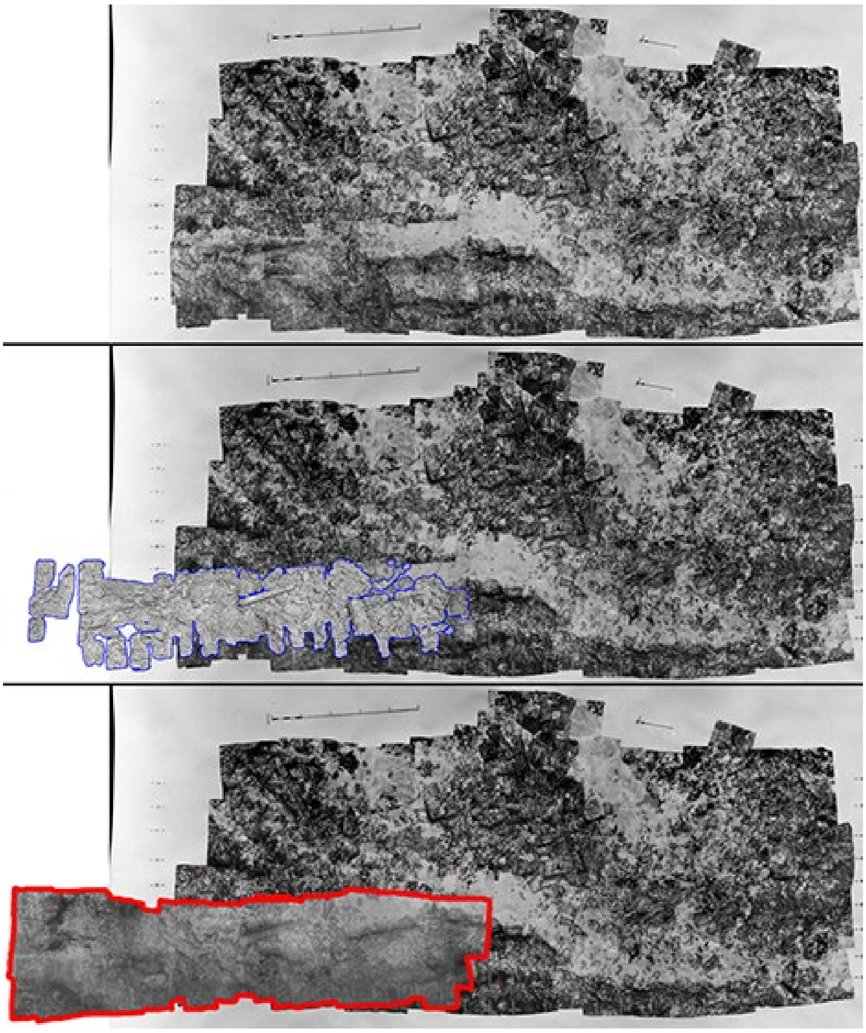

Figure 1. Photomosaic and 3D model of the Batavia.

b. The second reason is that even in areas where there is good overlap, a 2D photomosaic can be generated right up to the very edge of the area, which has been photographed, whereas the 3D reconstruction process can only build 3D models out as far as there is coverage by at least two camera images. A solution to this limitation is discussed below.

Expanding the 3D model

In order to generate a 3D model which combines the good 3D model detail achieved from the 3D reconstruction process with the wide coverage of the 2D photomosaic, we propose a new supplementary processing stage to produce an 'expanded' 3D model. In effect this process uses the detailed 3D model where enough data exists and pads this model with a 2D photomosaic where images are available. With this process the mesh of the default 3D model is 'expanded' at the edges to provide additional smooth canvas onto which 2D images from the edge of the 3D model could be laid on to. Thus, where enough image coverage was available to build a 3D model, that 3D model is used. However, where there is only enough information to produce a 2D photomosaic, the 2D photomosaic process is used.

The 'extrapolate' feature in PhotoScan performs in a similar manner to this by building beyond the default area of the 3D model, and filling gaps. However the extrapolated canvas that PhotoScan generates bends inwards, making it appear as if the model was sitting in a bowl or bathtub.

The method that we used did make use of the 'extrapolate' feature in PhotoScan to fill gaps in the model, but we use a separate method to generate the 'expanded' canvas around the default 3D model. Explaining this in more detail, 3D models were built in PhotoScan with the 'extrapolate' feature enabled. The models were then exported to another program, Autodesk Meshmixer (Meshmixer 2017) (free and in beta at the time of the project). In Meshmixer, the

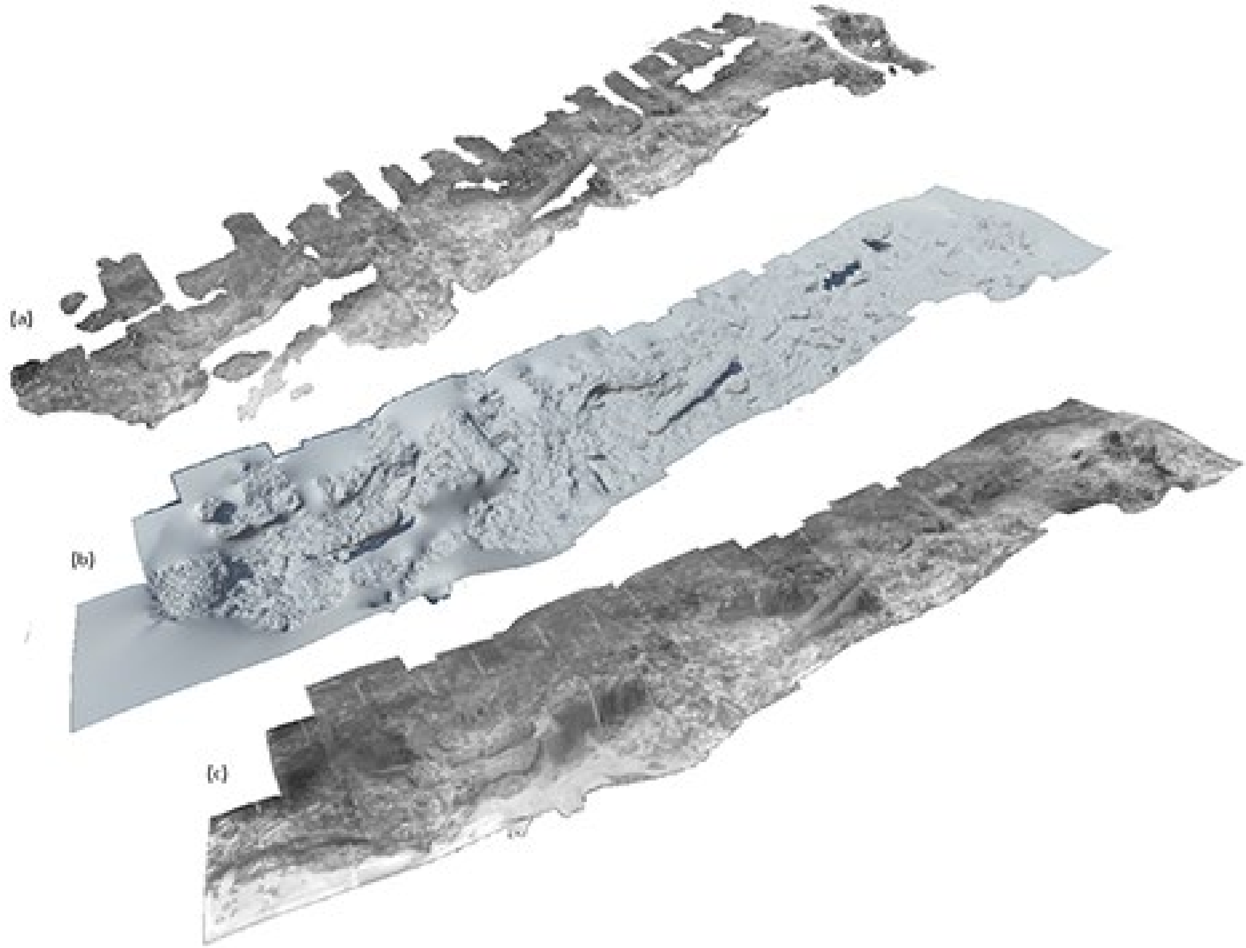

Figure 2. 3D model of the Batavia following application of PhotoScan and Meshmixer.

curved surrounding surface (created by the PhotoScan 'extrapolate' feature) was cut away. The edge around the remaining 3D model mesh was extruded in Meshmixer creating a smooth border surrounding the model. This 'expanded' mesh was then imported back into PhotoScan, where the photographs were reapplied to the model using the 'Build Texture' command.

An illustration of how this process works is provided in Figure 2. Figure 2a shows the default 3D model generated using the standard 3D reconstruction process. Figure 2b shows the mesh after it has been exported from PhotoScan and expanded in Meshmixer. The rough looking areas are the original 3D model and the smooth areas are the expanded area. Figure 2c shows the final 'expanded' 3D model after it has been imported back into PhotoScan and the textures applied onto the expanded mesh. When presented like this on a flat page the undulations and 3D detail are not easily apparent—the untextured mesh of Figure 2b provides the best hint of the 3D structure—but when viewed on a stereoscopic 3D display, the final 3D model becomes vivid and realistic.

Referring to Figure 1c, it can be seen that the resultant expanded 3D model covers substantially more than the original default 3D model. Unfortunately, this expanded 3D model has not covered the full area that was captured in the 2D photomosaic (due to the lack of image overlap as mentioned previously) but it has covered additional area that was not covered in the original 2D photomosaic (on the left). Other areas of the debris field 2D photomosaic have been built into 3D models but these are separate models not shown here.

Results

Using the above techniques a total of 22 unique 'expanded' 3D models were generated from the Batavia underwater photography dataset. The most extensive 3D model is of the Batavia debris field, as shown in Figures 1 and 2, and was built from 105 images. Another three 'expanded' 3D models (illustrated in Figure 3) have been built showing other parts of the debris field area. Another 13 'expanded' 3D models (illustrated in Figure 4) were built from the dataset. These 3D models show various sections of the Batavia hull timbers as they

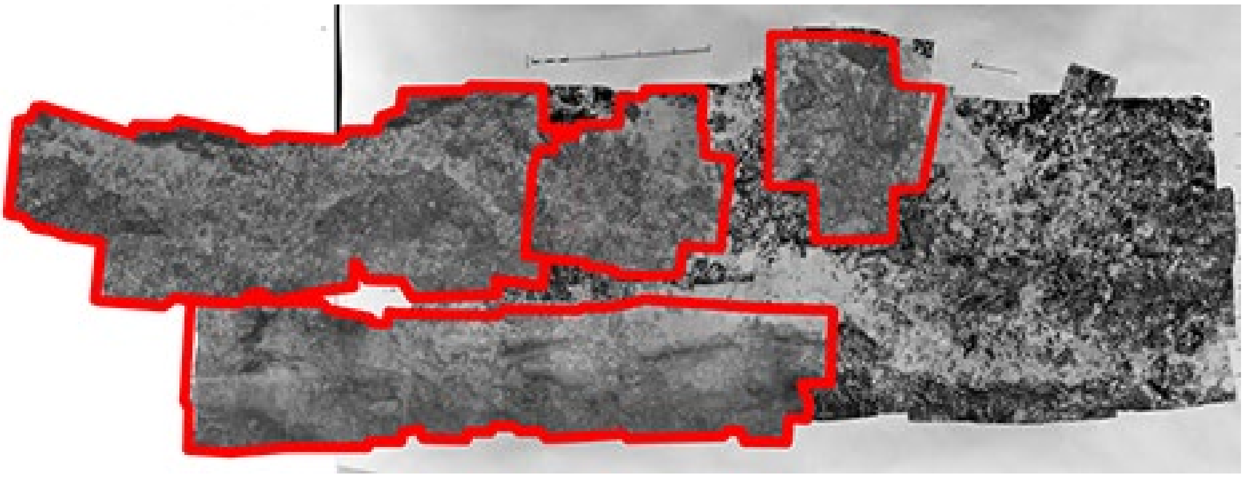

Figure 3. Expanded 3D models of other parts of the debris field area.

were being progressively uncovered and recovered. A few more 3D models were generated but are not shown here because they were relatively small, or have not had their position located.

Aligning the models

Once all the 'expanded' 3D models had been generated, it was desired to work out their orientation, position and size in relation to each other and to the wreck site as a whole. Two site references were used to assist with aligning the models—the 1970s 2D photomosaic mentioned earlier (shown in Figure 1a) and a set of hand-drawn line drawings of the Batavia hull timbers from van Duivenvoorde (2015). These two site references conveniently match a divide in the kinds of models created. Some models show the wreck site from before excavation (the debris field) and others focus on the timbers. The models from the debris field use the same photographs as those for the 2D photomosaic.

There are several pieces of information on a model, which could be used for alignment. Firstly, as the site was excavated markers were placed on timbers identifying them with a unique code. These codes correspond to how the timbers are identified in the timber diagrams. However, not all timbers are marked in all of the models. Secondly, the photographs used to make the models are all dated. The excavation progressively moved along the Batavia over time, and so in some cases these dates should roughly indicate the position of the model. Finally, prominent features in the models can be seen in the reference images as well as other models.

The alignment process was performed in a specially written program using Unity (Unity 2017). Unity is a virtual environment, simulation, game engine and editor program. The editor allows for the manipulation of 3D objects in a 3D environment. The reference images and the models were imported into Unity, so that the models could be directly compared to the references (shown in Figure 5). A script (program inside Unity) has been written to scale and position a model to a reference point. For example, a cannon in a model could be mapped to the cannon in a photomosaic and the script would move and scale the model so that its cannon aligned with the cannon in the photomosaic. Using the information outlined above, models were aligned to the reference images where possible. The remaining models were then aligned, if possible, to other aligned models. This left only a few models, which could not be aligned. These models were typically focused on a single feature, which was not marked, such as the muzzle of a cannon or a single timber.

Figure 4 roughly shows the positioning and orientation of the ship timbers 3D models in relation to the hull timbers diagram.

Discussion

It has been pleasing to see that 3D reconstruction processing of the Batavia underwater wreck site legacy image set has yielded a high number of detailed and expansive 3D models of the site. The 'expanded' 3D model technique has produced more visually useful models than was possible with existing techniques.

It is important to point out that the 'expanded' 3D model technique described here produces models, which are representative of the site and are not completely accurate. The expanded area is an approximation of the area, much like the 2D photomosaic assumes that the entire area is completely flat. In the case of a legacy dataset like this one, where the default 3D

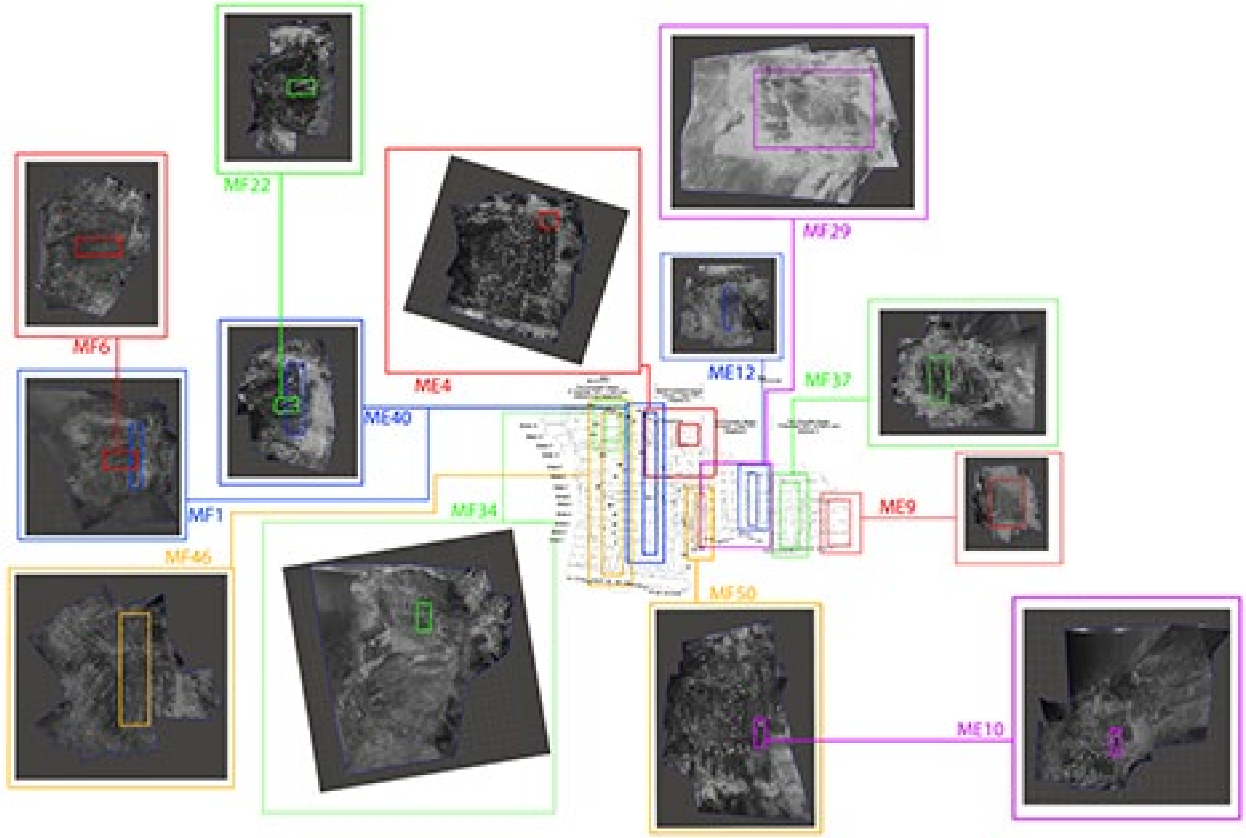

Figure 4. 13 'expanded' 3D models in relation to the positioning and orientation of the hull timbers diagram.

reconstruction process is unable to fully build complete 3D models, the 'expanded' 3D model process allows us to squeeze additional value out of the dataset. In some cases it may be important to know which areas have been expanded and, hence, are more representative than accurate. Thus, we implemented a technique in Unity where the expanded area could be switched on-and-off or made semi-transparent to clearly identify those regions in comparison to the 3D reconstructed 3D model areas. The general public will likely much prefer the expanded 3D models because they offer a more complete view of the site than the default 3D models, whereas a maritime archaeologist will likely wish to be able to switch between both the default 3D model and the expanded 3D model.

The work conducted on the dataset revealed that there had been some errors made with the 2D photomosaic. Some areas had been overlapped, repeated or stretched; however, this is to be expected with the manual analogue procedure used to construct the 2D photomosaic. We did attempt to use modern photo-stitching software to regenerate the 2D photomosaics; however, this was not successful beyond a few images. We also tried to improve the extent of the default 3D models by adding more images to the debris field model by adding manual tie points, however, this was not successful either.

The 3D models developed in this project can be imported into virtual environment software to illustrate the wreck site in a virtual reality (VR) experience using a range of different display hardware—ranging from large immersive 3D displays, to head-mounted displays, to regular desktop displays. The 3D models developed in this project can assist further archaeological examination of the site, or can be used to generate engaging displays for museum visitors. These museum displays may take the form of virtual 3D environments, which can be used as interactive virtual tours. This could allow visitors to undertake a self-guided or instructor-guided exploration of the site. Furthermore, these techniques may allow other image sets held by the WA Museum to be reconstructed both for analysis and presentation (Shaw *et al.* 2018).

There are a number of aspects of future work that could be progressed. The first is the generation of a single 3D model of the ship hull timbers by joining together a series of separate 3D models. The various 3D models do not currently show the entire hull in one model because the site was progressively uncovered in stages and the

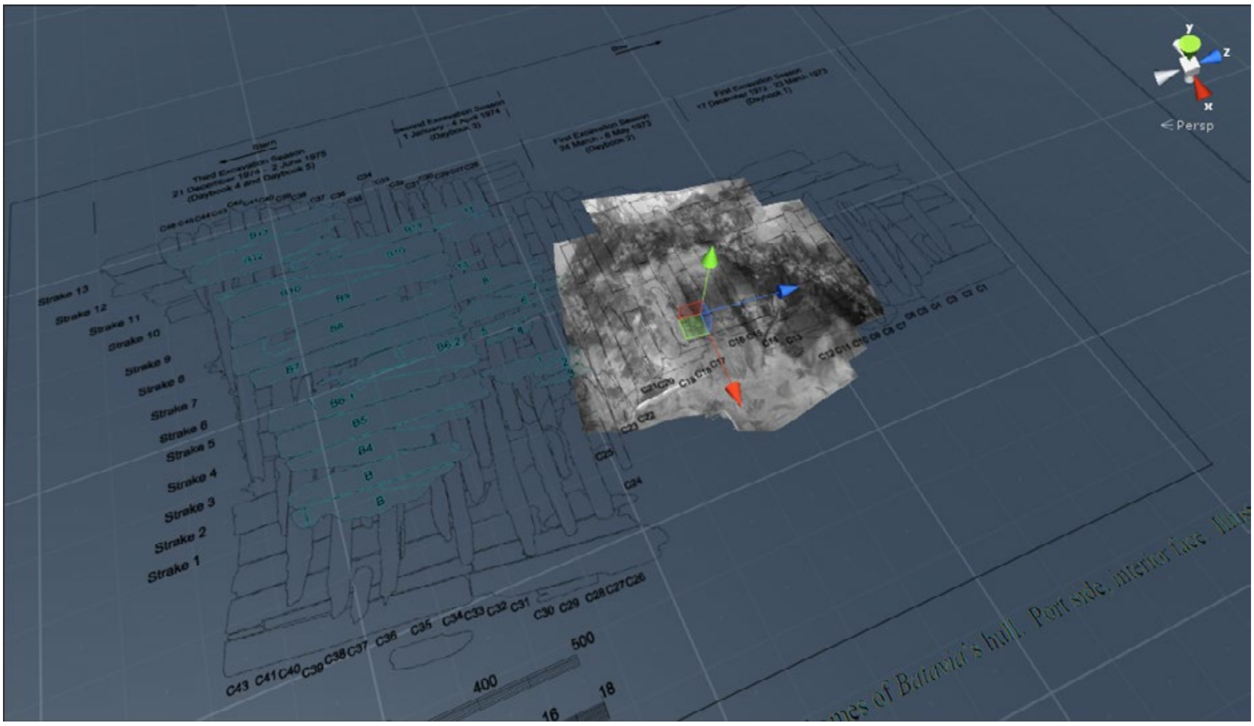

Figure 5. Comparison of the reconstructed 3D models to the line drawings using Unity.

various 3D models show progressive sections of the whole. Once timbers were uncovered and recorded, the exposure to the destructive seas often required them to be promptly raised, making further seabed recording impossible.

A process of manually arranging and joining the separate 3D models of hull sections will likely be necessary using 3D model editing and animation software. Similarly a more complete model of the debris field could be generated. Once these 3D models have been created it would be good to include them in the virtual reality simulation of Beacon Island titled ‘Beacon Virtua’ (Beacon Virtua 2016), which would allow users to visit the Batavia wreck site similar to how the museum staff saw it in the 1970s.

Conclusion

We have applied photogrammetric 3D reconstruction techniques to the 1970s legacy photographic collection of the Batavia wreck site to generate a large number of detailed and expansive 3D models. Legacy datasets can be very challenging for 3D reconstruction processing because the images will not have been captured with 3D reconstruction processing in mind and, hence, there may be gaps or lack of sufficient overlap between images. The success from this particular dataset has been improved because of the large number of photographs captured and because the photography was captured with the intention of generating 2D photomosaics.

On a technical level, we have: (a) implemented a technique to gain as many 3D models as possible from a large image set; and, (b) developed a process for generating ‘expanded’ 3D models, which improves the expanse and quality of 3D models generated from legacy photographs.

The 3D models developed in this project show the Batavia wreck site from a new and different perspective to the original photographs, and the photomosaic made from them. In our opinion, the 3D models make it easier to understand the overall composition and layout of the site. By comparison the photographs often focus on specific details and do not provide an overview, whereas the models each cover large areas, while still providing similar detail.

The models are limited in a few ways. Where the photographs were not in focus, or where something changed between photographs, the models will be hard to make out. Timber markers in particular are often illegible. Areas that did not have sufficient photograph overlap will be built poorly, sometimes leading to confusing shapes. The black and white colouring from the photographs can also make it difficult to make out the shape of the models when viewed in 2D.

We anticipate that the digital 3D models generated in this project will be used to develop new museum visitor experiences.

Acknowlegements

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Integrating Legacy Excavation Survey Data with New Technologies—the James Matthews Experience

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Abstract

This paper supports the contention that legacy excavation data, when integrated with new technologies, can provide valuable information to maritime archaeologists, which otherwise would not be obtainable. The Western Australian Museum (WAM) carried out four seasons of excavation and reburial on the James Matthews wreck-site between 1973 and 1977. During the 1975–1976 excavation archaeologists completed a detailed three-dimensional (3D) *in-situ* survey of the fully exposed starboard hull from keelson to deck level, and from bow to stern, recording almost 5000 points of interest. Digitising the full 3D survey data from the original survey sheets, held in the archive by the Maritime Archaeology Department at WAM created the opportunity to develop a fully 3D digital model of the buried remains of the *James Matthews* shipwreck using AutoCAD software and powerful computer processing with graphic capabilities. By rotating the view of the digitally reconstructed model, the shape of the hull and orientation/alignment of structural timbers became evident, revealing distortions and the effects of wreck event and post wreck-site formation processes not previously seen by visual inspection underwater or from the 2D plan. The 3D digital model also provides validation to new non-invasive sub-bottom profiling instruments (marine seismic reflection that penetrates into the seabed), such as the INNOMAR parametric SES-2000 compact SBP, for *in-situ* management and archaeological research purposes.

Keywords

James Matthews, legacy survey data, 3D digital model, wreck-site formation processes, sub-bottom profiler

Introduction

This paper examines, re-analyses and integrates with new technologies the legacy 3D survey data obtained from the original 1970s and 2000 archaeological and conservation surveys of the excavated, and subsequently reburied, *James Matthews* (1841) wreck-site. The significance of this legacy data, how it was collected, interpreted and presented using the technologies available at the end of the 1970s is also described. The survey data, together with archival information contained in the excavation Day Book (Henderson 1977a) including published accounts (Baker and Henderson 1979; Henderson 1975, 1977b, 1976), is used to construct a digital 3D model of the buried remains using AutoCAD software for the prime purpose of inter-comparison with, and validation of, sub-bottom profiler (SBP) data captured over this site.

The 3D model is also used to validate diver observations noted in the excavation Day Book regarding the hull orientation and shows damage not previously identified to the starboard hull resulting from wreck-site formation processes. Transforming the survey data into the 3D model demonstrates that legacy excavation data, when integrated with new technologies, can provide valuable information to the researcher which otherwise would not be obtainable.

James Matthews—Historical Background

The snow brig, *James Matthews*, was wrecked on the northern side of Woodmans Point, 7km south of Fremantle, Western Australia, on 22nd July 1841 (Figure 1). Little was known of the history, significance and shipwreck remains until the site's discovery in 1973 and the subsequent excavations, surveys and extensive archival research activities led by Graeme Henderson of the WAM. The legacy remaining from this wreck-site is not just about one known vessel, but rather three (*Voltigeur*, *Don Francisco*, and *James Matthews*). The excavated and reburied remains of the vessel are of 'international historic and archaeological significance' (Henderson 1977b: 79). While much information has already been gathered about this vessel, its trade and those who have owned or sailed aboard (see Henderson 2009), much more, however, can be learned from the remaining archaeological and archival material.

Between 1835 and 1841 the brig *Voltigeur*/*Don Francisco*/*James Matthews* operated as a slaver, a cargo vessel and an emigrant ship. The vessel was built in Bordeaux, France, as a slaver by Gabriel Giraud and launched as the *Voltigeur* on 1 January 1835. Following several voyages to Brazil, the brig was sold in 1836 to Don Francisco Felix de Souza, the notorious slave dealer of Whydah, and entered the Atlantic slave trade under

Figure 1. Location map of *James Matthews* wreck-site (Google Maps).

the Portuguese flag as the *Don Francisco* (Henderson 2009: 67–70). By 1837, with its sails and rigging nearly worn out, the ship was leaking along the bottom and the waterline due to extensive wood borer attack and overloaded with 433 slaves; the *Don Francisco* was overhauled and captured by HMB *Griffon* near the Caribbean island of Dominica. It was subsequently condemned by the British and Portuguese Mixed Commission Court, sold to Charles Leathem, repaired and renamed as the *James Matthews* (Henderson 2009: 107–230). The vessel entered general cargo duties and was further resold. In London, UK, Henry de Burgh took a mortgage over the vessel in March 1841, an agreement that he would pay for the vessel over time and become the vessel's new owner, with the purpose of sailing to the newly established Swan River Colony with general cargo, farm implements, 7000 slate tiles, fifteen crew and four passengers (Henderson 2009: 231). The *James Matthews* arrived safely at Fremantle on or around 21 March 1841 and moored at Owen's Anchorage. The following night during a gale, the anchor cable broke; the vessel drifted towards Woodmans Point and, having struck the bottom, sank broadside in heavy seas. The main mast was cut away in an attempt to right the ship (Henderson 2009: 255–59; Henderson and Stanbury 1983:16). Other accounts by Henderson (2008: 40–46, 1977b: 79, 1976: 245–46, 1975: 40) describe varying aspects of this history.

Wreck-site excavations

Following its discovery in July 1973, the WAM undertook multiple maritime archaeological excavations and surveys on the *James Matthews* site between 1974 and 1977 (Baker and Henderson 1979; Henderson 1975, 1976, 1977a, b). A limited excavation was undertaken by WAM staff and volunteers during January to April 1974, with the purpose of raising the upper layers of slate and assess the extent and condition of the site. During the summer of 1974–75 a second limited excavation was carried out to uncover part of the hull for recording and to recover any exposed cargo items and ship's equipment. The principal aim of the extensive (twelve weeks duration) 1975–76 excavation was to record the entire ship's structure, and to complete the raising of small artefacts for protection, conservation, and display. A survey of material lying outside the main hull structure was undertaken during a final short excavation season in the summer of 1976–77. Following each excavation season, the site was back-filled with stockpiled sand to provide protection to the exposed shipwreck remains.

Legacy survey data

The archaeological and historical value of this wreck-site, and of the associated legacy survey data, results from the well preserved, documented and either reburied or raised hull, rigging, cargo and personal items. The hull 'is a rare example of an Atlantic slave trader wreck of the illegal era, when slavers, built as slavers, were of a distinctive hull shape ... the only one that has enough surviving structure to develop reliable lines' (Henderson 2009: 269). Existing plans of slave ships are extremely rare so the hull of the *James Matthews* provides the only source of detailed nautical architectural information on the special requirements of shallow draft, fine lines for speed and various internal fittings and layout for the slave trade (Henderson 1975: 41, 1976: 246–47, 1977b: 79). Due to the anaerobic conditions under the hull, the surviving cordage provides unique examples of ship's rigging and demonstrates that 'standard books of the period are not fully representative' (Henderson and Stanbury 1983: 26). Most of the cargo found was owned by those on board the *James Matthews* and was intended for an agricultural pioneering enterprise. These settlers' supplies provide one of the earliest local collections and are of historical importance (Henderson 1975: 41, 1976: 247). Small personal items recovered from the *James Matthews* wreck-site may have come from its period as a slaver (having slipped between interior timbers), such as a short-stemmed clay pipe 'which is similar in appearance and dimension to one found with a male

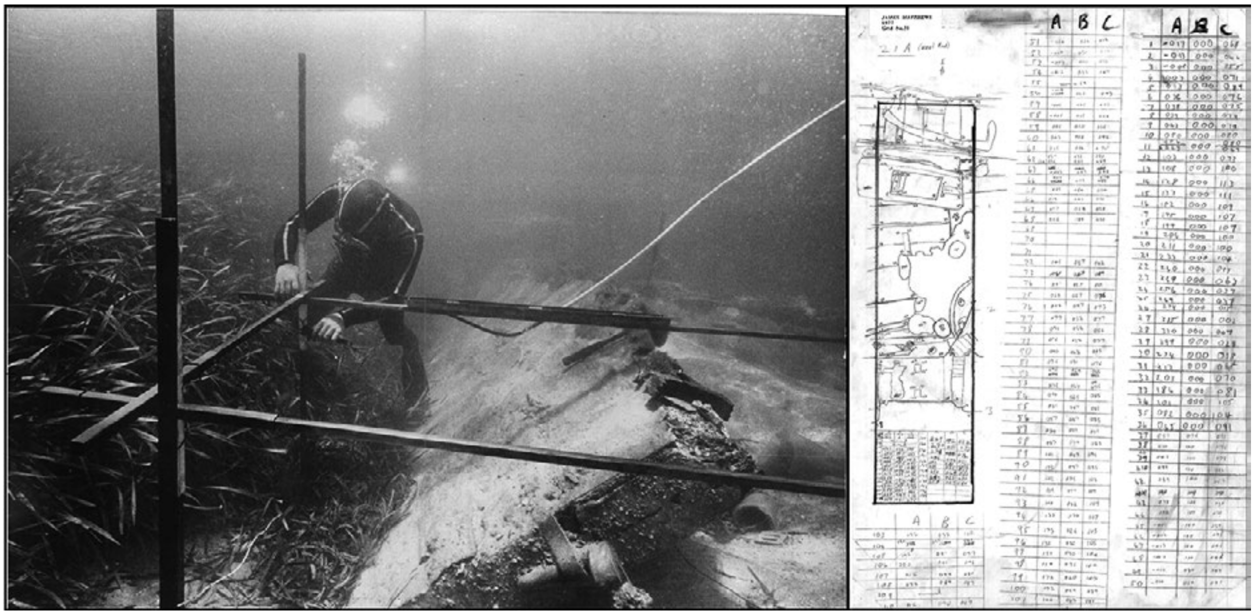


Figure 2. 3D underwater recording frame used on *James Matthews* site (P. Baker, WAM) (left), and typical survey sheet from underwater survey *James Matthews* site (right).

burial at Newton plantation, Barbados' (Henderson 2008:47–49, 2009: 305–07). This finding may challenge the assumption that enslaved Africans took very few possessions with them on board slaving vessels.

The 3D underwater archaeological survey during the 1975–76 excavation provides the most valuable legacy information on the shipwreck remains, including the starboard side of the hull from stern to bow and from keel to deck level, ship's equipment, and cargo. Exposure of the full extent of the *James Matthews'* hull required an airlift excavation of 30m x 6m x 0.5–1.5m of sand. Once the timbers were cleared, a 3D recording grid frame was assembled (see Figure 2) and recording commenced. The frame consisted of steel square hollow piping: four legs were initially hammered into the seabed at the stern end; 6m-long sides and 1m-long ends were connected to the legs using purpose fabricated 'sleeves'; all sides and end frames were levelled to form an elevated horizontal plane; and, all key features along the edges and within the 6 x 1m section of the hull were recorded in their horizontal (A, B) and vertical (C) positions relative to the top corner of the frame and the distance below the elevated horizontal plane. Once all recording was completed within that section, new legs were driven into the seabed a further 1m towards the bow and their sleeves set to maintain the same horizontal plane (and vertical height control) and the sides and end frames reconnected. All key features of the entire length of the hull were recorded in 3D by continuously 'leapfrogging' the frame every 1m (Baker and Henderson 1979: 231–34; Henderson 1977b: 75–78). All A, B, C measurements and associated location sketches were recorded by hand on underwater plastic film (Figure 2). In addition, underwater photography was extensively used to document the excavation, including overlapping vertical stereoscopic coverage along each of the 27 6 x 1m survey sections to aid interpretation of the recorded survey data (Henderson 1977b: 237–43).

A two-dimensional (2D) scale plan was drawn based on interpolations between all recorded A and B coordinates, supplemented by the plan sketches and stereoscopic photomosaics, of each grid section. The plan was originally drawn by Henderson on graph paper to a 1:10 scale (2.7 x 0.6m), then photographically reduced in size (Figure 3). Cross-sections of the hull at 1m spacing were also drawn using the A and C coordinates and together with planking and rib thickness measurements, sections up to deck level and preliminary lines plans were drawn (Baker and Henderson 1979: 235–37; Henderson 2009: 289).

It is important to note that the archived survey data, plans and photographic records represent what was found on the *James Matthews* site following excavation, and not necessarily what currently remains after reburial at the end of each excavation season. The bulk of items removed consisted of granite ballast stones, which were moved to one side of the site, and around 7000 pieces of intact and broken slate, which were raised (Henderson 1977b: 77, 79). Other small artefacts raised included construction items (window panes, door hinges and bundles of iron rods presumably intended for blacksmithing), carpenters' tools, domestic items

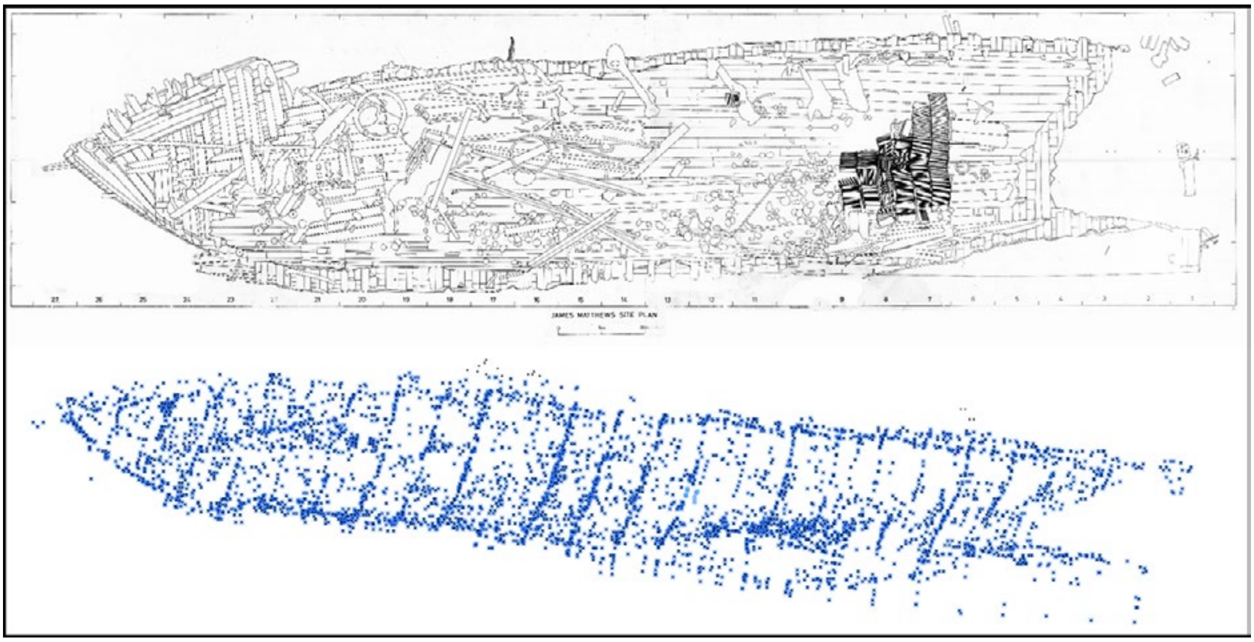


Figure 3. Henderson's 2D plan drawn from 1975–76 underwater survey of *James Matthews* site with 27 x 1m grid sections shown underneath (top), and oblique view of point cloud data used to create the *James Matthews* 3D digital model (below).

and ship's equipment including rigging, skylights, rope, nails, bolts and loose wooden structures (Henderson 1977b: 79).

In response to an observed increase in timber exposure on the seabed and significant loss of sand coverage over the site, WAM undertook a conservation pre-disturbance survey in 2000 concentrating on determining the condition of the hull remains and their suitability for a potential recovery, conservation and exhibition (Richards 2001). In this survey, six test trenches (each approximately 2 x 2 x 2m) were dredged at various locations to measure the extent of degradation of exposed and buried timbers and the corrosion potential of iron structural components. Sediment cores were also collected for chemical, geological and bacterial analyses. Like previous excavations, the test trenches were backfilled to rebury the hull timbers.

3D Digital Model Reconstruction

The 3D nature of survey data collected on the *James Matthews* site during the 1975–76 excavation season has not, up until now, been fully utilised and interpreted. While Ali (2016) digitally re-examined excavation records by modelling individual ship's timbers, which were recovered and recorded, the following section describes how the legacy *in-situ* survey data from the *James Matthews* site was digitised and used in AutoCAD software to create a 3D digital model. This virtual model was interpreted against diver observations made during the original underwater survey and conclusions drawn from scale plans, as well as being used to validate new non-invasive survey techniques.

During the 1975–76 survey, divers annotated 40 x A3 sized recording sheets with location sketches, location ID and A, B, C measurements across all 27 6 x 1m sections. In aggregate, a total of almost 5000 3D location measurements were recorded underwater. These original recording sheets were located in the WAM's Department of Maritime Archaeology archives, scanned at 200 dpi using the Department's HP Designjet T1100 MFP scanner, and for safe keeping and future use, copied to disc and to the Department's computer database as .tif files. Each sheet number, measurement ID and respective A, B and C values were then manually entered into a preformatted Excel spreadsheet. There were many instances where smudging, feint pencil marking and poor handwriting made reading and interpretation of the A, B, and C measurement numbers very difficult, and the use of electronic scanned versions of the original sheets became invaluable due to their ability to be enlarged by 400+ times in order to understand the characteristics of each diver's unique writing style. The 2D scale plan drawn by Henderson was also scanned at 200 dpi on the Department's scanner and copied to disc and the Department's computer database as a .tif file.

The Excel spreadsheet of all recorded survey data was imported into Autodesk AutoCAD 2017—Student Version (AutoCAD) to create a point cloud of data (also comparatively shown in Figure 3) with which to construct the 3D model. The 2D scale plan was converted into a .dwg file and imported into AutoCAD to be used as a visual background layer, as well as to correctly establish the scale of the point cloud data. Quality control checks were made to identify and remove any outlier data points generated by errors in digitisation. Given the density of measurement points along the sides of each 1m survey section, the QSELECT function in the 3D modelling component of AutoCAD was then initially used to draw the cross-sections of the upper face of ceiling planks based on all survey points at each 1m interval. Each cross-section was carefully examined against the background plan layer and the original survey sheets to identify measurement points associated with the ceiling planks and those items positioned on top of the ceiling planks. These latter points were removed and a spline function used to connect the remaining data points to create the initial hull cross-sections. Each cross-section was examined, and where significant gaps occurred between points along the spine, other nearby survey points on the ceiling planks were interpolated into the spline to improve the cross-sectional shape. Once all cross-sections were established, the upper (inside) surface of the ceiling planks was created using the LOFT command to smoothly interpolate between all cross-sections. The average measured thickness of ceiling planks based on the 2000 Conservation survey is approximately 6cm (range 3.5 to 9cm), and this value was used in the EXTRUDE command to create the lower (outer) ceiling plank surface. The ceiling planks then converted into a solid body using the 3D SOLID command.

Once the broad 3D shape of the hull was created in AutoCAD based on the ceiling plank survey data, the keel and additional features located on top of the ceiling planks such as the keelson, the remaining slate mound, pine timber planks, iron ballast and iron deck knees were subsequently added through similar processes. Each major component type was created on an individual layer within AutoCAD so that they could be viewed in isolation, or by turning on/off various layers, viewed in combination with all other layers. The survey points associated with each component were: identified from the background plan and original survey sheets/location sketches; connected by lofting; their thicknesses extruded based from survey information; and converted into solid objects. Clearances, contact and overlap between components on different layers were checked and errors adjusted accordingly. Where exposed and visible, the ship's ribs were drafted in the same manner. However, the majority of the ribs were only exposed at the deck line and keelson with most of their length hidden under the ceiling planks. In these circumstances, their ends were established from respective survey points and their upper surface shape determined by the shape of the underside of the ceiling planks at that cross-sectional location. These cross-sections were then lofted to the correct width, extruded to the measured thicknesses, and turned into solid 3D shapes. The outer planking was modelled in the same manner, using survey points on exposed planking where available, then using the underside of the modelled ribs to set their cross-sectional shape. Loft, extrusion and 3D solid commands were used to create a contiguous outer shape to the hull. Figure 4 shows the progressive development of the 3D with a plan view, and upper and lower slant views of the stern features.

To obtain a consistent digital alignment of many of the structural members in the 3D model was challenging. However, upon completion of the model reconstruction, these members reveal more about the wreck event and post wreck-site formation processes than does the 2D plan, and confirms/extends diver observations during the excavation and recording process. Baker and Henderson (1979: 237) observed 'indications of minor twisting of the keelson'. Figures 4A, 4B and 5A show the keelson significantly twisted both horizontally and vertically with break points around amidships, at the second (rear) mast step and at the stern. The forward section including the main mast step is twisted to starboard and rotated further than the mid-section. Interestingly the keelson and both port and starboard ribs remain intact in this forward section (albeit the port side ribs and planking are less than 1m in length), while the portside connecting timbers are missing in the middle and stern sections. While heavily degraded, the short stern section of the keelson also dramatically changes direction to starboard. The exposed keel at the stern is aligned to the mid-section of the keelson, but its vertical rotation is much greater than all sections of the keelson. Note that the scalloped shape of stern section of the hull does not reflect the design of the ship but rather is the outcome of damage done when a sand dredger 'bit' into the wreck (Pat Baker pers. comm. 22 August 2016).

Baker and Henderson (1979: 237–38) also discussed the practical challenges of accurately measuring the degree of the list of a shipwreck on the seabed, and while they reported that they had measured the angle of the keel and keelson of the *James Matthews* at regular intervals, they did not publish this information. To estimate the degree to which the ship heeled on the seabed, the entire digital 3D model was rotated vertically until the keel was vertical and the top surface of the keelson horizontal; however, as the alignment of the keelson and the keel are distorted, the answer is not simple. Figure 5A depicts a view from the stern with a best fit 30° vertical rotation. The keel remains under rotated (i.e. the list of the keel is greater than 30°), and the mid-section of the keelson is over rotated. The ribs supporting the slate mound were also examined

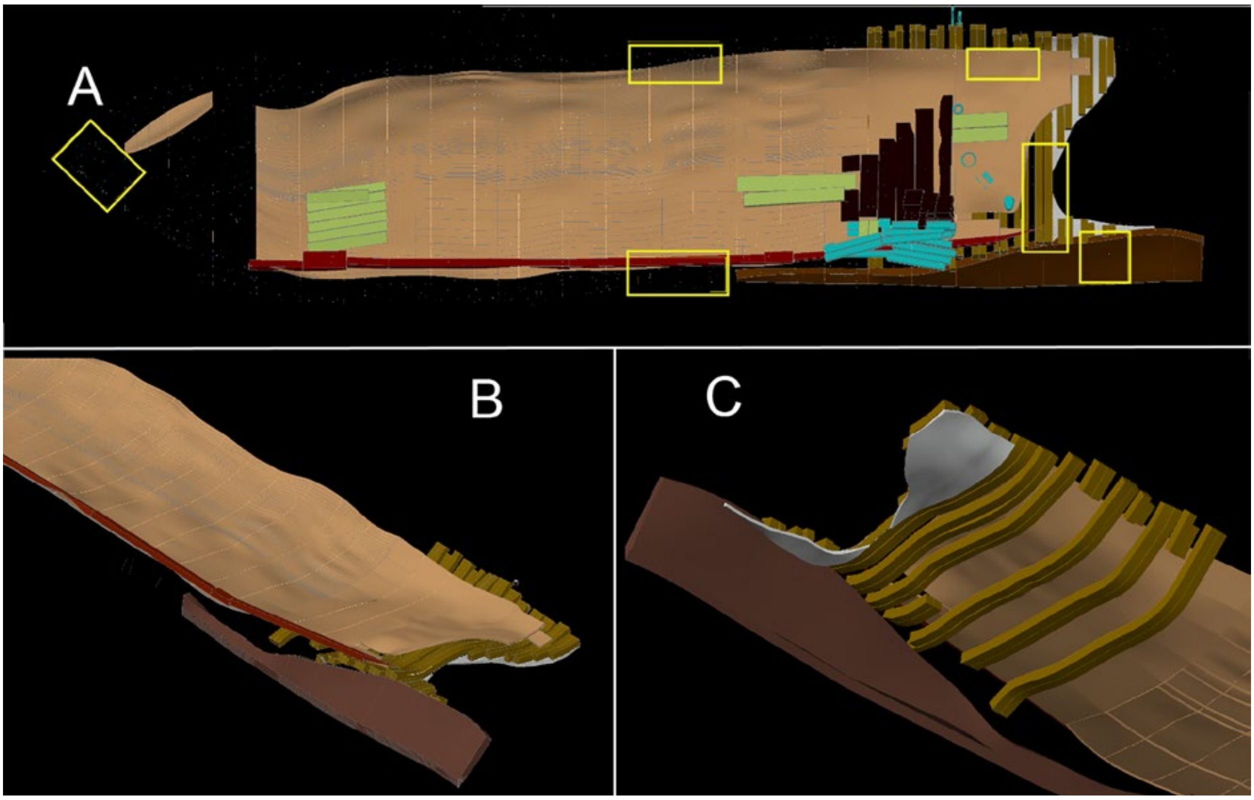


Figure 4. Plan view (A) of partially complete digital model showing keelson and keel (red-dark brown), ceiling planks (tan), ribs (mid-brown), outer planking (light grey), pine cargo timber (yellowy-green), iron ballast (blue), remaining slate mound (black) and 2000 test trench locations (yellow boxes); upper and lower slant views of 3D digital model showing inner face of ceiling planks, keelson and keel (B), and outer face of ceiling planks, ribs, outer planking and keel (C).

following the 30° vertical hull rotation and appeared to be hogged (weakened in the middle and sagged at each end) and with the iron deck knee still slanting towards the vertical (Figure 5B, brown rib). By further rotating this rib 20° around the hog point, a 'fairer' rib shape is produced, and the iron deck knee is close to horizontal (Figure 5B, upper portion of the green rib). This result indicates that during or post the wreck event, the ribs at the stern of the *James Matthews* cracked, possibly under load from the slate mound as it shifted when the hull listed to starboard, and probably when the structural support from the deck beams/port side of the hull was lost. The consequential distortion of the frame is important when interpreting the survey data, as alluded to by Baker and Henderson (1979: 237) that 'such things as a uniform distortion of ribs, or hogging or sagging, might well be impossible to detect and lead to inaccuracies in the resulting plans'.

SBP trial survey

While the digitally reconstructed 3D model of the *James Matthews* shipwreck hull, ship's equipment and cargo provides improved visualisation and new insight into a wreck and post-wreck event site formation processes, its main purpose was to help assess and interpret recent non-invasive SBP trial survey data collected across the site; and, based on a successful outcome of this trial, form the basis of a future quantitative comparative *in-situ* wreck-site comparison. In January 2015 a trial SBP survey was undertaken (Winton and Bergersen 2015) using an INNOMAR parametric SES-2000 compact SBP, with handheld GPS positioning and a theoretical horizontal beam footprint at anomaly depth of around 10cm. This seismic reflection instrument, originally developed for locating underwater buried pipelines, was selected due to its reported high measurement resolution, portability and ease of use (the 34 x 26 x 8cm transducer /receiver head is pole mounted to the vessel, forward of engines to avoid propeller noise, run on 240 volts and data collected and visually displayed in real time via a 30 x 40 x 30cm topside unit) (Innomar 2018). Other commercially available parametric SBPs include the Atlas Hydrographic GmbH (*Parasound*) and Kongsberg Defence Systems (TOPAS PS), and while the TOPAS PS and SES-2000 systems are available in different models optimised to operate in different water depths from very shallow water to full ocean depth, the TOPAS is less popular due to its high cost (Kozaczka *et al.* 2013: 100).

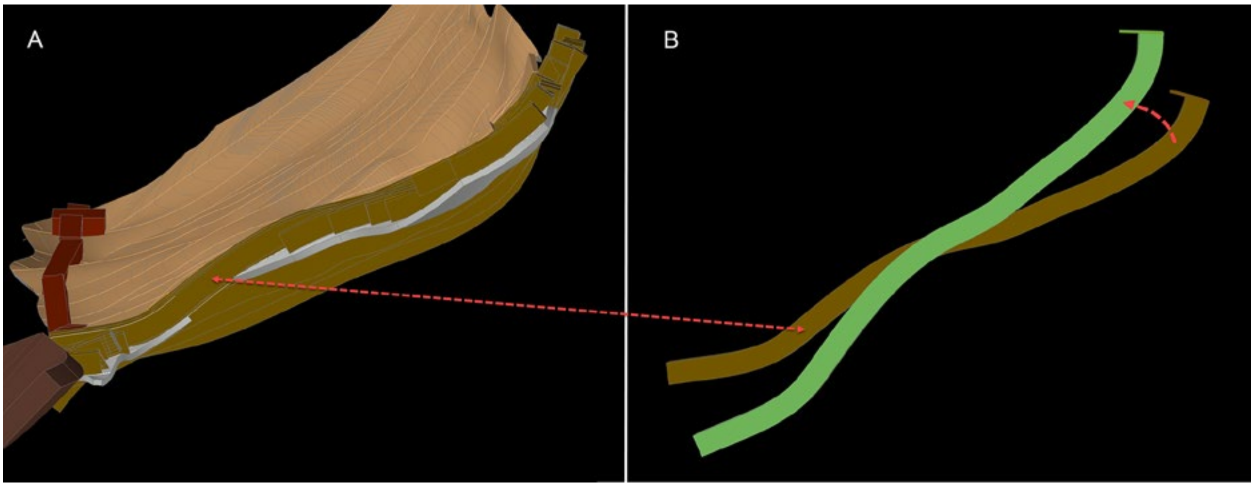


Figure 5. Slant view (A) of hull from stern at 30° vertical rotation showing twisted keelson and keel (red-brown), and end view (B) of hogged ribs cracked 20°.

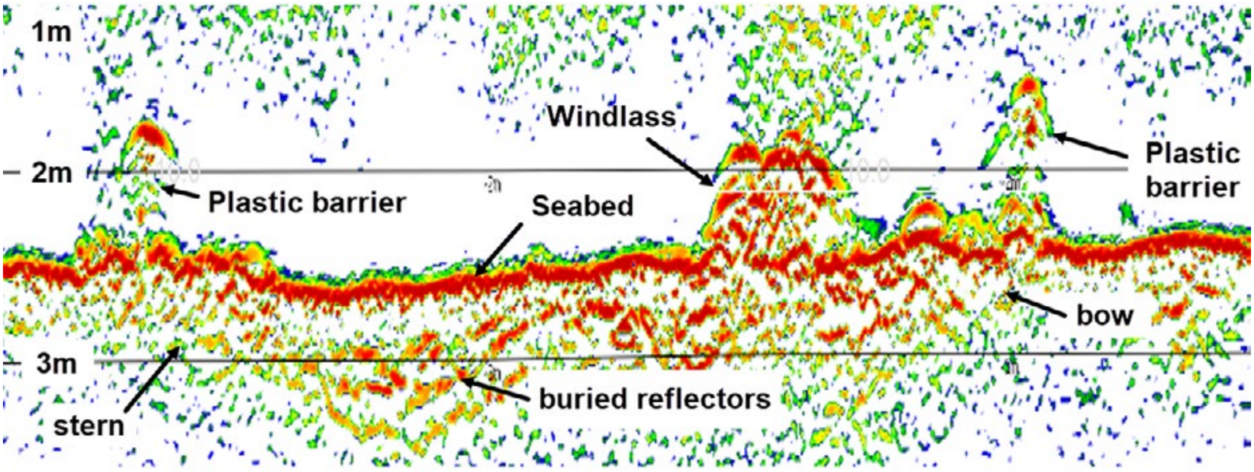
The aim of the trial survey was to ascertain the performance of the INNOMAR parametric SBP in surficial layers of medium–coarse grained calcareous sand, its ability to identify and map buried archaeological material and to quantify the corresponding depth of cover (depth of sediment from seabed surface to upper side of any buried material) (DoC). The results of this trial survey were encouraging with a typical sonar profile in Figure 6 depicting 'envelope summary' data along a longitudinal seismic line running from stern to bow (left to right) across the middle of the *James Matthews* shipwreck site. The horizontal black grid lines are depths below sea level drawn at 1m vertical spacing. The continuous bright red line represents the seabed, and the bright outer red hyperbolae (horseshoe) reflectors sitting approximately 1m above the seabed and 30m apart on the left- and right-hand sides of the line depict road crash barriers installed by WAM outside the perimeter of the buried remains in order to trap sand on top of the shipwreck material (Richards *et al.* 2014; Winton and Richards 2005). The large central inner red reflector sitting above the seabed depicts the windlass. Strong reflectors are seen to a depth of approximately 1+ m below seabed near the stern, and up to 2m below the upper surface of the windlass. The gap in reflectors from zero to a depth of approximately 20–40cm between the stern and the windlass may represent the surficial sand coverage (DoC) on top of the shipwreck remains.

A qualitative comparison of the partially complete 3D digital model to the SBP data can be assessed by observing the side view of the aligned digital model in the lower section of Figure 6. Note that the sonar profile represents a section down the middle of the hull, from stern to bow, and would not have detected any of the features along the keel/keelson nor along the deck-knees on the starboard side of the hull remains. Nevertheless, the strong sub-surface reflectors in Figure 6 provide a promising similarity to the upper and lower boundaries of the hull profile and warrant further detailed analyses.

The performance of the parametric SBP and results from this trial survey have been used to design a detailed SBP survey covering the *James Matthews* wreck-site at 1m line spacing with accurate RTK GPS centimetric positioning and vessel heave compensating sensors (Winton in press). A summary of the use of parametric and linear SBP instruments to maritime archaeological applications is also included in Winton's forthcoming publication. Once the bow and windlass sections of the 3D model are fully completed, and the local grid frame survey coordinate system transformed to the local WGS 84 navigational coordinate system, then the 3D model will be quantitatively compared to the newly acquired SBP sonar profiles. The accuracy and variability of measurements of DoC over the wreck-site will be quantified, and the ability to use non-invasive methods to map the extent, and potentially identify major material types associated with a complex shallow-buried wreck-site, will be assessed.

Conclusions

The re-examination, analysis and integration of legacy excavation survey data from the *James Matthews* wreck-site with new technologies provide valuable information and insight which has not otherwise been obtainable. During the excavation and archaeological survey of the *James Matthews,* divers visually noted that the ship lay on its starboard side and that there were indications of some twisting of the keelson. However, the angle on which the ship rested, and magnitude of this distortion



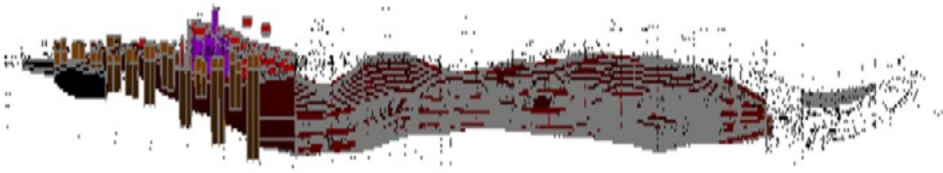


Figure 6. Longitudinal (stern to bow) SBP line collected January 2015 with SES-2000 compact SBP. Horizontal distance between plastic crash barriers is 30m, black lines at 1m vertical spacing (top) and corresponding side view of 3D model of buried remains (below).

could not be accurately assessed during the progressive exposure of structural timbers, nor was it truly evident in the subsequently prepared plan drawing. Together with hogging or sagging of ribs, these *in-situ* distortions may well have consequently led to inaccuracies in the drafting of ships lines.

Digitising the full 3D survey data from the original survey sheets, held in the archive by the Maritime Archaeology Department at the WAM, created the opportunity to develop a fully 3D digital model of the buried remains of the *James Matthews* shipwreck using AutoCAD software and powerful computer processing with graphic capabilities. By rotating the view of the digitally reconstructed model, the shape of the hull and orientation/alignment of structural timbers became evident, revealing distortions and the effects of wreck event and post wreck-site formation processes not previously seen. These distortions included compound twisting of the keelson and keel, longitudinal variations in the list of the ship on the seabed, and hogging and fracture of ribs. From a nautical archaeological perspective, this information may be used to assess the compounding effects of changing stresses due to the sudden movement of ballast and cargo in the hull during the wrecking event, together with the loss of structural support as key load-bearing or supporting timbers are degraded and lost.

The 3D digital model also provides validation to new non-invasive sub-bottom profiling instruments, such as the INNOMAR parametric SES-2000 compact SBP, for *in-situ* management and archaeological research purposes. Qualitative comparisons between the results from a trial SBP survey and the digital model, in terms of depth of coverage of sand on top of buried timbers and total burial depth of ship wreck material, are encouraging. The 3D digital model can also be used for quantitative comparisons to validate these parameters once further fine-scaled SBP surveys with centimetric survey positional accuracy are undertaken, and both the model and newly acquired SBP data are transformed to the same WGS 84 co-ordinate system. The potential benefits resulting from a validated non-invasive tool for archaeological research and *in-situ* management of maritime archaeological sites would be significant in terms of reduced disturbance and minimisation or elimination of field costs associated with other pre-excavation surveys. This benefit would be further enhanced if the quantitative comparison between the 3D digital model and the SBP survey can elucidate relationships between acoustic characteristics and known different buried material types such as structural and cargo timbers, iron deck knees and cargo, slate and stone ballast.

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Reconstruction of a Water Supply System Using Lidar Surveying

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Abstract

The reconstruction of a water supply and its evolution over time is fundamental to understanding the dynamics of a region in terms of spatial organisation as well as of trade and cultural flows. The use of LiDAR surveying together with aerial photography, analysis of archival data and ground checks allowed for the reinterpretation of territorial organisation across some areas of northern Italy.

Keywords

DTM LiDAR, routes, inland waters, river

Introduction

During this ongoing research, the use of Digital Terrain Model (DTM) LiDAR images, together with aerial photography and analysis of archival data as well as groundwork allowed for the reinterpretation of the territorial organisation of some areas within northern Italy (Figure 1).

In 2008 the Ministry of Environment, Land and Sea launched a survey campaign using laser scanners. This was concentrated along the main rivers, and more extensive coverage of only certain areas, of the Italian peninsula. The processed DTMs, albeit created for other purposes, provide topographic models useful in the reconstruction of the landscape structure underlying the present one: the low plains are associated with numerous modifications and variations of river routes while the consequences of floods on the high plains can be used to define ancient terraces and alluvial bands.

Rivoli, Truc Perosa, province of Turin, Piedmont

This locality is situated at the start of the Susa Valley in the Piedmont region of north-west Italy, in the catchment area of the hydrographic basin of the River Dora Riparia. From prehistory up to present times, this constituted a natural route of great importance for relations between north-western Italy and transalpine Europe. The numerous archaeological finds demonstrate that along this axis of communication there has been a passage of peoples and an interpenetration of cultures

Figure 1. Sites of the three proposed case studies.

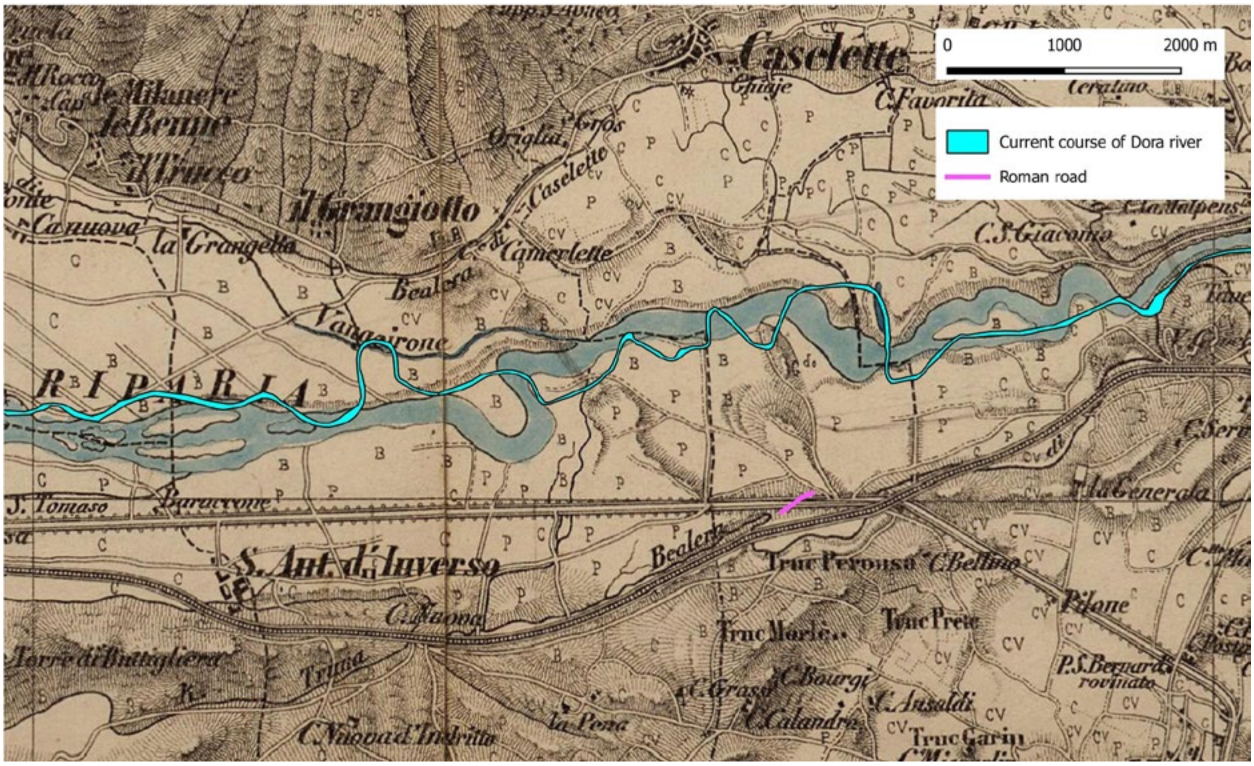

Figure 2. The remains of the Roman road superimposed onto the Gran Carta degli Stati Sardi (1852).

from at least the Neolithic age, with a more or less intense usage allowing for climatic phases and the practicality of the alpine passes. During the Iron Age, around 500 BC, the Susa Valley became part of the established commercial routes along which primary merchants were interested in the mineral deposits of the western Alps and contacts with transalpine populations. The findings of glass paste artefacts of Punic production in Avigliana, and pseudo focese type pottery in Susa (Barello *et al.* 2003: 27), testify to the vitality of this network. The use of this route by the Romans was known at least from the time of consul Marcus Fulvius Flaccus who chose this route to bring help to Marseille in 125 BC (Titus Livius, *Periochae* LX). However the widespread expansion of the Romans into this area and north-west Italy in general took place only in Augustus' time, with the foundation of Augusta Taurinorum (Turin) and Segusium (Susa) and, above all, by securing the viability of the routes over the alpine passes, forming strategic links with the territories of Gaul.

At the heart of this expansion was the road connecting the Po Valley with Gallia Narbonensis through Augusta Taurinorum and up into the Dora Riparia valley, through the Montcenis pass (Mons Matrona or Matronae Vertex) 1854m above sea level. There was considerable renovation of the existing road layout, which Ammianus Marcellinus (XV, 10, 8) attributes to the local sovereign Cottius who then donated it to Octavian Augustus. According to Strabo (IV, 6, 6) the work was instead directly realised by Augustus, in order to create an alternative route to that of the coastal road (IV, 1, 3).

This road is traditionally considered to run along the left bank of the valley septum in question before turning into the *statio ad Fines Cotti* (Borgata Malano di Avigliana, Avigliana), the headquarters of the Quadragesima Galliarum, the postal station and customs control on the border between Italy and the nearby province of the Alpes Cottiae. A short tract of the Roman road was here identified during rescue archaeology work. The most important finding is, however, located on the opposite side of the Dora Riparia, representing an example of the link between the morphological structure of the territory, rivers and communication routes. It is located approximately 2km from the western outskirts of Rivoli in the province of Turin, in proximity of the fluvial terrace. The local name, '*Truc Perosa*' (stone high ground), clearly defines the characteristics of this area, distinguished by the moraine cord.

Today, the original aspect of this territory appears, however, to have been profoundly changed by the railway and the state road n. 25, which cuts the archaeological site in two. Here, a stretch of the Roman road to Gaul has been identified for a total length

Figure 3. DTM LiDAR processing of the MATTM on the Carta Stato Maggiore Esercito Sardo (1816-30).

of approximately 70m. The road, which measures approximately 6m in width, shows a notable technical effort in its realisation, coherent with its function as a primary road axis. It is made up of a *statuminatio* of large cobblestones placed coherently in order to form a uniform bed on which a thick level, made up of layers of gravel and sand, has been spread. The road surface consists of unworked stones, placed flat and regularly laid down only alongside the kerbstones. A simple layer of strongly compacted gravel represents the last road phase. The road, dateable to the 2nd–3rd century AD, was flanked by buildings that were contemporary or at least still in use at the time but certainly obliterates a rural settlement of the Augustan-Tiberian age.

One of the most significant aspects is the fact that this feature is placed on the summit of the moraine, thus conveniently exploiting the natural high ground located on the margin of the fluvial terrace. This is a clear altimetric anomaly also recorded on old maps (Figure 2). The interpolation of these data with those deriving from LiDAR images, suggested a partial reconstruction of the causeway, which probably continued west along the moraine, exploiting its protected raised position (Figure 3).

Such considerations, albeit preliminary, provide a valuable basis for reflection that suggests the existence of an alternative, perhaps later route, alongside the well-known route to the territories of Gaul. The new route suggested on the basis of the material and geomorphological evidence appears to have been an alternative variant, built between the late 2nd and 3rd centuries AD.

As this project develops it aims to reconstruct this causeway (Barello *et al.* 2016: 142–44). The observations outlined here demonstrate how by deepening the research and extending it to an air photography investigation with appropriate LiDAR data visualisations, one could suggest a reconstruction of the route reflecting this itinerary connected to the road of the Gauls. This can be achieved not only on the basis of current findings, but also in relation to the morphological aspects of the areas crossed.

Pizzighettone, province of Cremona, Lombardy

Moving south-east, the evolution of the lower course of the Adda is represented by a series of digressions within the same riverbed. The river's meandering path is closely linked to variations due to changes in the erosion-deposition rate, which occurs alternately on the two banks. At Maleo and Pizzighettone (in the province of Cremona) numerous palaeo-bends of the river are still discernible and show their evolution over the centuries. Seventeenth-century AD interventions straightened the course of the River Adda between two bands placed north and south of the town. This caused the excavation of a new artificial riverbed between two meanders, one to the north and one to the south of the inhabited area. Its original course has survived in an oxbow lake known as the 'Adda Morta' ('dead' Adda; Occelli and Leonardi 2014).

Despite traces of gullies cut by the rivers, the area in question is basically flat and devoid of significant corrugations, with the exception of two morphological heights: the Cascina Seraina mound, behind the village of Roggione/Cascina St Archelao, and the S. Francesco and Maccalè terrace, leaning north-east, at a height of 8–10m, along the ancient confluence with the River Serio.

From the Cascina Seraina mound come the only findings of prehistoric age known in the area—a flint arrowhead and a stone axe and also material from the Roman and the Middle Ages. The terrace in the locality of S. Francesco and Maccalè where the Gallic oppidum of Acherre was to rise, had previously been inhabited during the Bronze Age. This was the site of a famous battle with the Romans in 222 BC. Later it housed the *statio* of Acerrae, visible on the *Tabula Peutingeriana* along the route from Mediolanum via Laus Pompeia to Cremona (Knobloch 2010: 25–34).

Even though it is difficult to reconstruct in detail the course of the Adda during ancient times at this section, it is certain that it flowed near the right edge of its valley, a circumstance that made the Cascina S. Francesco/ Maccalè terrace naturally protected on three sides, thanks to the slope of the sides and to the presence of water in the past at its foot. The morphological characteristics of the area, illustrated with particular evidence by DTM LiDAR, must have been the decisive reason for the choice of this site to control the ford in the river, corresponding with the image of Acherre passed down from ancient sources, defined as a *polis* in a strategic position and easily defendable. This fits in with studies showing the predilection for sites on natural hillocks near water courses, as an intentional and new settlement strategy carried out in the plains starting from the recent advanced Bronze Age.

Furthermore, the high-resolution survey has detected a succession of meanders of the palaeo-course of the River Adda, in part shown on historic maps. These were formed thanks to the particularly low gradients of the stretch examined. The latter also cause continuous flooding in the surrounding areas; the effect of the lateral movements of the riverbed are evident in its widening and in the arched profile of the edges of the morphological escarpments, which delimit the valley. The observation of the distribution of some findings of proto-historic age from LiDAR surveying shows a close relationship with the river, with collocations not only on the morphological high grounds, but also within the valley along the external profile of the palaeo-meanders (Knobloch and Perani 2011). Several mutations to the area's hydrogeological system in the historic age have occurred not only to the course of the Adda but also to the River Serio and adjacent areas, with evident consequences for the distribution of the settlements.

According to documentary sources, the southern extremity of the area was occupied by the so-called Gerundo lake or sea (where *Gerundo* derives from the Lombard expression *gera*, gravel). It comprised the final stretch of the Serio to the original confluence with the Adda near what is now Pizzighettone (today instead located near Montodine), in an area subject to flooding from the River Adda in the early Middle Ages. The Gerundo is more likely identifiable in a succession of oxbows in continuous evolution, whose extent would have been limited to the low-lying area occupied by the Adda riverbed and its flood plains, although the collective imagination managed to amplify its dimensions excessively and turn it into a 'sea'.

The term 'lake' or 'sea' would, therefore, define ground that is completely immersed in water. However, if any area is partially covered and marshy, typical of the lands surrounded by meanders of certain rivers, that would also explain, from a morphological perspective, why its limits are well defined in the southern part and rather uncertain in the so-called northern Gera d'Adda. Its formation may, thus, be due to the effects of flooding due to the increase in rainfall and the decrease in temperatures characterising the period between the 5th and 8th centuries AD. However, sources only mention it in 1204 AD, in an act of donation to the church of Sancti Martini de Trexenodi of land and a building located *costa et ripa Maris Gerundis* (on the shore and bank of the Sea of Gerundo; Casirani 2003: 273).

The limit of the basin is at present delimited to the west by the escarpment still highly visible in the vicinity of the River Adda from Cassano to Castiglione, where the bank should correspond to the alignment of the settlements of Maleo, Bertonico, Lodi and Comazzo. At the centre of the lake rose a long and narrow strip of land known in the Middle Ages as *Insula Fulcherii* or *Fulcheria*, derived from the Latinised genitive case of a Germanic first name, protected by water and located in a strategic position for the control of trading on the River Adda. Its conformation contributed in making the *insula* a border territory rich in fiscal goods under the king's control and considered State property since late antiquity (Casirani 2003).

The activity of the River Serio in the valley now called 'of the dead Serio' is documented by a *cartula commutationis* of AD 960, drawn up between Bishop Dagiberto of Cremona and Count Attone of Lecco (*Privilegia episcopii Cremonensis* or *Codice di Sicardo*, AD 715/730–1331, *cartula* n. 137). Near the original confluence with the

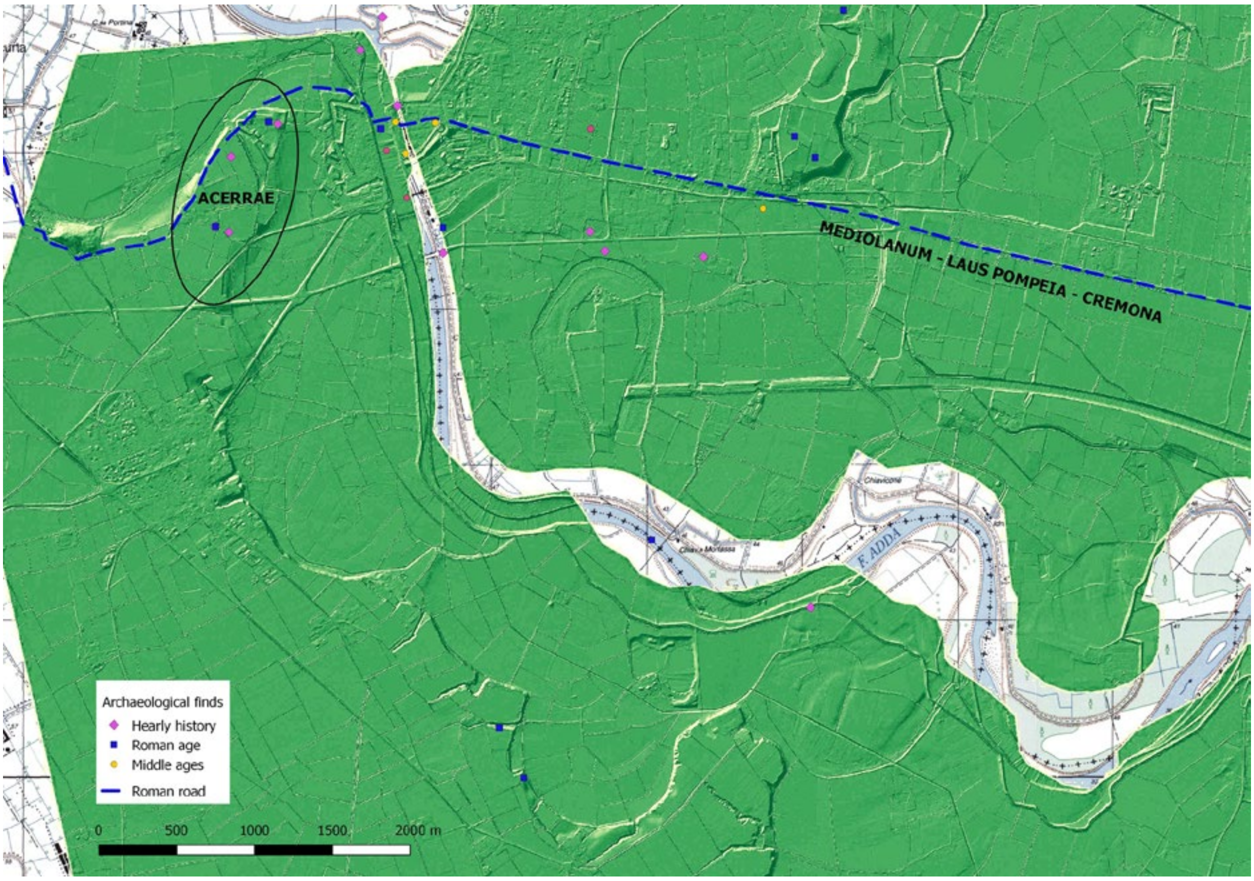

Figure 4. Archaeological finds and their location with reference to the palaeo-riverbed of the Adda (DTM LiDAR processing of the MATTM).

Adda, on the peak of the morphological escarpment, rose the inhabited nucleus of *Causario* (toponym now disappeared and mentioned for the first time in AD 753 but not beyond the 14th century); clear derivation of the original designation *Caput Sario*, identifiable as the site of the current Cascina S. Archelao (Ferrari 1992: 11–13).

The abandonment of the old river course for the current shorter route further north is a consequence of a 'forced deviation' which took place in historical times, caused by events independent of the water course and is probably attributable to a tectonic deformation of the earth's crust, which has caused it to flow towards the new route. It is difficult to be certain up to when the River Serio maintained its ancient route: the documents up to the 13th century AD trace it as passing through Rivolta (Ripalta Vecchia) and Rivoltella (Ripalta Arpina), which were then on its western bank, whilst approximately a century and a half later, in AD 1361, a convention drawn up between the Podestà and the Consuls of Crema shows that its route had already changed.

Another toponym, Sarrium (locality cited in a *placitum* of AD 976), associated with the inhabited nucleus of Maleo, is also traceable to the presence of the ancient confluence of the Serio. Sarrium was originally located near the mouth of the River Adda on the left bank but due to a mutation of the course of the latter, which probably also caused a cut in the final stretch of the River Serio, ended up on the right bank (Ferrari 1992).

The morphological evidence attributable to the riverbed's abandoned sections recorded by DTM concurs with documentary sources and toponymic evidence in reconstructing a landscape created by fluvial dynamics—at least until the mentioned cut and reclamations were realised in the 1930s, that was extremely changeable.

Today's archaeological record presents a distribution of settlements that the DTM LiDAR shows strictly related to the altimetric anomalies correlated to the meandering palaeo-course of the Adda and the old course of the Serio. The same relationship with the river is evident in the Mediolanum-Laus Pompeia route. In the area in question this descends from the edge of the terrace on the left bank to cross the Adda near the morphological heights of Località Roggione/Cascina S. Archelao before continuing north-west along the right bank on the terrace of S. Francesco/Maccalè. All

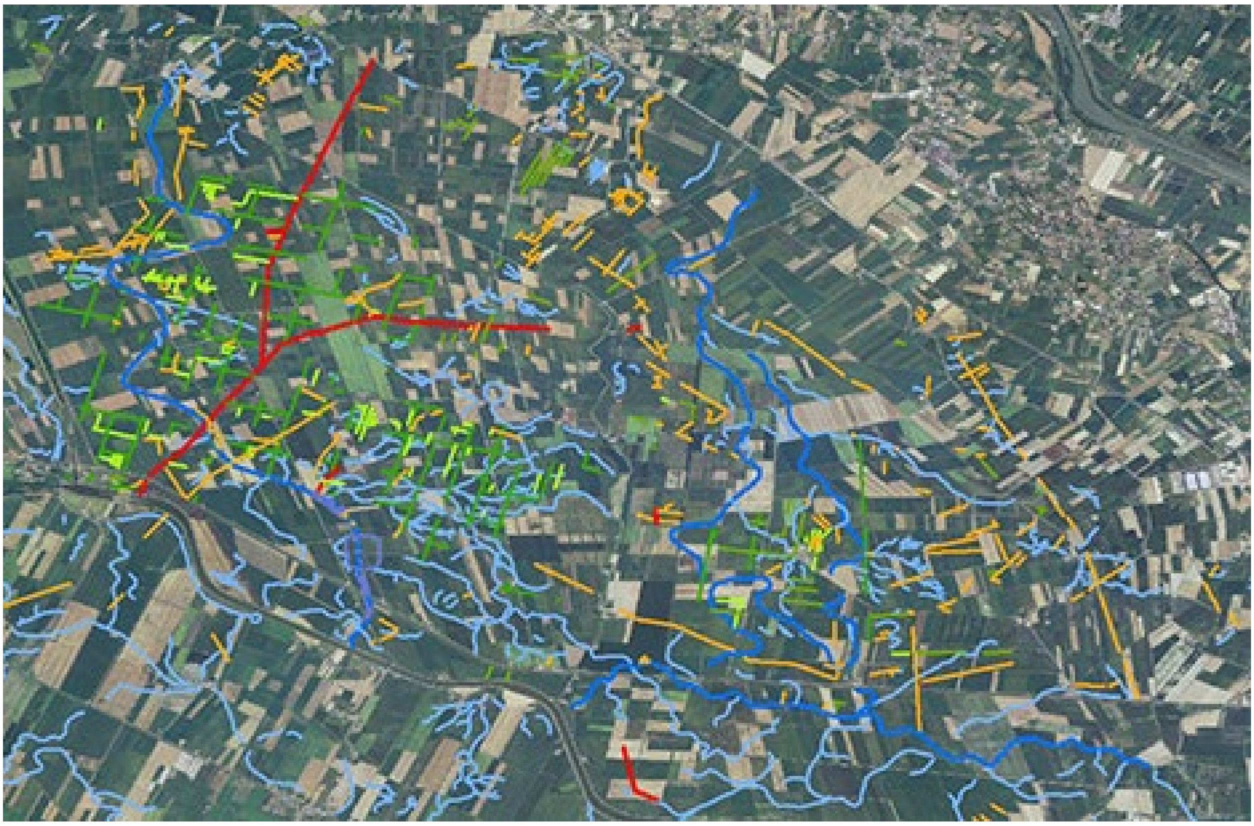

Figure 5. Identified anomalies drawn on orthophotos 2006, National Geoportal.

known evidence from Roman times is located outside the River Adda valley riverbed in an elevated position and protected from flooding (Figure 4).

The Great Veronese Valleys and western Rovigo

The low plains of the southern portion of the Great Veronese Valleys and the western side of Rovigo Polesineare have a different geological makeup. High-altitude aerial photographs of the area between the courses of the rivers Tartaro and Adige have provided a considerable volume of archaeological information for the area. Photographs have been compared with LiDAR images; and also with 2012 films by the Consorzio Bonifica Veronese. In an area with only micro-reliefs and a dense hydrographic network—factors that led to a repeated instability of the terrain through the centuries—the potentials and limits of the application to an exclusively remote survey came to light (Leonardi 2014).

From a geomorphological perspective, the area represents a 'humid zone' with difficult drainage that easily became a marsh without systematic water regulation. The extremely precarious nature of the environment equilibrium has brought about alternating periods of anthropic control of the territory, such as the Roman era, and times of domination by natural elements, in particular the marshes, as in the course of the Middle Ages and modern times.

The environment, apparently dominated by uniformity and monotony, is today characterised by a weak micro-elevation in which only the river banks of the courses of the Adige and Tartaro stand out. However, it was not rigid and static—the results of the evolution processes linked to the fluvial network have, in fact, over time caused mutations of the landscape. These are recorded in the map series and much more efficiently via aerial surveys, which also show significant modifications, sometimes within decidedly short chronological margins.

The general sequence of fine flood deposits, widespread and not erosive, has actually brought about the obliteration of vast marshy sectors of the territory and triggered terrain lowering and compression processes following land reclamation over the last century. Such circumstances, together with the ground characteristics, have revealed extraordinary details in aerial photography (Peretto-Bedetti 2013).

The archaeological rendering of an area, i.e. the information it can provide through several mediators

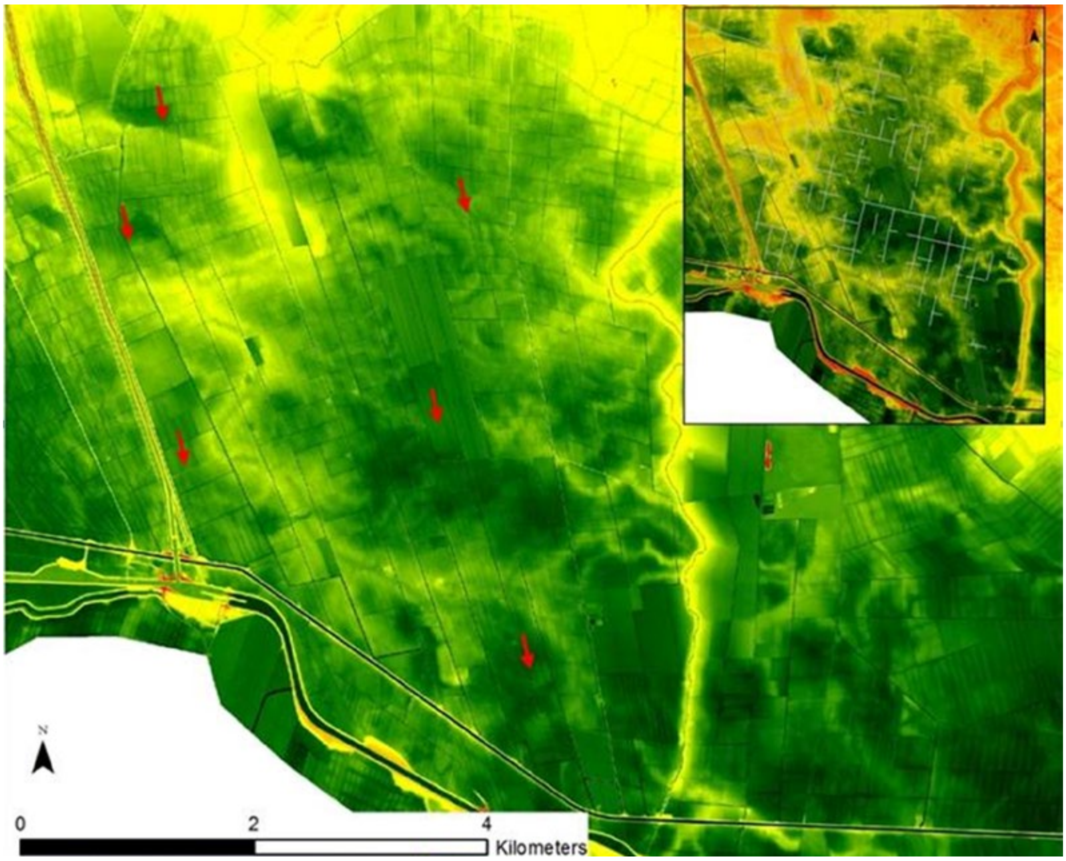

Figure 6. Morphological alignments recognised in the palaeo-valleys between Tartarus and Adige (Processing of DTM LiDAR Consorzio Bonifica Veronese 2012).

from quantitative and qualitative perspectives, is always influenced by the physical characteristics of the surfaces that make up the landscape. For that reason, the elements of interest that emerged—or their absence—constantly contain various sources of information. All the investigations have been carried out inside a geo-referenced working platform (ArcMap), integrating the previous archaeological information with observations from the National geo-portals, the Veneto Region and the LiDAR surveys.

The analysis of the photographic filming was carried out over ten distinct flights, enabling recognition of about a thousand traces of anthropic nature, with approximately 500 of natural origin. A first interpretation of the recognised anomalies has been attempted (Figure 5). Human, natural and uncertain evidence were separated and arranged in an information hierarchy. At the moment this is based solely on typological-topographical factors, and aims to define the predictive potential in the reconstruction of ancient river landscapes.

Available IDTM LiDAR images have enabled the elaboration of a detailed 3D model of the morphologies that still characterise the area, albeit in the presence of artificially induced erosive processes (subsequent to levelling and heavy modifications caused by the elevated levels of mechanisation of agriculture during recent decades). The complex and stratified fluvial landscape, resulting from the continuous evolutions of the Adige, Tartaro and Po were clearly visible: banked cordons of watercourses, low-ground areas and valleys with unstable hydrological systems were all easily identifiable.

Scholars have suggested a theoretical model of palaeoenvironmental evolution based not only on physiographic data, but also on the decisive input of palaeoethnological and palaeoclimatic information. The study of the area's geomorphological structures has improved through the study of historical maps (Peretto 1986), the continued improvement in the use of remote sensing and micro-reliefs and also of specific contexts that had already come to the attention of scholars for their connections with supposed or proven archaeological finds or historical/geographical events, including the use of manual core sampling along with petrographic analyses and radiocarbon-14 dating (Piovan 2008).

The integration within a GIS environment of all this information enabled observation of the reciprocal relationships between anthropic evidence and landscape elements. When not three-dimensionally perceptible, it was visible as chemical-physical variations on the ground. The geographical restitution of known sites overlapped with DTM has offered new information on the understanding and reconstruction of the anthropic landscape, adding new details to sites already known and discovering new ones. Some preliminary assessments have furthermore provided interesting elements for defining a hierarchy in the landscape emerging from the distribution of the settlements, the presence of key elements and the ways in which cultivated spaces are distributed.

The targeted visualisations of DTM have added a concrete dimension to some of the morphological elements of the anthropised landscapes whose function was only hinted at by aerial photography (Challis 2006). For example, this has been shown as a valid application in the series of parallel lines in the plain between the two tributaries of the rivers Tartaro, the Bussè Naviglio and Cagliara dyke resulting in an apparent relationship with the centuriated reticulum (these would certainly have played a part in the surveyors' thinking when arranging the drainage system of the farmland in Roman times); and, also the limits of that agricultural landscape constituted by the natural embankments of the ancient divagations of the Adige, still perceptible in the present day (Figure 6).

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Art and Documentation Serving Underwater Archaeology in the Interpretation of History

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Abstract

In the same way that a wreck provides information about the precise moment in which it happened, we obtain data about historical facts and information from contemporary images. Thus, a proper examination of iconographic documents and their interpretations can help our understanding of history.

In 1807, the British fourteen-gun schooner *Felix* of the Royal Navy was cast away off the coast of Santander, Spain. From research into this wreck, important documents and two relevant pieces of art came to light which give evidence for how this episode should be interpreted in history: an etching of the schooner and a portrait of Commander Richard Bourne. Analysing the etching in detail, we identify the type of vessel and rigging as well as the location of the cannon of the fortress which was shooting moments before the ship sunk in rough weather. The portrait depicts the principal actor involved in several historical events linked to the schooner. Bourne led several attacks on ships, privateers and batteries on the shores of northern Spain. In one of these, he was dangerously wounded and his military career came to an end. Once recovered, he was the founder of the successful shipping company P&O whose ships nowadays are crossing the oceans as reflected with the recent arrival simultaneously to Sydney of five of his P&O cruisers from different parts of the world.

Past and present come together with current social events to define the history that will be investigated by future nautical archaeologists.

Keywords

Wreck, art, portrait, P&O, Bourne

Introduction

As puzzle pieces connect to form an image, certain pieces of art can help underwater archaeologists to interpret history by connecting objects, places and characters. The different sources from which one obtains the information, allow us to establish a basic set of facts using the most diverse tools e.g. objects, documents, maps, plans, testimonies, and sometimes even pieces of art. It is important to note that no piece should be overlooked when the image of a puzzle is created. We should take into consideration the valuable contribution that a contemporary work of art can offer us. In this study, we seek to determine how our interpretation of an engraving and a portrait can influence our knowledge of an historical event.

Historical background

The northern coast of Spain played an important strategic role during the Napoleonic War, not only because it was a source of supplies and resources for France, but also because the Bay of Biscay was the western key to the Channel—the last obstacle to invasion plans of England. Another strategic point of this shore is determined by the proximity of the most significant Spanish factory of iron guns to the port of Santander.

Over more than two centuries, from 1622 to 1835, the Royal Artillery Factory of La Cavada (*La Real Fábrica de La Cavada*) was the main artillery supplier to the Spanish Navy. La Cavada is located in Cantabria, a region of northern Spain. This prime location was determined by the proximity to: firstly, the raw material required for carrying out its work, such as iron mines of high quality and abundant forest to obtain the wood for the foundries; and, secondly, ports and shipyards where the mounting of guns occurred. Together with the incorporation of modern manufacturing techniques, the expertise of Flemish workers helped improve production—the artillery from La Cavada became one of the best in the world, helping to maintain Spanish sea power during those years (Maza Uslé 2007).

From a nautical archaeological perspective, the importance of the ordnance from La Cavada is reflected in the fact that any iron gun found in a shipwreck or fortress linked to the Spanish Empire from the 17th to the 19th centuries is quite likely to have been manufactured in La Cavada.

For all these reasons, this shore was a theatre where different warlike actions such as amphibious operations, naval battles and sieges of coastal villages were played out. The Royal Navy's fourteen-gun schooner, *Felix*, under the command of Lieutenant Richard Bourne, was a significant protagonist playing an active role in England's attempt to thwart Napoleon's ambitious plan until his ship became wrecked in the Bay of Santander.

The historical importance of this ship comes from its origin—it was one of the first examples of an American-constructed schooner of this class that adopted by the Royal Navy. Later, its specific characteristics would give rise to the evolved design of this type of rig that would be so important in the history of sailing throughout the 19th century well into the era of steam.

The *Felix* was originally a French private schooner belonging to La Rochelle. It was captured by the English frigate *Amazon* in July 1803 and taken to Portsmouth. It was copper-bottomed and the rig conserved its original fine Virginia design. For these reasons, the Royal Navy under the Command of Lt Richard Bourne quickly purchased this ship. This man and his ship worked marvellously together. He played one of the most active roles in the Bay of Biscay during that period. Soon after Bourne's assignation to the English Channel fleet, the *Felix* would play an important role in the actions of the subsequent four years until her tragic end (O'Byrne 1849).

In 1804, during peacetime between Great Britain and Spain, the British Admiralty gave orders to capture the Spanish fleet coming from America. The Spanish frigates *Medea*, *Clara*, *Fama* and *Mercedes* were intercepted while on their way from Montevideo to Cádiz, by the English frigates *Indefatigable*, *Lively*, *Amphion* and *Medusa* in a battle close to the Santa María cape a few miles to the south-west of Cádiz. Suddenly, the *Mercedes* frigate with its crew of 250 blew up. The consequent recovery of her plundered cargo in 2012 by treasure hunters would constitute some of the more famous pages in the recent history of nautical archaeology.

Several days before and obeying the same order that was given to Commander Graham Moore by the Admiralty to carry out this action, the *Felix* was sent to patrol the northern coast of Spain. Then, eight leagues west of Santander and close to Santoña, four French *chasse marées* suddenly appeared. Following a pursuit, they were captured carrying the considerable sum of 62,000 Spanish dollars (Leyland 1902).

In 1805, the active blockade that had held the *Felix* on this coast, affected trade in the area. In order to capture the *Felix*, the French schooner *La Représaille* of 14 guns was armed with a letter of marque under the Spanish flag and renamed *El Vengador*. The battle at the entrance of the Bay of Santander lasted more than four hours and after several unsuccessful attempts to board, both ships retreated with heavy damage and numerous casualties.

In August 1806, a landing party consisting of two boats with 40 men from the schooner *Felix* assaulted the garrison of the battery consisting of four 24-pounder cannons being managed by 18 men. It is easy to imagine that in these boat actions, when men are rowing fast to the shore, they do not make an easy target and from the battery there is only time to shoot and reload twice before the boats are too close, coupled with the challenge of it being unlikely that the garrison would be able to aim downwards to try to shoot them again. Once on land, these men quickly ran to the fortress. There, the outnumbered Spanish garrison only had time to shoot their muskets and pistols once before fleeing. At that moment, the British spiked the guns of the fortress and burnt three *chasse marées* that anchored here under the protection of the battery. However, the Spaniards' garrison was reinforced with soldiers from the castle situated two miles inland. They were returning to the battery; now the tables were turned again so that the British had to flee to the boats and to their schooner (Casado Soto and Gonzalez Echegaray 1975).

Such quick actions were very typical of the period and this schooner saw several such actions in this region. In a similar event in the narrow port of Ea, Biscay, the commander was dangerously wounded. As a result, his military career came to an end. However, his relationship with the sea continued.

Once recovered, Bourne turned his naval skills to business. He joined his brothers Henry, William and Frederick, in running the lucrative mail coach business they had established in Ireland in the late 18th century. Granted a contract in 1789 by the Irish government to introduce a mail coach service to the country, the brothers built and maintained roads to Limerick and Cork and subsequently to Drogheda and the north of Ireland. With heavy capital investment and a long lease, a monopoly of the tolls and ownership of the inns and hotels which lined the route was established (Strange 1970).

Exhaustion, no doubt exacerbated by his old wound, forced Bourne to step down from the mail coach and

Figure 1. PAI9465, National Maritime Museum, Greenwich.

road business in 1823. After investing some capital in a new shipping company set up by his brother, William, running two steam ships between Dublin and London, he travelled overseas to recover from his health issues. However, when poor management threatened the shipping business, Bourne returned to Dublin and took back control, refinancing the failing enterprise The Dublin and London Steam Navigation Company flourished, and, in 1835, Bourne negotiated an exclusive contract with the Spanish government to run a steamer service to the Iberian Peninsula (Harcourt 2006).

Two years later in 1837—now in partnership with London ship brokers Arthur Anderson and Brodie McGhie Willcox—Bourne co-founded The Peninsular Steam Navigation Company, securing the valuable government contract to carry the mail between Falmouth and the Peninsular ports, as far as Gibraltar.

This was followed, in 1840, by the even greater reward of a contract to carry mail to Egypt and then, in 1842, to India. Bourne owned six of the seven steam ships which launched the new shipping company. The large amount of capital required to purchase steam ships capable of such arduous voyages was secured when the company was incorporated by Royal Charter on 31 December 1840 as The Peninsular and Oriental Steam Navigation Company (P&O). By the merger and acquisition of smaller shipping companies and by securing new routes, such as to Singapore and down the Nile, the growth of the company was rapid and its success—even to this day—was assured (Strange 1970).

Soon after that, the ships of the P&O travelled as far as it was possible from London. Australia was one of the more remote places where merchandise and people were transported to write a new history of the continent.

The only one of the P&O founders with seafaring experience, and with highly astute business sense, Bourne maintained a keen and active interest in his business into his later years. Eventually infirmity forced him to retire to his home at Blackheath near London, where he died on 9 October 1851 (Howarth and Howarth 1987). However, the ship under his command that fought off the northern coast of Spain, the schooner *Felix* had been lying at the bottom of the Bay of Santander since 1807 (National Archives ADM 51/1589). Its 14 carronades were jettisoned overboard in a final attempt to save the ship shortly before casting away from shore and succumbing to gunfire from La Cavada's cannons.

Methodology

The principal method used to accomplish this study involved researching the archives and primary sources to obtain documentary records related to the vessel. After the compilation of data, documents, plans and logs, we identified two important pieces of art. Thus, we focused our research on: a) the comparative analysis of the iconographic objects with other similar contemporary ones; and, b) their interpretation and roles within a well-known historical event.

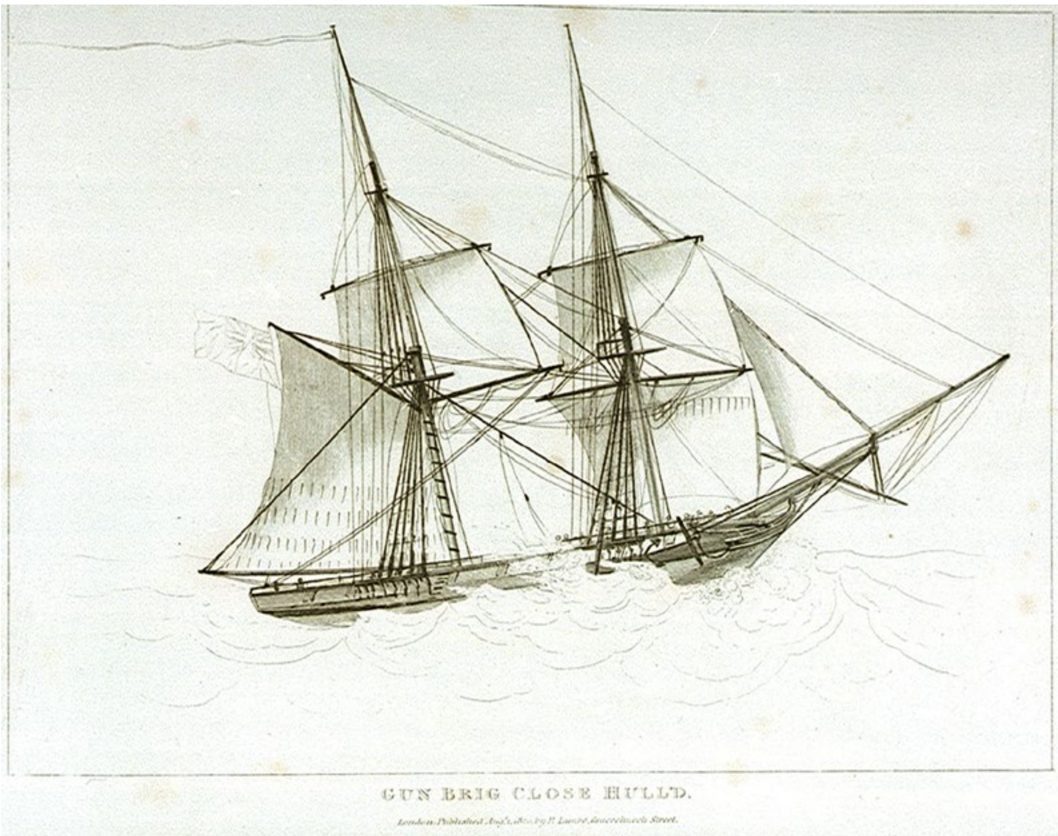

Figure 2. PAD7703, National Maritime Museum, Greenwich.

Results

The present work was carried out in two separated comparative studies; the first was a comparison of an engraving of the fate of the *Felix* with another belonging to the same period, titled 'Gun Brig Close Hull´d'. The second study was a comparison between two portraits of Richard Bourne.

Study 1: Comparative analysis of the two engravings

In the National Maritime Museum of Greenwich, we obtained a clue about the existence of an engraving with the title 'Fate of the *Felix* Schooner'. However, this image was not immediately available because it had not been catalogued yet. We eventually obtained the image and the high quality in the representation of the engraving was remarkable. It shows the precise moment on 21 January 1807 when the four twenty-four-pounder cannons, manufactured in *La Real Fábrica de La Cavada*, opened fire from the battery of San Martin located in Santander, targeting the British schooner HMS *Felix*. Fleeing from the shots and in a terrible gale, the schooner failed to reach open sea and shipwrecked on the coast opposite the battery. Only one crewmember survived the shipwreck.

Characteristics of the* Felix *engraving (Figure 1):

Title: Fate of the *Felix* Schooner
Credit: National Maritime Museum, Greenwich, London
Object ID: PAI9465
Description: Print
Date made: After 1807
Materials: Etching
Measurements: Sheet: 107mm x 184mm, Plate: 85mm x 141mm
Artist: Unknown

The above engraving was compared with one previously identified and located in the National Maritime Museum of Greenwich, with similar characteristics. In the latter, we see a brigantine in a rough sea on a starboard tack with several members of the crew on deck (Winfield 2005).

Characteristics of the Gun Brig engraving (Figure 2):

Title: Gun Brig Close Hull´d
Credit: National Maritime Museum, Greenwich, London
Object ID: PAD7703
Date made: 1 Aug 1820
Materials: Etching

Measurements: Book: 202mm x 264mm
Artist: Lamb, R

Study 2: Comparative analysis between the two portraits of Richard Bourne, Lt. commander of the *Felix*.

Both portraits show the image of Richard Bourne. The first was the only portrait known of him until 2015 and was presented to the Board of Directors of P&O by his widow and family in 1853.

Characteristics of the picture (Figure 3):

Title: Captain Richard Bourne
Credit: P&O Steam Navigation Company, Heritage Collection, London
Object: Portrait of Richard Bourne
Date made: *c.* 1850
Materials: Oil on canvas
Measurements: 1000mm x 800mm
Artist: Thomas Francis Dicksee

Figure 3. Richard Bourne, Thomas Francis Dicksee. P&O Heritage.

The second portrait, recently discovered, is a miniature watercolour on ivory mounted in a plain gold frame with pendent loop that belongs to the descendants.

Characteristics of the picture (Figure 4):

Title: Captain Richard Bourne
Credit: Particular collection, Spain
Object: double-sided miniature portrait of Captain Richard Bourne Royal Navy (1770-1851) and in reverse, his wife, Louisa Helena Bourne, née Blake.
Date made: *c.* 1840
Materials: watercolour on ivory, mounted in a plain gold frame with pendent loop
Measurements: oval 78mm x 3 inches high
Artist: Unknown Irish school *c.* 1840
Provenance: Louisa Blake Mahon, née Bourne, daughter of the sitters by family descent.

Figure 4. Richard Bourne, Martin Downer Works of Art Ltd.

Discussion

In this study we have compared different art objects and interpreted the relevant information they convey to us. Thereafter, we have integrated it within an historical context to better comprehend a past event.

The first characteristic to take into consideration when we saw the engraving of the *Felix* schooner was the fact that at the top of the picture, there were several holes regularly separated—26mm between them. It gave the impression that the image was torn from a book; furthermore, three of these holes are broken. There is a book titled *The mariner's chronicle; or Interesting narratives of shipwreck*, London 1825, concerning several 19th-century catastrophic wrecking events in which the sole survivor described the *Felix* wreck. These short stories were in most cases represented by images describing the episodes, but not in the case of the *Felix*. This engraving could be part of this book. However, the book to which the *Felix* engraving belongs remains unknown for now.

With this engraving, we determined that the rig of the ship is a type of schooner. This point is very relevant because from local archives related to the activities on the north coast of Spain, we discovered that the ship was sometimes identified as a brig and sometimes as a schooner. In addition, sources disagreed over the number of guns carried when she was lost, somewhere between 12 and 14. However, in the Admiralty Order, it was clearly specified that the *Felix* be supplied with a set of 14 carronades. This data is in line with the present engraving where seven portholes were visible across the hull (one covered by waves).

In the *Felix* engraving we observed that the landscape was very accurate. Thus, we identified the precise locality of the episode represented by the author. Behind the schooner, we identified historic buildings from Santander City like the Cathedral, the quay, and the fortress of San Martin. Moreover, the recognisable landscape with the Castle Hill and the Magdalena's peninsula, even the buoy of the anchorage, allowed us to estimate where the place is presently represented.

Furthermore, the smoke that one can see in the middle of the image indicates that the schooner was being shot from the San Martin battery. These guns of the fortress and batteries of the Santander Bay were founded in the nearby Royal Armoury Factories of La Cavada. That is other reason why this engraving is really valuable—it is a unique contemporary image of the smoke from a gun of La Cavada firing from the fortress towards a ship. From a nautical archaeology point of view, nowadays, the importance of the ordnance from La Cavada is reflected in the fact that any iron gun found on a shipwreck or fortress linked to the Spanish Empire from the 17th to the 19th century is quite likely to have been manufactured in La Cavada.

Our interpretation suggests that this episode happened on 21 January 1807,a few hours before the ship was wrecked, in line with the testimony of Henry Ellard, the sole survivor of the *Felix*.

Another important point to be considered is related to the unknown artist responsible for this engraving. With the purpose to identifying it, a second engraving titled 'Gun Brig Close Hull´d' was evaluated. Comparison between the two ships shows us a great similarity in the image represented, especially of the hulls. Both show the starboard side of the ship at just the same moment that a wave was passing over, the angle of the bow and masts is equal and the small bodies that crowd the deck are so similar that it is difficult not to appreciate the possible influence of the image on the artist responsible for the *Felix* engraving.

The last part of the study relates to the recently discovered portrait miniature of Richard Bourne, commander of the *Felix* schooner. Until 2015, the only public known image of Richard Bourne was the oil on canvas of Bourne standing by Thomas Francis Dicksee. It was dated 1850 and nowadays is exhibited in the hall of the P&O shipping company building in London.

In 2015, a former antiques dealer at Sotheby's, London, put on sale a piece of art consisting of a portrait miniature watercolour on ivory, mounted in a plain gold frame with pendent loop. The value of this discovery lay not only in the importance of this piece of art but also because it is the only known portrait of Bourne in the uniform of the Royal Navy. In this portrait, we also observed that Bourne bore one star in the epaulettes and a medal. This one could be the Naval General Service or the Naval Gold Medal. Moreover, during his naval career, Bourne received two awards from the Lloyd´s Patriotic Fund, due to his successful actions in Spanish waters.

We compared this portrait with the only other picture that is currently known of Richard Bourne, the oil-on-canvas by Thomas Francis Dicksee dated 1850 that was presented to the Board of Directors of P&O by his widow and family in 1853. It shows Bourne standing in civil dress as a businessman.

The two portraits of Bourne reveal two different moments in his lifetime, matching with the role that he played in different historical periods as Lieutenant Commander in the Royal Navy and ship owner in the P&O Company.

Conclusion

Documents and archives have helped us to find the place, time and characters of our research but the images provided by artworks play an important role in the interpretation of a specific historical event. In the same way that an instant moment captured by a photograph will speak in the future of today's historical moment, new technologies and networks are the sources where the archaeologists of the future will conduct research.

In this study we determine how an engraving and a portrait transmit a message with significant information about an historical event. At first glance, these objects act as mute witnesses and the researcher is required to interpret them to further understand the history behind them.

Like pieces of a puzzle that at the end form a complete image, we show how the investigation of the wreck of a British schooner off the northern coast of Spain tells us the history of the ship's commander and his link to Australia.

It is not far-fetched to assume that a recent event like the simultaneous arrival of five P&O cruisers to Sydney recorded on videos and uploaded to social networks will constitute the modern sources of information for tomorrow's nautical archaeology studies.

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A New Look at Old Cannon: Interim Report on the Gun Rocks Site

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Abstract

A scatter of cannon lying at the base of Gun Rocks since at least 1769 was first investigated by the Tyneside British Sub-Aqua Club 114 in 1970. These recreational divers set the standard for that time, logically surveying and researching and writing a report on their findings. They also commissioned the local television station to record their investigations at Gun Rocks near the Farne Islands, England.

Historic England (formerly English Heritage) commissioned Wessex Archaeology in 2013 to conduct a site survey, and invited the Tyneside Club to participate. The exposure of the club divers to both current archaeological practice and equipment reinvigorated the club's interest in the site. Of particular interest was the trial use of photogrammetry to model several of the cannon.

In 2016, a new initiative to examine the Gun Rocks site was undertaken by a collaborative team comprising the Tyneside Club, volunteer archaeologists, Flinders University and Wessex Archaeology. Newly discovered underwater cannon were captured in detail using photogrammetry, which, when combined with legacy data, provided a fresh interpretation of the site and contributed to Tyneside's long-term goal of comprehensively identifying the wreck and sharing their knowledge with other divers via a dive trail.

Keywords

Cannon, photogrammetry, recreational divers, wreck, training

Background

The Gun Rocks site is near the Farne Islands off the north-east coast of the United Kingdom (Figure 1). A scatter of cannon lies around the two outcrops of Gun Rocks, which were named as such because a cannon was reportedly found on top during the 1700s. While the presence of these cannon from a wreck has been known for centuries, the origin of the ship and timing of the wreck remains a mystery to this day, despite considerable research. The first recorded investigation of this wreck site took place in 1970 and was completed by the British Sub Aqua Club (BSAC) Tyneside 114. This club has maintained a connection to the wreck and a new generation of divers continues to examine the site to the present day.

The Farne Islands consist of 33 islands, islets or rocks at low tide but only 23 at high tide (Young 2012: 1). The Gun Rocks are totally submerged at high tide and visible to 3.6m above sea level at low tide. The seabed to the north and west of Gun Rocks drops away at a fairly steep angle to a plateau approximately 15m below sea level. To the east and south of Gun Rocks, the seabed has a more gradual gradient and averages a depth of six to eight metres below sea level. Beyond this area to the south, the seabed swiftly drops away to a depth of 16m.

The numerous, often submerged islands and rocks of the Farne Islands, combined with their location in an area of high shipping for hundreds of years means that there a great many wrecks in this area (Young 2012). This has also led to the area becoming a popular diving location with thousands of divers exploring the natural and cultural heritage dive sites amongst the islands every year. Gun Rocks has been, and continues to be, one of the popular shallow wreck dive sites of the Farne Islands.

Up until 2013, the known Gun Rocks site consisted of a scatter of cannon immediately at the base of Gun Rocks on the south side at six to seven metres below sea level. This area is characterised by an undulating seabed interspersed with large boulders and cobbled and pebbly areas. In 2013, a side scan sonar survey discovered another cluster of cannon on the plateau

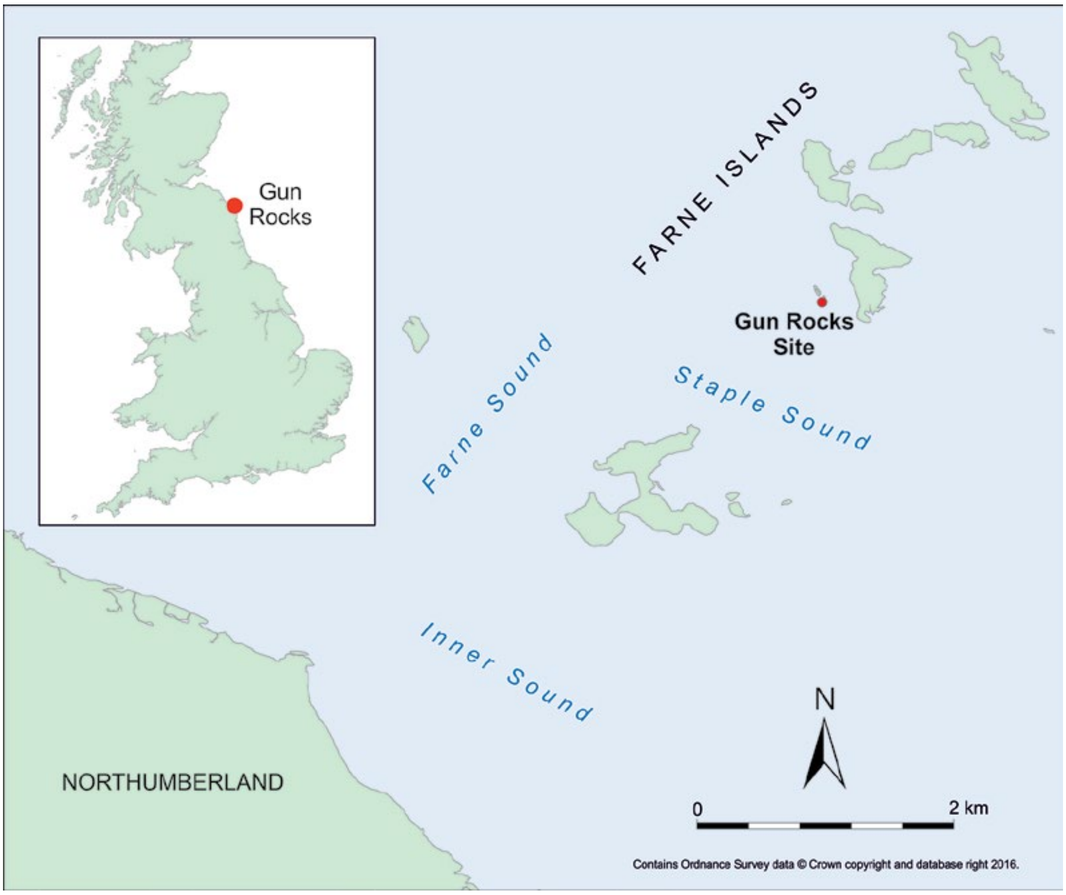

Figure 1. Gun Rocks wreck location map. Crown Copyright, Wessex Archaeology.

30m to the west of Gun Rocks. In this area, the seabed is very flat with a predominance of cobbles and the occasional boulder and an average depth of 16m.

History of site

It has been local knowledge that the wreck existed since the 1700s; however, the beliefs around the nationality and type of vessel wrecked have changed over time. The first written evidence of the Gun Rocks wreck is in the 1769 tourist guide by Thomas Pennant. He recorded in his book *A Tour in Scotland* that a Dutch frigate of 40 guns was wrecked on Gun Rocks approximately 60 years earlier (Pennant 1769). The Gun Rocks wreck first appeared on a chart in 1778. It was a map of the local area recording shipping hazards and was part of the developing shipwreck rescue service (Sutherland 1778).

The connection between the wreck and nearby Bamburgh Castle was first recorded by John Sharp, trustee of the Castle in the second half of the 18th century, when he wrote in his official documents that a Dutch ship of 40 guns wrecked 'probably in 1704' (Sharp 1778–91). He recorded the account of how one of the cannons came to be at Bamburgh Castle; in 1744, 'Nm and Richd Evans(sic)' a father and son diving team, raised an iron cannon and a brass cannon from the Gun Rocks site. The bronze cannon was sold as valuable scrap while the iron cannon was left on the beach to be buried by the sands until an extraordinary high tide in 1767 exposed it again. The lessee of the beach on which the cannon was found allowed John Sharp to take ownership of it if he could take it away. The artillery piece was transferred to Bamburgh Castle where it was restored and tested with gunpowder. The chamber of this cannon was said to be in good condition compared to the rest of the weapon as it had a charge in it when discovered. Identified as a nine pounder, it would have been fired using 3lb or 4lb of powder. The cannon was used as a signal gun at the castle from 1767 as part of the shipwreck warning system until the time John Sharp's document was written in 1780. The inclusion of quite specific dates and particulars of people and events in John Sharp's account of the wreck's origins suggests that there was likely some factual basis behind the account although as John Sharp was writing over 80 years after the wrecking event, the extent of this factual basis remains to be seen (Sharp 1778–91).

The cannon remains on display at Bamburgh Castle today, although until recently its signage interpretation did associate it and the wreck with the Spanish Armada.

This was the standard folklore for the wreck in the late 19th century and it was based on no more evidence than the fact that numerous Spanish Armada vessels possessing cannon had wrecked in these waters (Young 2012: 209).

Local knowledge of this wreck remained throughout the ensuing years; however, it was not until the 1960s that any great interest was shown in the wreck. The advent of SCUBA meant that the underwater world was more accessible to the average person and at only six to eight metres deep, and in an area sheltered from the tide, the Gun Rocks wreck is a prime site for divers.

Historical site investigation

Tyneside BSAC 114 first started diving the wreck in the 1960s and by the middle of 1970 there was enough enthusiasm in the club to start investigating the site. Bill Smith was the keenest of the club members and he led a team of twelve divers in a well thought out and professionally executed diving project that included a survey of the site, research of raised finds, the recording of a TV programme; and, concluded with a very thorough report of his historical research and the dive club's practical diving activities and findings (Smith 1970).

Over 14 dives, the divers completed a range of tasks that began with clearing the dense kelp to reveal small finds that were raised, reported, recorded and researched. It is important to note that the raised wreck items were reported to the Receiver of Wreck during this investigation because although it is a legal requirement in UK waters, it was not, and continues to not be uniformly observed by all of the diving community. The fact that this was done, and also recorded in the report, shows the level of professionalism of this project. Examples of artefacts raised were: a bronze pulley wheel, sword handles, parts of blades and scabbards, lead sounding weights, cannonballs and a box still containing the remains of swords (Smith 1970: 20).

Part way through the diving investigation, pitons were inserted into the rock as reference points for the trilateration survey of each of the *in situ* tagged cannon. This allowed the team to record twenty cannon and numerous small artefacts although only fifteen cannon were included on the site plan in the report (Smith 1970: 60).

Almost from the beginning of the project, Bill Smith was in negotiations with local television station, Tyne Tees, to document and publicise the activities of the dive club on this site. Preparations of the seabed for being recorded for TV were incorporated into the daily diving plans to ensure that kelp had been sufficiently cleared. On the eleventh dive, after great preparation, the dive club attempted to raise a cannon for the TV programme. However, the lift bag arrangement malfunctioned and the lift attempt was abandoned. Overnight a new plan was devised and the cannon was successfully raised the following day, under the watchful gaze of the Tyne Tees TV cameras and a large crowd of onlookers (Figure 2). This cannon, along with many of the small finds, were assembled in the TV studio and examined during the TV show. After the programme had been recorded, the cannon was sent to a museum in Newcastle-upon-Tyne for conservation and eventual display (Smith 1970: 47).

Figure 2. Tyneside 114's raised cannon being filmed, 1970 (© Gun Rocks Collection).

Throughout the 1970 diving season, Bill Smith sent details, drawings and photographs of the small raised finds to experts at the Victoria and Albert Museum and the National Maritime Museum for identification, which would contribute to the historical information about the wreck. The experts concluded that the small finds were from a merchant wreck from the late 16th and early 17th centuries (Smith 1970: 65, 69–70).

As well as researching the raised small finds, the divers also investigated the cannon that were left *in situ*. This was done by knocking the concretions off some of the trunnions to reveal makers' marks. Three of the cannon were marked with 'F' (Figure 3) while others had 'G', 'S' or 'H' on the trunnions (Smith 1970: 59–60).

Towards the end of the 1970 diving season, a marine archaeologist was also invited to the site to advise on future investigations of the wreck (Smith 1970: 49–50). This once again proved that these recreational divers had best archaeological practice at heart throughout the investigation. Unfortunately, by dive seventeen, interest in the project was waning from all but a few

Figure 3. 'F' marking visible on cannon trunnion after concretion removed (© Gun Rocks Collection).

of the dive club members and that led to the end of Tyneside's archaeological investigation of the site at that time. Bill Smith wrote up all the club's activities and findings into a comprehensive report, which also included a site plan of Gun Rocks (Figure 4).

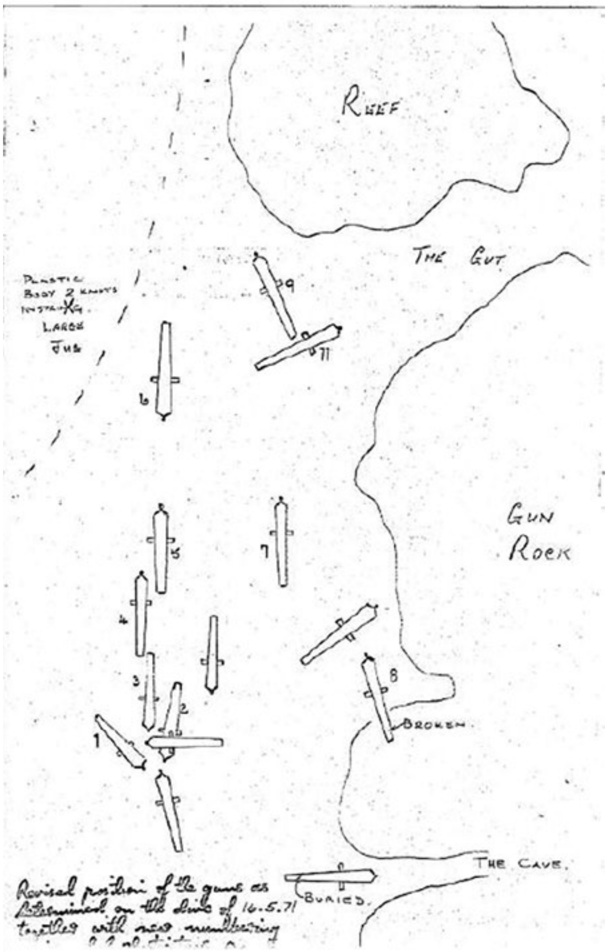

Figure 4. Gun Rocks site plan created by Tyneside 114, 1970 (© Gun Rocks Collection).

After the 1970s Tyneside investigation concluded, the wreck site continued to be a popular local dive location. The next recorded archaeological investigation took place in 1995 when the site was dived twice by the Archaeological Diving Unit (ADU) as part of the *Protection of Wrecks Act* diving contract operated by Historic England (formerly English Heritage). The ADU located eight cannon of a mixture of patterns and calibre, to the west side of Gun Rocks along with groups of iron shot. Both cannons and iron shot showed signs of recent interference by divers and while the ADU assessed the site it was not as popular with divers as it once had been; there was no doubt that some looting had still taken place. Despite this threat, the ADU did not consider Gun Rocks suitable for protection under the Act, however, it did recommend garnering support from the Nautical Archaeology Society and encouraging local diver custodianship to prevent further deterioration of the site (ADU 1995).

Interest in the Gun Rocks wreck was renewed in 2010 with Tyneside's Gun Rocks Project II to coincide with the 40th anniversary of the club's initial investigation (Hunt 2010). The divers had an impressive list of goals for this investigation, including identifying the name of the ship, and while they did not achieve many of the goals, they certainly created interest in the site for a new generation of club members, which continues to this day.

The 2010 investigation commenced with a research phase in which the club members consulted with the original team of divers to learn more about the initial investigation and what to expect on site. In preparation for one of their key aims of re-surveying the site, key club members attended a Nautical Archaeology Society practical survey course. The club members also identified their strength in underwater photography and practiced creating a photomosaic on land and in a pool.

Over the period May to September 2010, a changing team of club members visited the Gun Rocks site on four occasions. On the first dive, seven cannon were located and a rough site sketch was completed, however, the divers concluded that extensive kelp clearing was required if any further survey work was to be successfully completed on the site. As one of their aims was to complete a Seasearch Survey of the marine life on Gun Rocks, they completed that on the first and second dives before commencing kelp clearance on dives three and four. Divers did note that there were cannonball shaped depressions in the cannon concretions showing evidence of recent looting.

Along with finding another cannon to the north of Gun Rocks, on dive four, the cannon were numbered in preparation for later survey (Hunt 2010: 8), which never took place. Tyneside were not successful in their major aim of identifying the name of the ship or their goal of comparing the current site condition with the 1970 survey, however they were certainly successful in other ways. One of Tyneside's aims for the Gun Rocks Project II was to promote the club and BSAC through the local media (Hunt 2010: 4). A fairly regular stream of published and online articles, grants, conference papers and club presentations is evidence of their success in this aim (www.gunrocks.co.uk/media).

New site investigation

Based on the renewed interest in the site, Historic England commissioned the commercial archaeology company Wessex Archaeology in 2013 to investigate the wreck to establish the extant remains and to determine if it was under any human or environmental threat. This investigation commenced with a geophysical survey of the area to inform the later diving operations (Wessex Archaeology 2013a). Multibeam swath bathymetry data was acquired by the survey company EGS as part of the Centre for Environment, Fisheries and Aquaculture Science Marine Conservation Zone bathymetric survey. A magnetometer survey was also completed but the results were not useful due to the high magnetic field of the rocks. Side scan sonar was also completed and it was similarly unsuccessful close to Gun Rocks due to the rocky bottom, however, further away to the west the side scan was very informative and located six previously unknown cannon on the plateau.

In September 2013, a team of commercial archaeological divers from Wessex Archaeology, in conjunction with a separate team of recreational divers from Tyneside, investigated the Gun Rocks site by ground-truthing geophysical anomalies, establishing the extent of archaeological remains on the site and documenting some of the cannon through photogrammetry (Wessex Archaeology 2013b).

Thirteen heavily concreted cannon were located amongst the dense kelp on a rocky seabed of varying depths in an area approximately 20m by 20m to the south and south-west of Gun Rocks. They were heavily concreted cast iron smooth-bore muzzle loading (SBML) artillery pieces. Historical reports showed that some of the cannon had been moved over time and this was further proven from the rope still wrapped around one cannon on the seabed. The only small finds made on the site during this investigation was a small section of lead sheeting and two iron shot found amongst the cannon.

Another six heavily concreted cast iron SBML artillery pieces were located by side scan sonar 30m west of the 13 cannon. They were lying on a cobbled flat seabed with sponges and a few urchins as the predominant sea life.

A swim search was carried out between these two cannon sites to see if other cultural material was in the area that might link the two groups together but no finds were made. The lack of other cannon material in the Farne Islands area, however, suggested that these two sites were most likely connected.

The two Gun Rocks sites were recorded through standard photography, diver measurements and the acoustic diver tracking system. Wessex Archaeology also used photomosaic and photogrammetry to record various features of the first Gun Rocks site.

At the completion of fieldwork, the collated measurements, key features and photographs of the 19 cannon were examined and it was discovered that there was no uniformity of dimensions amongst the cannon around Gun Rocks, not even matching pairs of cannon. There was also no logical distribution pattern of the cannon on the seabed. Cannon lengths ranged from 2000mm (6'6) to 2833mm (9'3) with bores similarly varying from 70mm (2 ¾") to 145mm (6"). These measurements and key photographs of the cannon were sent to ordnance experts Charles Trollope and Nico Brink for further analysis. The range of guns on site were mostly small to medium calibre and comprised: a two-pounder, eight six-pounders and possibly one other six-pounder, another six cannon were eight-pounders, and the largest of the cannon was from the original site, which was identified as an 18-pounder and another large cannon from the site on the plateau was identified as either an 18 or 24-pounder (pers. comm., Charles Trollope, January 2014).

Charles Trollope concluded that the varying dimensions of the cannon on board meant that these artillery pieces were probably not being used for on-board defence but for re-use or ballast. While all armed vessels had a range of calibre weapons on board at any one time, it was usual to have different groups of matching calibre weapons to serve varying purposes rather than the mismatch assemblage displayed at the Gun Rocks site.

One characteristic across the site was the condition of the guns. Many of them were damaged with at least three having blown out muzzles. Two other cannon had missing or damaged buttons and several had deep pitting on the body of the cannon. It is likely that the concretion covers other damage on the cannon as well. Taking the damage into account and the fact that there

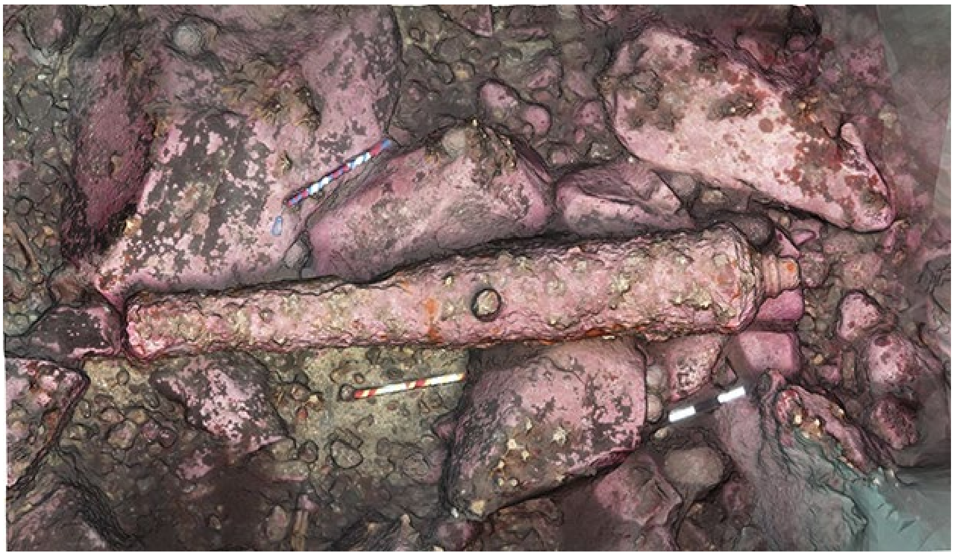

Figure 5. Photogrammetry model of British cannon by John Brown.
Crown Copyright, Wessex Archaeology.

was no uniformity amongst the cannon measurements, this supported the theory that they were for ballast or re-use rather than defence weapons.

Based on the initial photographs taken during this survey, Charles Trollope and Nico Brink concluded that these were most likely Swedish cannon. Added evidence for this argument came from the Tyneside divers of the 1970s when they located trunnion markings under the concretion. The three cannon that were marked with 'F' on their trunnions (Smith 1970: 59–60) were identified as Swedish cannon from the production centre at Finspong, Ostergotland (Kennard 1986: 74).

Cannon founding was a major industry in Sweden and was first established by the Dutch de Greer family and supplied most of the Dutch requirements for iron guns from the 1620s onwards (Martin 2005: 192). Nico Brinck also suggested a production date of between 1670 and 1710. The 2013 investigation concluded that this was a merchant vessel with broken Swedish cannon for the Dutch market as ballast that was blown off course.

Wessex Archaeology presented their research on Gun Rocks at the Ordnance Society's Guns from the Sea conference in 2015. This included displaying some 3D photogrammetry models of cannon that had been created after the report had been written (Figure 5).

Cannon experts had already seen photographs of these cannon, however, when they saw the detail in the photogrammetry model, they were able to more accurately identify the cannon as an English piece by John Brown. This was based on the pattern profile of the cascabel that was not obvious in the underwater photographs previously sent to the experts. This enhanced post-fieldwork photogrammetry analysis of the cannon led to the revision of the Gun Rocks wreck story and inspired further investigation.

John Brown held the position of King's Gunfounder in 1613. He had a gun foundry in Brenchley, Kent (Ffoulkes 1937: 75). Upon his death in 1652 his sons, John and George, continued in the family business (Hall 1952). Brown guns were made for the Dutch market as well as for local use. The cannon sent to the Netherlands survived in the historical record, as there were no foundries to reuse the metal. Many Brown guns that remained in British ownership were recycled once they had become damaged or obsolete (Bull 2008).

The John Brown cannon (Figure 5) would have been manufactured between 1613 and 1652 (Kennard 1986: 50). However, the wreck probably occurred several decades after this time as the cannon is highly damaged and shows many years if not decades of use.

By the end of 2015, it was known that a few of the cannon were Swedish-made in Finspong, probably at the end of the 17th century or early 18th century and at least one of the cannon at Gun Rocks was most likely a British-made gun from the first half of the 17th century. As there was such a variety of sizes and calibres of guns and many of them were damaged, it was still likely that these cannon were being used as ballast or being transported for recycling.

The success of the 3D photogrammetry models in identifying the cannon inspired the two archaeologists who had been involved in the Wessex Archaeology investigation (the authors) to continue the research in a volunteer capacity. Some members of the Tyneside dive club were also interested in working on the site again particularly if it involved developing their skills in photogrammetry. An independent expedition was planned for the middle of 2016. The authors volunteered their time and archaeological skills and guided the local dive club through the continuing investigation of the Gun Rocks site using the latest imaging techniques that had been developed on the site in 2013. It was decided that photogrammetry of the cannon would be the most productive method of examining the site as there was only a small chance that any more identifying small finds would be located on site.

The project was further supported by Wessex Archaeology and Flinders University who provided computing power and personnel to process the photogrammetry models and contributed to the financial costs of presenting the findings in Australia at UNITWIN and IKUWA in 2016.

The volunteer archaeologists and recreational divers completed a number of days on site clearing the kelp and capturing the cannon through photogrammetry. This was as much an up-skilling exercise as it was fieldwork and data capture, which was fortunate because much of the photogrammetry models did not work out due to the inexperience of the recreational divers in the technique of photogrammetry. Despite receiving training in photogrammetry, the models produced by the divers were not of a sufficient quality to reveal the identifying features of the cannon. However, the dive club was still enthused and had developed more skills and was planning for the next season to continue the work.

As part of the 2016 research, some of the original 1970 diving team were interviewed to gain a greater understanding of their investigation and to record the details before too many more of them passed away. Apart from recording the social history surrounding the site, these interviews also helped to reveal further details about the small finds that were raised in1970.

Attempts were made to re-examine these small finds to see if new techniques would reveal more information about them. However, despite repeated requests for divers to display the Gun Rocks related contents of their private collections, only two finds were made available. A cannonball and a sword hilt were photographed but no further information was revealed from this process.

Results/Discussion

The wreck site consists of two areas of scattered cannon that are of mixed small to medium calibres, of at least two different manufacturers and with many showing signs of pre-wrecking damage. Some small finds have been discovered in the past and it may be possible that more may be found in the future between the rocks and gullies. No wreck structure has ever been found on this site and due to the rocky nature of the seabed, it is unlikely to preserve any wreck remains.

Attempts have been made to re-examine the small finds raised in 1970s. Due to the intrinsic suspicious and protective nature of some divers, it has been impossible to view any more than two old finds. By slowly developing trusting relationships with the diving community, it may be possible to examine these small finds in the future and perhaps reveal more information about the identity of the wreck.

Attempts have also been made to re-examine the Tyne Tees TV footage from 1970. Numerous searches and enquiries have located the out-takes of the footage at the Yorkshire archive and this is in the process of being digitised to allow for viewing, however, it appears that the original TV programme has been deleted.

The whereabouts of the cannon raised as part of the TV show has also been investigated. No Newcastle-upon-Tyne museum has found a matching record in their catalogues. A possible conclusion is that the conservation was unsuccessful and the cannon was 'deaccessioned'.

In 1970, it was possible to base the analysis of the wreck site on a broader range of artefacts as small finds are often the most datable items on a wreck. However, as no more small finds have been located on the seabed in recent history, the analysis of the site has to be based on the cannon only. Another challenge for this process is that permission has not been given to remove any concretion from the cannon and, therefore, any distinguishing marks are obscured. Fortunately, the technique of photogrammetry can reveal some level of the obscured design detail such as reinforcing rings.

The Tyneside divers continue to develop their photogrammetry skills and this will hopefully produce more photogrammetry models of cannon in the future. The models that have been created so far have been integrated into the bathymetry of the site to create an illustrative site plan that can help examine site formation processes (Figure 6).

The Future

This site still holds potential for much work in the future although it may never be possible to identify the name of the wreck. Apart from the creating of photogrammetry cannon models, there is scope for archival research to assist in the identification of the wreck. Various local archives have been consulted in

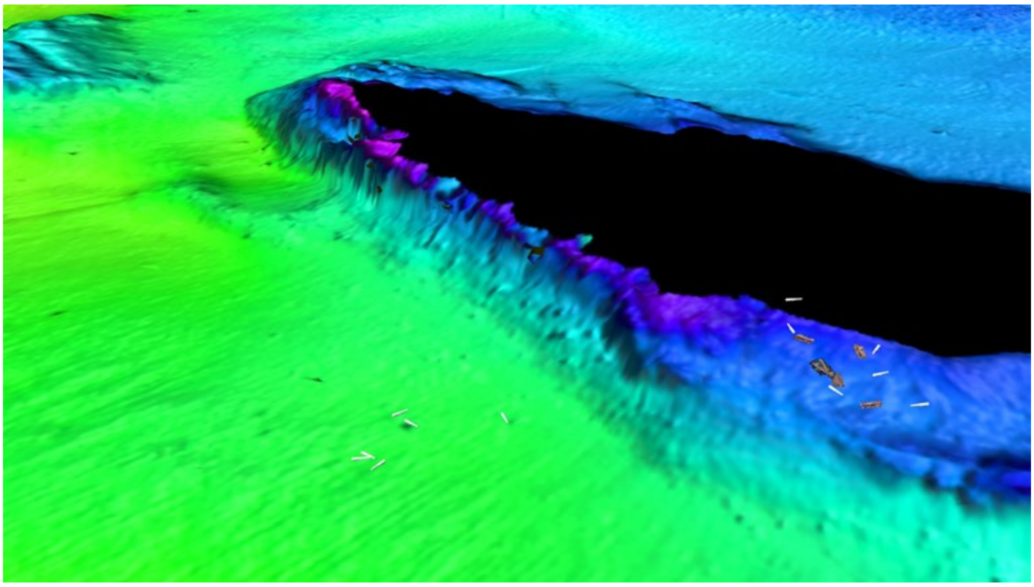

Figure 6. Multibeam of the entire site. Crown Copyright, Wessex Archaeology. All data has been made available under the Open Government Licence (http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/). Interpreted data may be liable to change.

an attempt to connect the shipwreck remains with historical records of local shipwreck events. The research into the Gun Rocks wreck has itself become an archive. The reports, photos, finds and films of the 1970 expedition are also being researched and documented through several club members' efforts.

There is also potential for invigorating underwater heritage tourism through this wreck. Tyneside divers have planned a dive trail on the site, which has been supported by crowd funding and two separate grants. It will be set up during 2017 and allow divers to follow a path around the site to view all the cannon and understand more about the history of the wreck and the investigations that have taken place on the site through underwater guide slates.

Tyneside club is still enthused to investigate the site, particularly using photogrammetry and they will continue to have the support of a professional archaeologist into the future. Time and tide willing, the remainder of the cannon should be recorded through photogrammetry in the not too distant future and may reveal more details as to the origin and dating of the shipwreck.

Acknowledgements

This ongoing project would not have been possible without the Tyneside 114 divers both past and present. Gratitude is extended to Nico Brink and Charles Trollope for their cannon identification skills. The support of Historic England, Wessex Archaeology and Flinders University is also appreciated.

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Prospecting and Digging to 1100m with an Rov: The 2016 *Nuestra Señora De Las Mercedes* Campaign

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Abstract

The Spanish frigate *Nuestra Señora de las Mercedes* was sunk in 1804 by the English Navy in peace time and this shipwreck was salvaged in 2007 by Odyssey Marine Exploration. In 2012, the Supreme Court of Washington passed final judgment in favour of Spain, forcing Odyssey to hand over all objects plundered from the wreck. After the successful legal work, it was necessary to conduct the archaeological work, which is presented in this paper.

So far, three scientific expeditions to the *Nuestra Señora de las Mercedes* have been organised by the National Museum of Underwater Archaeology in collaboration with the Spanish Institute of Oceanography (2015 and 2016 campaigns) and with the Spanish National Research Council (2017 campaign).

In this paper we focus on presenting the results of the 2016 campaign, especially on the *chafalonia* (an archaic Spanish term for old silver objects that were going to be melted down to extract the silver) silverware analysis.

Keywords

Deep water archaeology, *Nuestra Señora de las Mercedes*, Museo Nacional de Arqueología Subacuática ARQVA, *chafalonia* silverware, culverins

Introduction

Justification for, and origin of, the project

Although this paper focuses on the 2016 campaign, it is important to note that the entire project is the consequence of a salvage on a Spanish shipwreck that falls under Spanish State Policy on Underwater Cultural Heritage, which is based on a two-pronged policy: legal and archaeological.

When the Spanish government came across, on 17 May 2007, the announcement of the North American treasure hunting company 'Odyssey Marine Exploration, Inc.', that they had moved to Tampa, Florida, with *c.* 600,000 silver coins of a (supposed) English wreck sunk in international waters, Spain's reaction was immediate. The first initiative involved notifying the US Courts that the Spanish Government would be presenting a claim based on the suspicion that Odyssey Marine had plundered a Spanish vessel. Spain based its defense of the case on extraordinary documentation from the General Archive of the Indies (Seville) amongst others, in such a way that from 2009 to 2012, various judicial decisions were made in the US Courts in favour of Spain.

Finally, on 17 January 2012, it was shown conclusively that the shipwreck *Nuestra Señora de las Mercedes* (henceforth, '*N. S. Mercedes*', or simply, '*Mercedes*') was a Spanish ship and that its cargo must return to Spain. This concluded Spain's five-year legal battle that had been initiated by the Ministry of Culture in June 2007.

On 25 February 2012, all the cargo of coins plus a series of lesser but historically valuable objects, was flown from Tampa, USA, to Madrid. Ten months later, in December

2012, the goods were deposited at Cartagena's National Museum of Underwater Archaeology. Furthermore, in 2015 a US Court ordered Odyssey to pay Spain $1 million for 'bad faith and abusive litigation'.

After successfully concluding the case from a legal perspective, the next step was to undertake the archaeological work. The Museum believed that the Spanish Government should not be satisfied with the data provided by Odyssey. It was necessary to verify from an archaeological perspective, the state of the wreck, and to carry out scientific investigation. The main challenge was the extreme depth of the shipwreck—at about 1135m, this was a level at which no European country had ever carried out an archaeological excavation. In the spring of 2014, the director of the National Museum of Underwater Archaeology presented to the Ministry of Education, Culture and Sport, a proposal for the 'Project Mercedes 2015', to undertake an expedition to the wreck, which was finally approved.

So far, three scientific expeditions to the wreck *Nuestra Señora de las Mercedes* have been organised by the National Museum of Underwater Archaeology. In August 2015 and September 2016, we worked in collaboration with the Spanish Institute of Oceanography (IEO in Spanish), using its oceanographic vessel *Ángeles Alvariño*. In August 2017, a third campaign was held from the oceanographic vessel *Sarmiento de Gamboa* of the Spanish National Research Council (CSIC, in Spanish).

Location

The shipwreck is located in the Gulf of Cádiz, south of Portugal, off Faro, at a depth of about 1136–1138m. It is outside of the 12 miles of Portuguese national waters, and outside the 12 miles of the Contiguous Zone. The wreck is on a small rise, right at the end of the Guadalquivir contouring channel (SE), and very close to the gentle Faro canyon head to the west. The bottom here is completely flat and horizontal with no outcropping rock formations. This seabed is completely covered by very fine, pale grey sand, through which the upper sections of ingots, cannons, groups of coins, and so on, can be seen proud of the seabed.

Project objectives

- To precisely locate the archaeological site of the frigate *N. S. Mercedes* and verify the veracity of the coordinates provided to the American Courts by Odyssey;
- To document the site and 'operations' conducted by the aforementioned company, Odyssey;
- To document the current state of the remains of the shipwreck at the seabed surface. The team aimed to determine what had survived from the sinking in October 1804, and in what state, as well as after the intrusions made by treasure hunters from Odyssey;
- To undertake acoustic prospection of the seabed to characterise the geomorphology of the sinking zone;
- To draw up a detailed bathymetric map of the sinking zone to serve as a reference to help the ROV (Remote Operated Vehicle) navigate safely;
- To draw up an archaeological plan of the remains;
- To document, by means of ROV video recordings, the present state of the shipwreck remains in order to measure the damage caused by the Odyssey's plundering, and to extend our knowledge about the sunken vessel; and,
- To place a memorial at the site, dedicated to the civilians and military personnel who perished in the attack.

Main technical equipment

The oceanographic vessel *Ángeles Alvariño* from the IEO was used in the 2015 and 2016 seasons. This is a modern ship, 46.7 m long and 10.5 m wide, built in 2012 with the following equipment:

- A positioning system comprising a Seapath 300+ and a GPS Differential Trimble Ag132 navigator;
- A Kongsberg K-Pos DP dynamic positioning system;
- An EA600 single beam echo sounder;
- A Simrad EM 710 multibeam echo sounder;
- A SV-PLUS X velocity profiler; and,
- A TOPAS PS-18 (Topographic Parametric Sonar), a parametric sub-bottom profiler.

The ROV *Liropus 2000*, owned by IEO, has its control centre located in a container on deck (Figure 1). This is a Super Mohawk Sub-Atlantic model, with six motors, five cameras (one HD and another to work in low light conditions), GPS, sonar, a sample tray, two hydraulic arms (for taking solid, liquid and gas samples, and other elements). It can be submerged up to a depth of 2,000m. The ROV stays inside the TMS (Tether Management System) until 20–30m before it reaches the sea bottom. The TMS is an excursion cable management system that houses and protects the ROV during lowering and hoisting manoeuvres.

In 2015 the ROV had two manipulators: one factory standard 'Hydrolek' arm and a 'Titan ROV', a new titanium manipulator developed by the company ACSM and the CIA group from the University of Vigo. In 2016 the capabilities of the ROV were improved with two titanium arms and a new camera able to realise archaeological zenith photos.

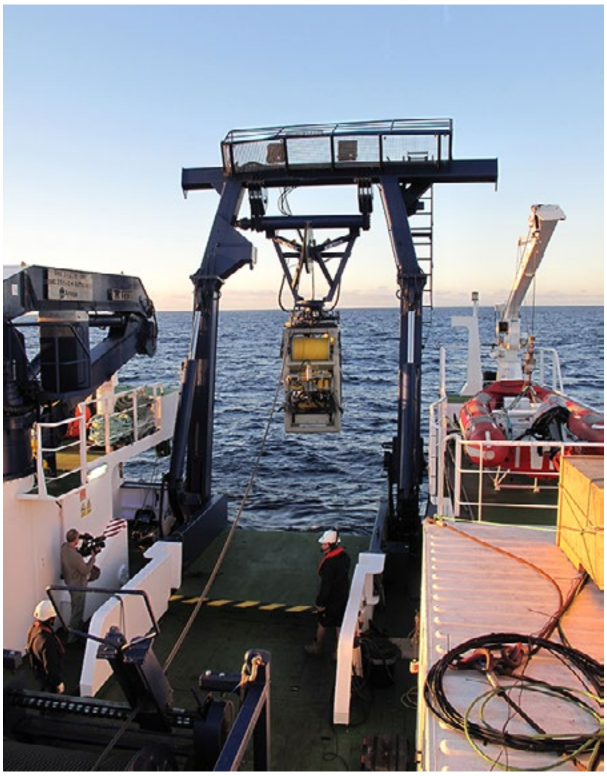


Figure 1. ROV *Liropus 2000* used in 2016 comprising two titanium arms, several video cameras and a new camera.

2015 campaign

The 2015 campaign lasted from 18th to 23rd August. The deep archaeological survey was a complete success locating, at 1136–1138m deep—reaching, recording and digging the remains of the *Mercedes*. First, a geological survey of the area was conducted (bathymetric map, reflectivity study) using multibeam, sound velocity profiler and TOPAS. After that, an archaeological study was carried out using the ROV *Liropus*. Several hundreds of artefacts were referenced, positioned with very high precision, and documented: anchors, iron and bronze cannons, copper and tin ingots; a set of silver crockery and cutlery, silver candlesticks, a gold pestle, etc. Then, an archaeological excavation was carried out using a water-jet and an extremely careful methodology. Thirteen small objects were extracted to document unknown aspects of the frigate. Finally, a bronze plaque was deposited in the archaeological site as a memorial in honour of the victims who were murdered on 5 October 1804, when the *Mercedes* frigate was attacked by an official English Navy fleet despite the Peace Treaty of Amiens (1802) being in place.

The Ministry of Education, Culture and Sport of Spain published the results of this first campaign in Spanish and English (Negueruela *et al.* 2015, 2016a, 2016b). A Spanish version is available online <https://sede.educacion.gob.es/publiventa/arqueologia/20500C>.

2016 campaign

Objectives

The objectives of the 2016 campaign were:

1. To continue the work undertaken during the first campaign regarding knowledge about the wreck, namely:

- Extent of the site;
- Dispersal of the remains of the frigate;
- State of preservation of materials;
- Continue the archaeological mapping;
- Progress interpretation and analysis of the wreck; and,
- Fill the gaps in documentation from the 2015 season: concrete targets were focused on the south and south-east areas of the wreck, which were not documented in 2015 and therefore left gaps.

2. To extract a small number of objects according to the following criteria:

2.1. Pieces that are listed in the documents of the General Archive of the Indies. Extracting such pieces was aimed at definitively identifying the frigate as the *Nuestra Señora de las Mercedes*, and eliminates the slightest shadow of doubt about its identity; and, to prevent it being raised by anyone in the future, especially anyone closely associated with Odyssey.

2.2. Unique objects that give us new knowledge about the period. All this, based on historical-cultural, museographical, conservation, archival and legal reasons:

A. Bronze culverins from the 16th century;
B. Howitzer of bronze, couple of the one extracted in 2015; and,
C. Elements of deteriorated silverware (*chafalonia*) referred to in the General Archive of the Indies documents.

2.3. Complete the cartography of the sinking area of the *Nuestra Señora de las Mercedes* Frigate.

Dates of the campaign

In theory, our general calendar of the campaign was planned as follows:

September 7th: Boarding in Cartagena.
September 8th–10th: Crossing the point of destination.
September 10th–18th: Archaeological works.
September 18th–19th: Crossing back to Cartagena via Cádiz.

Institutions involved

- National Museum of Underwater Archaeology (ARQVA, Cartagena), Ministry of Education, Culture and Sport, Spain—the organizing and responsible institution for the campaign. Personnel involved: director and three technicians.
- Spanish Institute of Oceanography (IEO, Santander), Ministry of Economy and Competitiveness, Spain—provided the ship, *Ángeles Alvariño*, the ROV and the oceanographic technicians.
- Spanish Navy, Ministry of Defense—provided two observers.

Beginning of the campaign (7th–15th September)

On the 7th, at 11:00pm, the ship *Ángeles Alvariño* sailed from Cartagena carrying Museum staff, IEO staff and the two guests: the Navy observer and a guest from DEGUWA (German Society for the Promotion of Underwater Archaeology). On the journey, the ship was anchored at a point off the coast of Almeria while the IEO technicians performed various tests with the ROV. On the 9th, we arrived at the shipwreck location.

From the first hour of the morning of the 10th, the on-board indicators showed the impossibility of descending the ROV due to waves higher than 1m, as the sensors indicated. This meant that no archaeological operation could be carried out all day. The weather forecasts, constantly consulted from both the captain's command bridge and the ROV technicians, provided for a 'good sea window' on the 11th from 2:00pm. This day was planned for a Navy ship to sail from the port of Huelva carrying several Spanish media journalists.

The Navy ship arrived next to the *Alvariño* about 1:00pm on the 11th; and, towards 2:00pm, we began to immerse the ROV facing an apparent weather improvement (dive 1), but when reaching 150m depth the technicians had to suspend the operation and re-raise the ROV due to bad sea conditions. So on the 11th no archaeological operations occurred. At 4:00pm, the group of journalists left on the *Alvariño*. That day, on the 11th afternoon, all the meteorological forecasts began to indicate the impossibility of working before the 16th. Given this, which announced waves of more than 2m, the captain decided to move to Cádiz where we would expect weather improvement by the 16th. On the night of the 15th, we departed from Cádiz to the site to be present for the 16th morning.

Changes to campaign objectives due to sea conditions

As the days progressed, the weather forecasts and sea conditions means that we expected some hours of good sea conditions for the 16th, and the possibility of working also on the 17th (which in the end proved impossible). Facing such an unfavourable situation, the tense wait was spent conducting two drills on deck, attempting to meticulously measure the time needed to develop the operations once we arrived on the seabed. The purpose was to organise the work, assuming that we only had a few hours, to take advantage of the maximum time that could be available on the bottom and optimise profitability for the project.

Consequently, the archaeological planning had to be changed. We were forced to discard, one after another, the initial objectives of the campaign. The tasks of completing the mapping of the entire wreck, recording of scattered archaeological elements and documenting of the south and south-east areas of the site, had to be cancelled. Instead, it was decided to maintain two objectives that by their spatial concreteness would be easier to fulfill: to work on the chest with silver *chafalonia* and, if time permitted, on a Renaissance culverin (Figure 2).

The chest with silver *chafalonia*

The criteria for choosing this amongst several possibilities was that it is the part of the cargo best documented in the General Archive of the Indies, which we hoped would contribute significantly to definitively identifying the wreck.

It should be considered that the materials extracted in the 2015 campaign included a gold pestle, remains of two silver candelabra, remains of six pieces of silver cutlery, a set of three plates in very bad condition which were adhering to each other, as well as a howitzer. The silver elements, by their poor state of conservation, allowed us to propose that they could be the *chafalonia* cited in a document of the General Archive of the Indies. It is, however, certain that in the 2015 campaign, we could not establish an 'objects–documents of Seville' relationship with an absolutely uniquivocal and definitive conclusion.

Among all these documents preserved at the General Archive of the Indies, one (AGI, Lima, 1535, N.6, folio 173) listed some objects loaded onto the *Mercedes*. This listed very specific aspects and details about some objects such as 'silver *chafalonia*', 'gold mortar and pestle', that are not usual in other documents (Figure 3). These details are:

4. The name 'Encina' as commissioner of some of the objects.
5. The 'XX' mark engraved on some silver objects.
6. The seals of the Royal Tax (*Quinto real*).
7. The weight of the gold pestle and mallet.

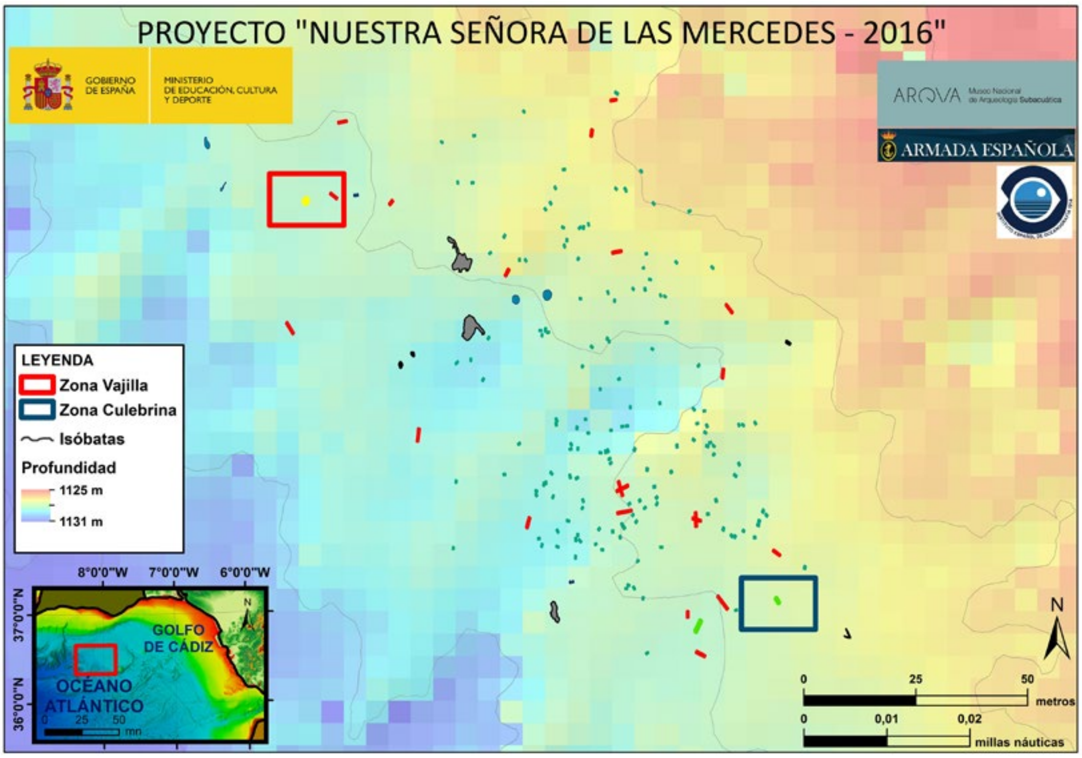
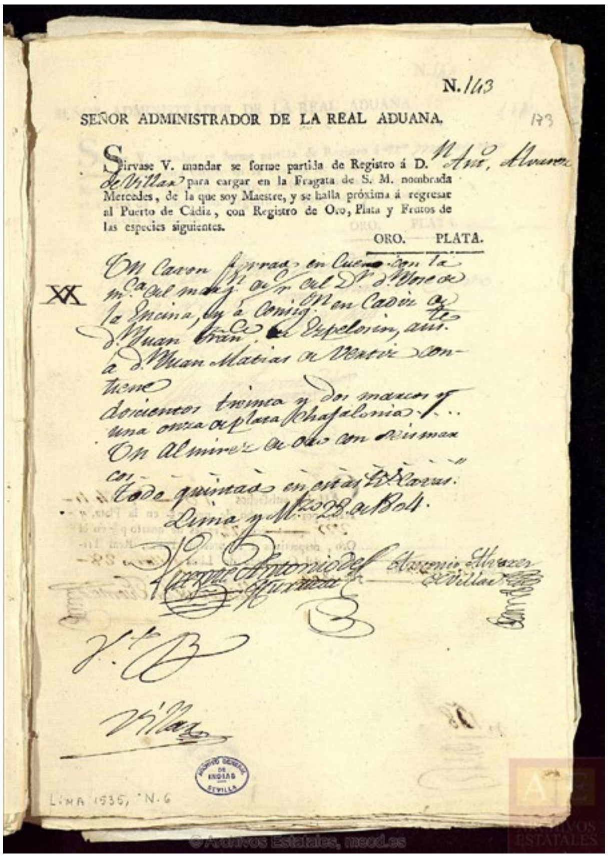


Figure 2. Map of the site in 2016 showing the two areas where 16 September works were concentrated: tableware in the north-west red box, and culverin in the south-east blue box.


N. 143

SEÑOR ADMINISTRADOR DE LA REAL ADUANA.

Sirvase V. mandar se forme partida de Registro á D. para cargar en la Fragata de S. M. nombrada Mercedes, de la que soy Maestre, y se halla próxima á regresar al Puerto de Cádiz, con Registro de Oro, Plata y Frutos de las especies siguientes.

ORO. PLATA.

Lima

LIMA 1535, N.6

Figure 3. General Archive of Indies document with description of the shipment of the chest and its contents (A.G.I., Lima, 1535, N.6, Folio 173).

If we could find any of these elements we would greatly progress with the definitive association of the wreck with the *Nuestra Señora de las Mercedes*.

Work on a Renaissance culverin

The second objective was the identification and extraction of at least one of the Renaissance culverins that we had located in 2015, since the document AGI, Lima, 1440, N.25, folio 756 quotes ‘two useless bronze cannons’. The combination of these two factors (location of some elements containing silver objects and one of the culverins) would provide certainty of the wreck’s identification as the frigate *Nuestra Señora de las Mercedes*, forever, and in an uncontestable way.

End of the campaign (16th–20th September)

Once all the sensors of the ship guaranteed us the possibility of working on 16 September, we had as a priority, the work in the area of the chest that contained a cargo of silver *chafalonia*. At last, on the 16th, the good sea conditions allowed us to start with the intended work. At 8:00am we begin to descend the ROV (dive 2). In less than two hours, the chest was located. Once there, as in 2015, the water lance was used to excavate the archaeological objects and clean them from the sand deposits that covered them. As they were cleaned, several were extracted (Figure 4) in the confidence

Figure 4. Zenith photograph of the ROV working on remains of the chest with numerous silver objects (crockery, cutlery, candelabra, coins) and a gold mallet.

that they would provide us with the guaranteed identification we were after.

As a result, the work on the target had started at 9:40am and continued uninterrupted until 1:00pm. During that time, a complete 'package' of photographic and video documentation was made for each of the steps. At 1:00pm, the ROV emerges from the water and the campaign director proceeds to record the minutes, after which the museum technicians carry out their inventory, measurement and packing in the afternoon. The third dive began at 3:38pm to proceed with the extraction of one of the bronze culverin. However, and unfortunately, due to the tension of the machine, the rope broke, leaving the cannon and transponder at the bottom. There were also many problems, due to the increasing swell, when reintroducing the ROV into the TMS, which was achieved at 10:07pm; it reached the surface at 10:53pm.

On the 17th, the campaign director was informed by the IEO's responsible representative that the operation would be very risky in those conditions. Therefore, there will be no more attempts to raise the culverin, and the extraction had to be aborted. On the 18th, the Ángeles *Alvariño* sailed from the site to the port of Cádiz. On the morning of the 19th, all the material extracted was loaded to a truck that was escorted by Civil Guard vehicles from Cádiz to the National Museum of Underwater Archaeology in Cartagena. At 10:00pm, the truck arrived at ARQVAtec (the Museum laboratories at Cartagena) where all equipment was unloaded. The materials were unpacked on the 20th.

Recovered materials

Of the set of several thousand pieces that we located and of the several hundred for which we recorded positions, only 35 pieces were extracted in 2016: the gold mallet that corresponds with the pestle extracted in the 2015 campaign, both of gold and 34 pieces of silver corresponding to soup plates, flat plates, two large incomplete fountains, a large deep centerpiece platter with horizontal handles, various forks and spoons, coins and other items (Figure 5). Several of these elements were concreted together and needed to be separated in the laboratory.

First conservation treatments

During the archaeological survey *Nuestra Señora de las Mercedes* in 2016, 35 individual or joint objects were recovered from the wreck site: a mortar of a gold mallet and series of silverware and silver coins. The gold mortar

Figure 5. Objects recovered in the 2016 campaign.

and the rest of the silver objects, due to their chemical stability, do not present serious conservation problems after extraction from the seabed. Thanks to the X-ray diffraction analysis of the greenish concretions of the plates and candlesticks recovered in the previous campaign (2015), it was shown that they consisted of copper oxychlorides like clinoatacamite Cu2Cl(OH)3, atacamite and paracatamite CuCl2(Cu(OH)2)3, lying over the greyish concretions that consisted of silver halides (embolite AgCl and bromargirite BrCl). Therefore, the intervention for the preventive conservation of these objects after their recovery was minimal.

To protect them physically, they were wrapped in polyethylene film and placed in a custom-made polyethylene foam packaging (Ethafoam®) inside a large safety box. In this way, they were transferred safely to the Museum's conservation and restoration laboratory. In the Museum, we did not yet have silver coins in their original state, i.e., not altered by Odyssey. This was why the team recovered four lots of coins from the site, two individuals and two aggregates. They were protected with a sealing of Escal®, a transparent barrier film with effective resistance to penetration of oxygen and water vapor, because the inner layer consists of ceramic deposited under vacuum on the PVA substrate. This procedure has maintained the composition of the original corrosion products to be preserved in order to properly study them in the future.

Analysis of the 2016 campaign results

Assessing the preservation state of the site

The lengthy exploration and visual inspection of the objects found on the sediment by the ROV cameras permitted us to discover, on the one hand, the nature of the bottom, and, on the other hand, the preservation conditions of the archaeological objects that were not plundered by Odyssey or that survived their destructive incursion. The sea floor consists of very compact clay-rich sediment that is brownish in colour. On top of this surface is another layer of very thin pale grey sand.

The objects from the sunken frigate lie on the lower layer, which served as the deposition bed due to its being very compacted. In short, the objects penetrated the upper layer of very fine sand until they came to rest on the lower strata of compact clayey marls. For this reason all the objects from the shipwreck are surrounded by the upper layer and, in the case of some objects, partially sunk into the deposition layer. The materials are dispersed over a very wide area, and occupy a large part of the site. They appear on top of the seabed with their upper sections uncovered, meaning they are exposed to strong currents, which have an impact on them.

We observed numerous animal macroorganisms at the site including the remains of fish, crustaceans, sea urchins, sponges, molluscs, and so on, demonstrating the environment's aerobic conditions. The strong current, together with these aerobic conditions, has caused extensive oxidation of the iron objects, which are seen to have very thick layers of corrosion and concretions. This is so severe that one can hardly see the shape of the iron cannons due to the disfiguring concretions that have grown on their surfaces.

The silver objects are oxidised with greenish layers due to the corrosion of the copper content in their alloy, and they display grey-violet compounds due to the formation of soft, insoluble silver halides. The small objects, like the pieces of cutlery, appear to have sharpened ends due to the surface wear caused by erosion.

The bronze elements, which are harder, are apparently more resistant to the erosion, and appear to be in a better state of conservation. When they are still buried, as in the case of the culverin that could only be partially documented, their decorative and structural details show a high level of definition.

No organic objects were observed, such as the wood of the vessel. If it remained exposed, macro- and microorganisms would rapidly degrade it. Only if it remains buried will it likely survive, but in this case, it would not be visible during a visual inspection of the surface. Given the limited stratigraphic potential of the site, it is unlikely that wooden structures from the frigate are present.

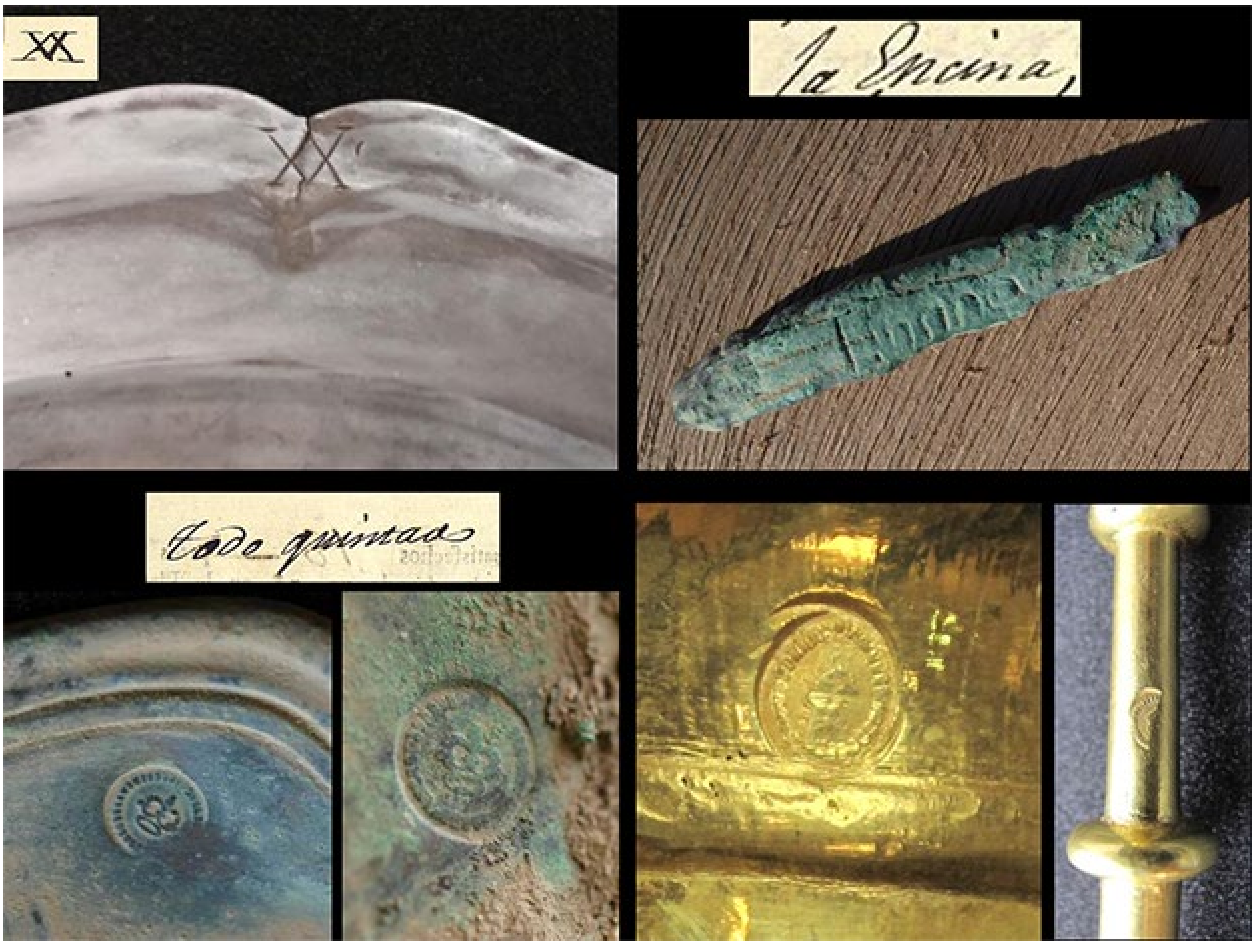


Figure 6. Trademarks in the AGI and on objects recovered in 2016: 'XX', 'Encina' and the seal of the Royal Tax (*Quinto real*).

Object trademarks included in the General Archive of the Indies

As referred to before, as the *Mercedes* was a royal frigate, all the documents regarding the frigate from the cargo to the captains' diaries, were preserved in the Army archives and on the General Archive of the Indies. By the study of these documents, some of them where chosen as they provide very specific information about objects that could be used to identify the frigate as the Mercedes without any doubt, if we were able to connect the information on the document with the objects. Among all the documents there is one—about one specific chest that was loaded to the frigate from a particular person (AGI, Lima, 1535, N.6, folio 173)—that lists very specific details making this object almost unique, as explained earlier. Once we recovered the objects, we were able to connect the information as follows:

- In that document, the sign 'XX' is registered in the margin with the express indication that it appears on some of the plates. We have been able to identify this sign on several of the dishes.
- The same document describes the objects sealed. We have also been able to identify the seal of the Royal Tax (*Quinto real*) on some plates and cutlery.
- Also, the reference document refers to the gold pestle and mallet, whose weight, once both extracted, confirmed what is reflected in the document.
- Furthermore, two of the objects recovered are engraved with the surname 'Encina', which appears in the same document of the General Archive of the Indies as the surname of the original owner of the objects.

These four elements are irrefutable evidence for the definitive identification of the wreck (Figure 6).

The precise coincidence of the materials recovered by the Museum in 2015 and 2016 with the precise data of the cited document of the Archive of the Indies definitively settles the identity of the wreck investigated as the frigate *Nuestra Señora de las Mercedes.* The precision of this identification is unprecedented in Spanish underwater archaeology.

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The Six Million Dollar Hand: A Robotic Hand for Remotely Operated Deep Archaeology

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Abstract

Today, underwater robotics allows access to deep-water wreck sites for analysis and, sometimes, for their exhaustive study. If we want to achieve this, we have to do better than operating light touches on the upper archaeological layer, or just picking up an isolated artefact as the only evidence of a cargo. Indeed, it is important to consider the exhaustive study of these wrecks that are so rich in information for archaeologists. However, the issues of dealing with remote artefacts on deep wrecks are far from being resolved. During the last five years, DRASSM has performed a large number of tests in order to develop robotic devices able to remotely mimic the gesture of an archaeologist and has then focused on the whole study of abyssal shipwrecks. On this experimental basis, in 2015, the ANR 'SeaHand' Project was born, involving DRASSM, the P' Institute (CNRS), the Montpellier Laboratory of Informatics, Robotics and Microelectronics (LIRMM, University of Montpellier) and industrial partners. Project SeaHand aims to develop a haptically controlled underwater robotic hand designed to perform archaeological work in deep water. 'Haptically' means that this hand provides the pilot with the sense of touch, allowing the handling of fragile artefacts.

This paper is about the technologies that we used and their results in our most recent work.

Keywords

Robotics, deep-sea archaeology, DRASSM, France, ROV, abyss

Introduction

Since its creation in 1966, the French Underwater Archaeology Research Department (DRASSM) has made a point of keeping up to speed with the various technological revolutions that have marked the history of our discipline, and it is for this reason that French archaeologists have endeavoured, since the early 1980s, to develop techniques for the study of wrecks lying at great depths. For many years such research was carried out with the help of large industrial groups and several research laboratories, but the results of these various experiments have often turned out to be disappointing.

In 2006 DRASSM decided to refocus its strategy concerning deep-water wrecks by developing its very own underwater vehicles and new methods. Moving steadily towards its goal, DRASSM has in the last five years surveyed nearly 50 wrecks at depths ranging from 300 to 1200m below the surface.

1980–2011: back to the pioneer age

In 1980, the Bénat 4 wreck, lying at a depth of 328m off Toulon, enjoyed the honour of being the subject of the first deep-water excavation in France. Initial results were promising and DRASSM has continued to research deep-water wrecks ever since because of their strong scientific potential, namely that ships sinking to such depths are always very well preserved. Even if the events leading to their wrecking were violent in nature, perhaps a storm or a battle, once the tumult and turmoil subside, the vast distance from the water's surface ensures little or no human intervention. Another benefit of the deep is the absence of waves, oxidation and, most of all, *teredo navalis* or naval shipworm, a tiny mollusc with a devastating appetite for wood.

Back in 1980, we did not realise the strategic importance of at least inventorying the deep-water components of our collective history—but we do now! A combination of improved diving technology (such as the development of rebreathers for SCUBA divers), exploration, commercial treasure-hunting and the expansion of fishing activities (to make the most of a diminishing resource) means that deep-water wrecks are now, more than ever before, under threat from deterioration and destruction. In short, in the preceding ten years the pillage and destruction of deep-water wrecks have become so widespread that we cannot expect this underwater heritage to survive unscathed. At the bottom of the sea lies a vast repository of artefacts that must at all costs be protected so we may study them and realise their scientific potential.

Using the submersible *Cyana* on these early excavations rendered abundantly clear to us the pressing need for developing archaeological methods specific to the deep. So in 1990, on the *Sainte Dorothea*, the wreck of a Danish 17th-century merchant ship, which lies off the south coast of France, DRASSM's archaeologists began the research and development necessary to achieve this goal. First of all, COMEX, a French robotics firm specialising in deep-water work, helped survey the wreck.

Then many tests took place through the 1990s to try out new methods and explore the intricacies of using mechanical excavating tools, sometimes on deep-sea wrecks but also on remains lying in shallower and, therefore, more accessible waters. In 1993 and 1995, DRASSM carried out much work in the Mediterranean on wrecks situated, respectively, at 660 and 450m below sea level. This time DRASSM used IFREMER's submersible, *Nautile*, which the French oceanography institute had developed to survey the remains of that world-famous wreck, the *Titanic*.

However, year after year, DRASSM's archaeologists realised that using third-party equipment in conjunction with scientists who were new to the field of archaeology created its own set of intrinsic problems. Basically, although institutions, industrialists and armies were happy to help archaeologists when they could by making their equipment available, it soon became apparent that they had their own ideas on how operations should be conducted and archaeologists would often find themselves relegated to the sidelines despite it being their show. Indeed, the owners of the equipment, robotic or otherwise, would retain direct control and all the external scientists were invited to do was to give an opinion. That said, these companies and organisations with whom we worked in the 1990s did help us develop suitable and innovative methods, such as using imaging and photogrammetry to build a representation of what we were finding on the seabed.

2012–2016: towards technical independence

Slowly but surely, DRASSM has worked ever since towards acquiring its technological independence so that it can carry out its own operations with its own equipment. In 2012, the launch of our scientific research vessel the *André Malraux* certainly gave a boost to its endeavours, but she is not the whole story when it comes to developing and trialling devices for use in surveying and excavating artefacts preserved in the deep. Therefore, earmarking an authentic archaeological site in the south of France for this purpose became unavoidable. The site features the *Lune*, a French naval vessel that sank off Toulon in 1664. The wreck lies 90m down and, being extremely well preserved, is an ideal subject for these studies.

The *Lune* was built over three years from 1639, had two decks, and carried 54 guns. On 6 November 1664, she set out from Toulon during a ferocious storm and, five nautical miles south of the coast, soon foundered. Her sinking was so sudden that the few witnesses who survived the tragedy reported that she 'sank like a stone'. Only a handful of the 800 aboard survived, probably no more than 40 people.

For the following three centuries, the story of the *Lune* was be forgotten until, in May 1993, her remains were brought to light. The *Nautile*, IFREMER's underwater exploration vehicle, came across the site quite by accident. DRASSM soon surveyed the old two-decker in her final resting place off the port of Carqueiranne, in 91m of water, and produced a detailed plan of the site. With the survey complete, it was decided that the great depth and the remarkable preservation of the wreck were two very good reasons for holding the site in reserve until such time as suitable technology and techniques became available for its comprehensive excavation and study.

With 20 years' experience in developing and testing innovative methods for excavating deep-sea wrecks under their belt, the archaeologists at DRASSM started planning works on the *Lune* in 2010, and two survey campaigns followed in 2012 and 2013. Our primary goal has always been to develop methods and machines for excavating deep-water wrecks, and to study them with as much scientific integrity as can be afforded for shallow-water sites.

A large part of the work undertaken on this test site has been devoted to the question of recovering artefacts. This remains one of our biggest challenges, and an altogether more complicated one was replicating human touch through the intermediary of a robotic device. Standard robotic equipment is, unsurprisingly, designed for industrial or military purposes and, for the most part, ill suited to specialist archaeologists wishing to deploy it underwater.

Hydraulic arms, which are a common feature of ROVs, are powerful but not particularly suitable for handling fragile objects because every attempt to move an object places it at risk. In 2013, we performed tests with a hydraulic arm fitted to a crawler, aiming to try out a device which could raise heavy objects, but we had to abandon this idea because the crawlers turned out to be very clumsy, and were quickly blinded by the sediment they disturbed as they moved.

Suction-cup devices like those used by the COMEX on the Grand Ribaud F shipwreck in 1988, are still an interesting idea but only work with one type of object that has to be hard enough to be held by its surface, and sufficiently smooth for the suction to gain a hold. Many other tests have been carried out during these few years, involving sophisticated equipment such as the French Navy's Newtsuit, which was developed by Nuytco Research and used in 2012 on the site of the *Lune*. However, while it is very impressive, it still requires a human operator.

Finally, the best result obtained during this first exploration period was certainly the shovel method, already used on the Mardi-Gras site in the Gulf of Mexico in 2007, and in Corsica at a depth of 360m. This method is worth exploring because it is the only way of recovering an object by supporting it from underneath. First of all, it includes the claw system designed by our brilliant 'mad scientist' Vincent Creuze of the Montpellier Laboratory of Informatics, Robotics and Microelectronics. Basically, it is a simple gripper, comprising two comb-like appendages mounted on an axle that can gently recover objects situated directly underneath it (Figure 1).

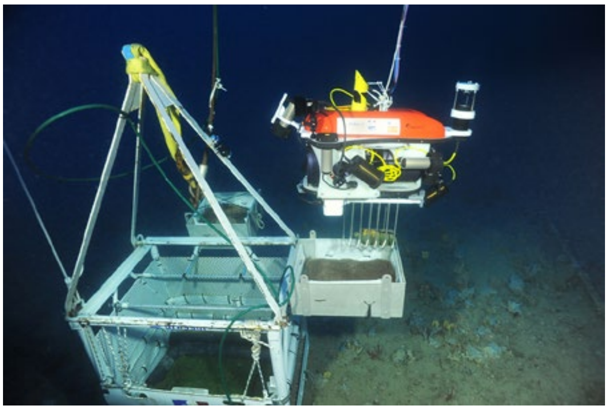

Figure 1. LIRMM's ROV fitted with sampling claws deposits an artefact in the deep-sea sampling case (F. Osada and T. Seguin, 2014 © DRASSM).

The combs are a perfect grab mechanism because they slide under the targeted object, and they also protect the recovered object by forming a sort of cage around it. We obtained very good results with this claw and so decided to develop a version for more powerful robots that would be capable of lifting heavier objects. So the next model moves under its own power and should be able to raise objects of up to 20kg (Figure 2).

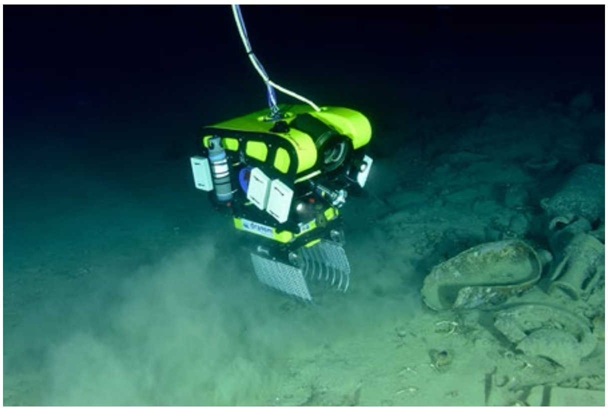

Figure 2. DRASSM'S ROV *Hilarion*, fitted with heavy sampling claws (F. Osada and T. Seguin, 2015 © DRASSM).

However, the claw system is not at all suitable for raising objects that lie in awkward places or are so fragile that they require more refined gripping systems. In 2014, once again on the site of the *Lune*, we tested a gripping prototype designed and built by Gilles Lopez, founder and director of the French company Techno-Concept (Figure 3).

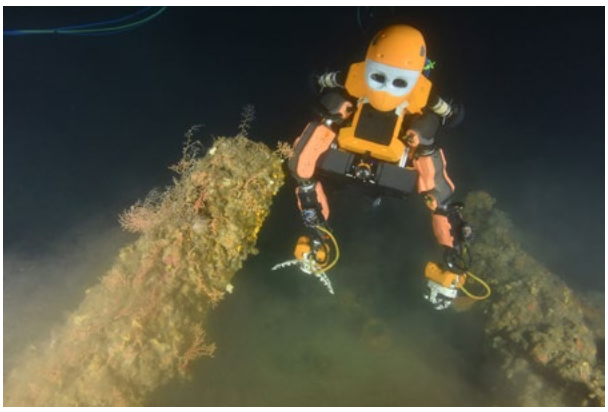

Figure 3. Trials of Techno-Concept's robotic hand off Toulon (F. Osada and T. Seguin, 2014 © DRASSM).

This robotic hand features the capacity to determine, by itself, at what point it has to stop squeezing when seizing an object. It does this through an ingenious self-adapting system, which is purely mechanical. The phalanges, which are jointed and activated by a complex system of cables and springs can adapt themselves with great ease to a wide variety of shapes. Once the object has been seized, the hand locks in position and maintains a secure hold on the object without compromising its shape or integrity. Tests on this very first version of the Techno-Concept hand have shown

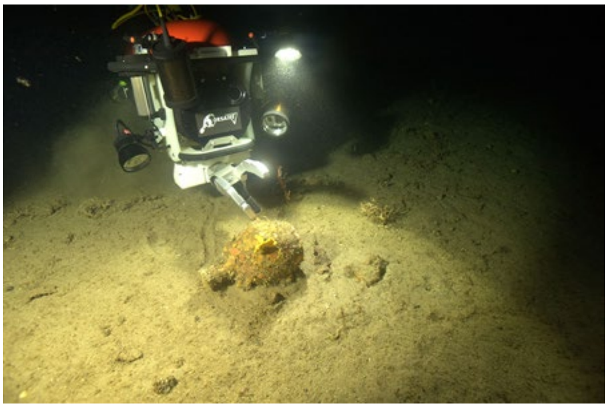

Figure 4. Techno-Concept's robotic hand on the *Lune* shipwreck (F. Osada and T. Seguin, 2014 © DRASSM).

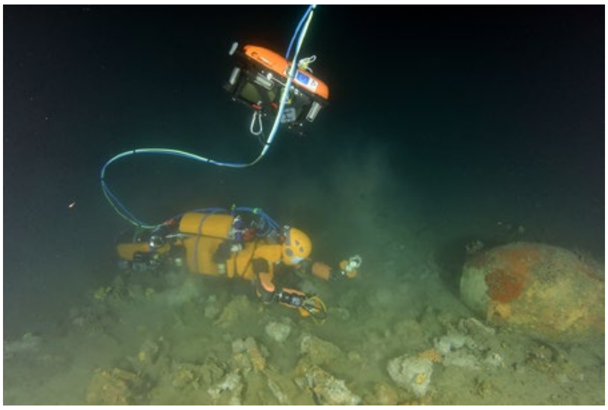

Figure 5. Stanford's humanoid robotic diver 'Ocean One' on the *Lune* shipwreck (F. Osada and T. Seguin, 2014 © DRASSM).

it to be fragile, but the concept has been proven sound, and work to improve its design is in progress (Figure 4).

2016: Ocean One: 'sci-fi' trials in the deep

However, the biggest event for French's submarine archaeologists in the last few years remains the meeting with Oussama Khatib, a professor at the Stanford Robotic Laboratory to whom the archaeological projects of DRASSM were duly presented.

Professor Khatib was already aware of these works and he immediately told us about a program that he and his team were working on. Called 'Ocean One', Professor Khatib's project was to create a human-looking robot capable of moving and undertaking complex tasks underwater while providing its human pilot with the essential sensations of touch and three-dimensional sight, two senses that are incredibly important to archaeologists. This project clearly occupied the same field, and at that initial meeting, the DRASSM and Stanford University teams took the decision to collaborate.

Ocean One's first trial campaign took place in April 2016 on the site of the *Lune.* Despite never having left its test tank at Stanford University in California, Ocean One was capable of working at a depth of almost 90m, collecting archaeological artefacts from the wreck and putting them in a basket, which had been placed nearby by another robot (Figure 5).

This first operation has allowed us to validate the various technological choices that have been explored these last four years and has shown that this field enjoys a vast potential for improvement. Most importantly, it demonstrates that the chosen research route—that of building a humanoid—a genuine avatar of an underwater archaeologist, has infinite promise.

As a result of our experiments on the *Lune* excavation, Ocean One should be undergoing in the following months a series of improvements. We had planned to undertake in 2017 the next trial on a wreck dating from the Roman period, probably 2nd century BC, lying in French waters at a depth of almost 400m.

The next stage: Project SeaHand

Officially launched a few days after the completion of Ocean One's field trials in 2016, Project SeaHand is supported and financed by the French National Research Agency (ANR), which includes the Institute Prime, LIRMM, DRASSM and industrial partners. It is an innovative project, which aims to develop a seagoing hand and its associated command system, and to experiment using this hand for the specific purpose of recovering artefacts. In the first instance, the researchers and engineers in charge of developing SeaHand are using as the starting point for their work the latest developments in robotic hands and haptic devices. They have extensive knowledge of such devices, which have been developed for numerous experimental applications.

The final version of the specifications and objectives for the project is, essentially, the fruit of feedback and analysis generated during previous trials in the field.

Without going into too much detail on the specifications, SeaHand must be able to:

- Function under electric power, in the sea and under extreme pressure;
- Seize objects of a size ranging from a coin up to a dish, weighing up to 1kg in the water, under the command of an operator;
- Adapt to the shape of the targeted object without damaging it;

- Measure the force it employs so the surface operator can assess the nature of the object and the risk of breaking it during handling;
- Function in excavation conditions where sediment, such as sand and silt, present a risk of abrasion; and
- Assist the surface operator in controlling the hand through, for example, visual relays and force indicators.

In order to better understand the constraints of the human archaeologist, we recorded movements and gestures in the lab. An operator's hands and arms were fitted with sensors and then filmed by a set of cameras while he simulated numerous ways of excavating and recovering archaeological objects. This technology, which has much in common with the 'motion capture' used in animated films, allowed us to record movements in great detail, to model them and, as a result, to reproduce them.

It is, in our opinion, absolutely essential for the archaeologist to be able to feel, through the intermediary of the robot, the object as if he or she were actually present, diving on the wreck in person. He or she has to be able to detect immediately the nature of an object, what it is made of and how resilient it is.

Our intention is not to design a robot like the ones used by industrial operators or the military, but one that would be a genuine avatar of the underwater archaeologist. In other words, the robot has to be able to take the place of a human diver, and allow the pilot to control its movements and analyse the nature or the condition of the objects discovered. Our goal is, therefore, to invent a robot that would be nothing less than the underwater projection of the archaeologist at the water's surface, to such a degree that the human pilot would forget he or she was not actually on the sea bed working on the site himself or herself.

Last but not least, we inserted into the specifications a clause that we believe fundamental for the future of marine archaeology: we made it clear that archaeologists would have to be able to pilot this robotic device themselves without having to take a long training course or specialise in the piloting of such machines. Our stated aim was that any archaeologist should be able to learn within a matter of hours how to use the robotic device so they can carry out the excavation work themselves rather than, as is so often the case, giving instructions to a professional pilot who then does the work in their stead. In our experience, not only is the work completed quicker and more efficiently when done by the archaeologist, it spares that period of time taken to communicate information to the pilot, and the time it then takes the pilot to assimilate and act upon that information: such delays, however short, can place an artefact in danger (Figure 6).

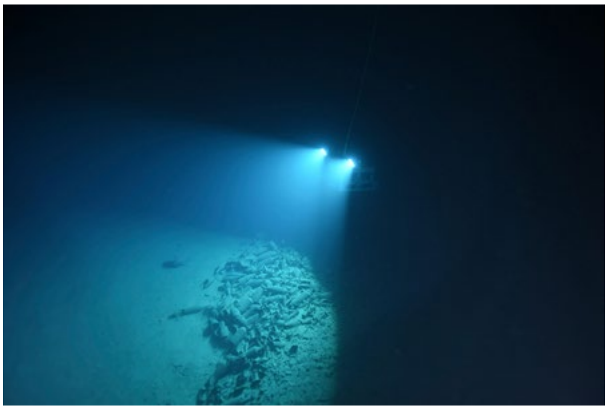
Figure 6. Aleria I shipwreck (1st-2nd century AD) 350m deep (F. Osada, 2013 © DRASSM).

Project SeaHand should, by 2019, bring us closer to realising this dream... of having deep-sea archaeology 'at our fingertips'.

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Erosion and Archaeological Heritage—Protection Measures for Lakes Constance and Zurich (central Europe)

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Abstract

The prehistoric lake-dwelling settlements (so-called 'pile dwellings') in the shallow-water zones of the circum-Alpine lakes are amongst the most precious archaeological and cultural assets of humankind. This is why some of the more than 1000 known sites in six countries were selected and inscribed on the list of UNESCO's World Heritage sites in 2011 (Figure 1).

A number of sites on Lakes Constance and Zurich are included in these. The remains of houses, cultural layers and finds, even entire villages from the Stone and Bronze Ages were preserved in a unique way under exclusion of atmospheric oxygen beneath lacustrine deposits. Prehistoric dugout canoes as well as historic shipwrecks and buildings lie, often unexplored, underwater to this day.

But the millennia-old settlement layers are now increasingly at risk of being lost to erosion. Sites and finds are gradually disappearing every year along many shorelines because archaeological layers are washed away by wave actions.

This led to archaeologists and limnologists from Switzerland, Germany and Austria coming together to launch a joint international project (Interreg IV—Erosion and monument protection on Lakes Constance and Zurich). The aim is to explore the causes of the sometimes drastic water erosion, to test ecologically sustainable erosion protection measures and to prepare for a better long-term monitoring of the underwater cultural heritage (Brem *et al.* 2013; Heumüller 2012).

Keywords

Erosion, protection, monitoring, *in situ* preservation, pile-dwelling sites

Introduction

The organic materials from prehistoric lake-dwelling villages have been excellently preserved thanks to the extraordinary conditions that exist underwater, i.e. embedded in permanently wet sediments within an anaerobic environment. The finds include a diverse range of tools and implements, textiles, a variety of plant and animal-based food remains, the oldest known wheels and, finally, construction timbers, which are used to date the settlement phases to the year by dendrochronological analysis.

These fragile objects only survive as long as they are covered and protected by lacustrine deposits. In recent decades, many of the known sites have come under significant threat from various sources. Construction in the littoral zones in particular—specifically harbour installations, quayside walls, landing stages and the dredging of shipping channels—has set processes in motion which have had a direct or indirect impact on the cultural heritage that lies underwater. Together with the decreasing shoreline vegetation and intensive shipping on the lakes in general, they have created wave action dynamics, which have a direct influence on erosion in shallow-water areas (Figure 2).

Monitoring erosion and site protection

Various attempts have been made over the past 25 years or longer to protect areas with exposed archaeological finds and features in the shallows of Swiss and German lakes (Hafner 2008). The most popular method to date has been to cover entire areas with geotextile and a layer of gravel. Questions regarding the sustainability of these measures and their impact on the ecosystem, however, have remained unanswered so far.

That is why an interdisciplinary project was carried out between 2008 and 2011 in the tri-border region around Lakes Constance and Zurich, the results of which were published in 2013. The project had three goals:

- To measure wave action in the different lacustrine areas in order to gain a better understanding of the causes and intensity of the processes of erosion and accumulation;
- To carry out experiments using various protection measures and to monitor their compatibility with local shallow-water ecosystems; and
- To try out various techniques for long-term monitoring of the exposed shallow-water areas.

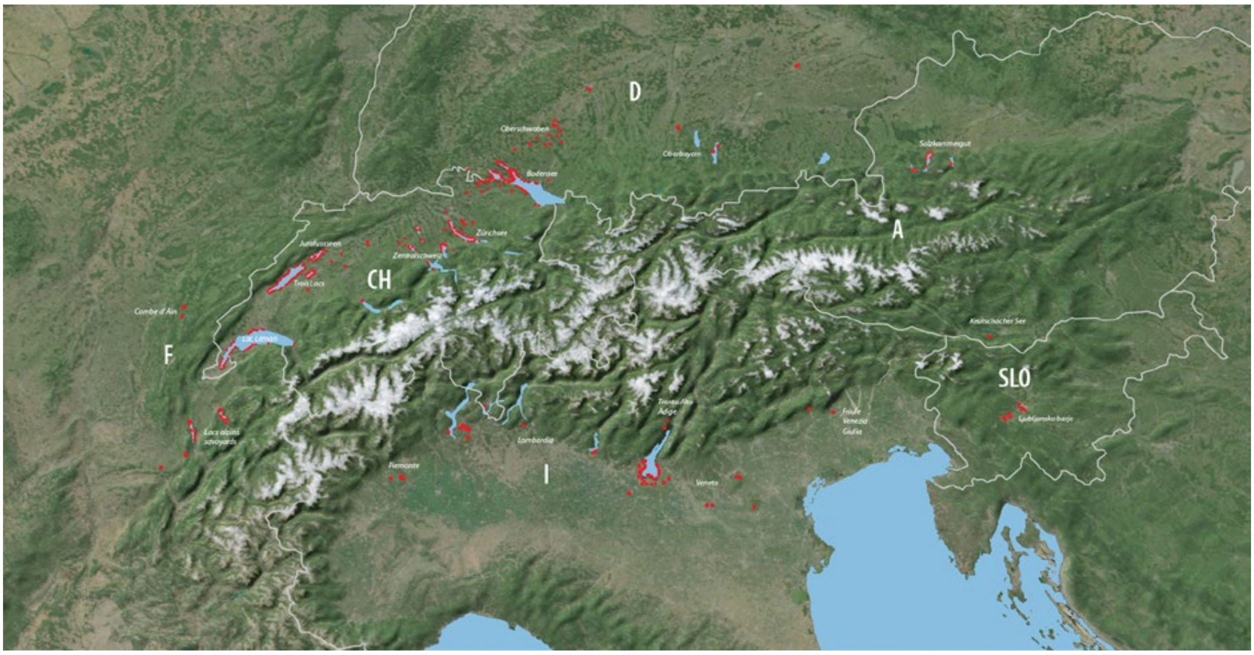

Figure 1. Overview. The circum-Alpine countries and lakes in central Europe. Out of more than 1000 settlement sites in Germany (D), Switzerland (CH), Austria (A), Slovenia (SLO), Italy (I) and France (F), 111 have been given UNESCO World Heritage status. Twenty-four of these are located on Lakes Zurich and Constance (Swiss Coordination Group UNESCO Palafittes, Graphic: NASA-«Blue Marble»/A. Zwahlen).

Figure 2. Erosion markers. Monitoring erosion at a site (dark organic layers with prehistoric piles and light-coloured, sterile deposits). Stansstad-Kehrsiten, Canton Nidwalden, Lake Lucerne (Amt für Städtebau, City of Zurich, Underwater Archaeology and Dendrochronology).

Wooden piles and metal rods with markings driven into the ground have proved to be an effective means of identifying the rate of erosion (Figure 2). Ideally, such erosion markers are installed at each site in several rows leading from the shoreline into the lake. Regular measuring of these markers and monitoring of the lakebed over time allow us to gain reliable data on the rate of erosion. Precise surveying of the erosion markers using a GPS ensures their traceability.

Wind and waves are the driving forces behind the energy input, though there is a clear difference between the waves caused by wind and those created by boats and ships. The measurements taken so far have identified massive erosion in the exposed shallow-water zones, particularly after one-off events, such as storms with high wave motion. The energy input caused by shipping accounts for up to 50% of the total energy created during the high season, depending on the degree of exposure. Certain sections of shoreline have proved to be almost free from erosion and a number of bays have even been identified where sedimentation is currently occurring. Other practices were also part of the monitoring, including traditional documentation of the extension of cultural layers and pile fields as well as bathymetric surveying and several series of sediment corings.

One of the questions was how to measure the transportation of objects along the lakebed. This led to the creation of special gravel tracers consisting of concrete pebbles with a magnetic core and fluorescence colouring (Figure 3). These were deposited in test areas and their precise locations were recorded. A year later divers monitored the position and orientation of each individual tracer before retrieving and counting them. The distribution patterns observed allowed us to make statements regarding the direction and distance of displacement. Initial results obtained from its trial period at Lake Constance suggest that this newly developed tracer technique is very useful.

Figure 3. Tracer pebbles. Red-coloured magnetic tracers spread over the lakebed. Steckborn-Schanz, Canton Thurgau, Lake Constance (Amt für Archäologie Thurgau, M. Schnyder, www.archaeologie.tg.ch).

Experiments in the traditional covering of archaeological sites involved spreading various types of geotextiles over different test areas and weighing these down with various amounts of gravel of different grain sizes. Rectangular areas in between were left exposed as reference areas (Figure 4). It will be interesting to see if these create sediment traps accompanied by natural sedimentation. This would contribute to a significant reduction in the cost of such protection measures.

The project has officially ended and will be followed seamlessly by long-term monitoring of the sites. Periodic measurements carried out at each site will allow us to identify any new erosion problems, which in turn will give us an opportunity to react quickly, either by putting protection measures in place or by mounting rescue excavations.

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Figure 4. Protective cover. Aerial view of the lattice-structured gravel covering in Sipplingen Bay. Baden-Württemberg, Lake Constance (Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart, Hemmenhofen, O. Braasch).

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In Situ Preservation and Monitoring of a Wooden Shipwreck Discovered in an Intertidal Zone in Korea

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Abstract

Sixteen shipwrecks have been excavated underwater in South Korea over four decades. Of these, Jebu shipwreck No.1 and Jebu shipwreck No.2 were located in intertidal zones and are continuously monitored *in situ*. Analyses confirmed that the timbers of both Jebu shipwreck No. 1 and Jebu shipwreck No. 2 are of hard pine. The maximum moisture content was 594% in the outermost layer of Jebu shipwreck No. 1 and 531% in the inner layer, whereas it was 401% in the outermost layer of Jebu shipwreck No. 2, evidence of a significant rate of deterioration for both shipwrecks. These results were also confirmed by the chemical composition and the relative increase in lignin following the decomposition of holocellulose determined by Fourier transform–infra red (FT-IR) analysis. Three sessions of monitoring every three months (nine months) revealed that the amount and direction of sediments and habitation of brown algae and marine plants on the wrecks varied during each monitoring period. In addition, sediments have accumulated on the nets installed to protect Jebu shipwreck No. 2, and shellfish were observed in some parts of the timbers.

Keywords

Wooden shipwreck, intertidal zone, *in situ* preservation, waterlogged archaeological wood, monitoring

Introduction

A trading ship sailing to Hakata, Japan, from Kyeongwon, China, in 1323 was wrecked off the coast of Shin An, South Korea. An underwater excavation in 1976 uncovered this shipwreck, which was the beginning of the discovery of Korea's underwater cultural heritage. As the news and achievements of the Shinan shipwreck investigations were continuously reported through the media, public interest in Korea's underwater cultural heritage grew substantially. These results are demonstrated in Table 1 based on the number of underwater cultural heritage reports produced. There were 46 reports written in the 1970s, one of which was published in 1971, and the rest in and after 1976. In the 1980s, discovery reports of underwater cultural heritage sites increased significantly.

Excavations of underwater cultural heritage sites in Korea, which began in 1976, have taken place at 25 sites over a 40-year period with 16 shipwrecks being fully examined by 2016. Three of the four fully excavated sites have completed conservation and are currently on display with one wreck still in storage (Table 2). Eight shipwrecks are still undergoing conservation; one is drying, four are undergoing treatment, and three are desalinating. Two shipwrecks surveyed in 2011 and 2014 were re-buried on-site after excavation due to the lack of preservation facilities. Two shipwrecks found in intertidal zones are currently being monitored *in situ*.

Currently, not all shipwrecks reported can be excavated and preserved, so research and guidelines on re-burying and site preservation are required. Accordingly, we would like to examine the state, and feasibility, of preserving shipwrecks in intertidal zones by continuously monitoring Jebu shipwreck No. 1 and Jebu shipwreck No. 2, which are preserved *in situ*.

Materials and Methods

Samples were taken from Jebu shipwreck No.1 and Jebu shipwreck No. 2 and used to determine the state and rate of deterioration of both sites.

Species Identification

Three samples including annual tree-ring evidence were taken from the side plank of Jebu shipwreck No.1, and two from the bottom plank of Jebu shipwreck No.2. Samples were stained with 1% safranine (in distilled water), dehydrated in ethanol, and embedded in paraffin after xylene substitution. Embedded samples were prepared by using a microtome to take trilateral slices with a thickness of 10μm and then filled with Canadian balsam to make a permanent preparation. The prepared permanent preparation was analysed by observing the constituent cells through an optical microscope (Olympus BX53) (Park *et al*. 1987).

Maximum Moisture Content

The samples collected from the outermost and inner layers of Jebu shipwreck No. 1 and the outermost layer of Jebu shipwreck No. 2 were placed in a beaker and vacuum degassed to ensure the wood was a fully

Table 1. The number of discovery and underwater excavation reports of underwater cultural heritage sites in Korea.

Period	1970s	1980s	1990s	2000s	2010s	Total
Cases of reports of discoveries	46cases	122cases	20cases	51cases	62cases	301cases
Underwater excavation	1case	3cases	3cases	10cases	8cases	25cases

Table 2. The number of shipwrecks either excavated or reburied between 1976 and 2016.

Classification	Exhibition	Storage	Drying	Consolidation	Desalinization	Reburial	In-situ monitoring	Total
Number of shipwrecks	3	1	1	4	3	2	2	16

saturated. The weight of the water-saturated wood was measured and dried at 105°C until the weight became constant to measure the total dry weight (Jensen and Gregory 2006).

$$MCmax = \frac{Mswet - Mms}{Mms} \times 100$$

Where
MCmax: mass of maximum water per mass of cell wall materials(g)
Mswet: mass of water in wet sample(g)
Mms: mass of cell wall material(g)

Chemical Composition

For chemical analysis waterlogged archaeological wood samples were freeze-dried and ground with a Wiley mill for 40–50 mesh powder. The extracted components of the wood were quantified by standard TAPPI methods as follows: hot water (TAPPI T207), alkali (1% NaOH, TAPPI T212) and organic solvent (ethabol:benzene=1:2, TAPPI T204). The lignin content was quantified by the 72% sulfuric acid hydrolysis method (TAPPI T222) and the holocellulose content was quantified by sodium hypochlorite according to Wise (Wise *et al.* 1946). The ash was quantified after pyrolysis in a carbonisation furnace at 575 (TAPPI T211).

Fourier Transform – Infra Red Spectrometry (FT-IR)

The wood sample extracted with the ethanol and benzene mixture above was used for the FT-IR analysis. The sample was crushed and the resultant powder with a mesh size less than 300 mesh was mixed with potassium bromide (KBr) and pelletised. The KBr disc was then analysed by FT-IR (TENSOR 27, Bruker Optics, Germany).

In situ monitoring

The hull remains were monitored *in situ* every three months in March, June and September 2017. The monitoring involved visual observation, recording the qualitative condition and photographic documentation.

Results and Discussion

Species Identification

Three side planks of Jebu shipwreck No.1 and two bottom planks of Jebu shipwreck No.2 were all identified as hard pine (*Pinus* spp.). Hard pine is a coniferous, the early to late wood cross-section is important and the boundary from annual ring of the cross section is clear. The tangential section indicated mixed uniseriate and fusiform rays that included horizontal resin canals, and bordered pits were arranged in a single row. Cross-field pitting, where longitudinal tracheid and radial parenchyma cells intersect, was observed as window-like pitting. In the horizontal wall of the ray tracheid, dentate thickening was observed. Consequently, the wood was identified as hard pine of *Pinus* of Pinaceae.

The Jebu shipwreck No.1 and No.2 were constructed of hard pine, like many examples of traditional Korean-built ships that have been excavated to date. Hard pine is not strong but is abundant in Korea, easily manufactured and dried. It has a slow rate of decay in relatively humid conditions. In addition, it has a specific gravity of 0.50, so it is used in shipbuilding because of its excellent buoyancy.

Maximum Moisture Content

The maximum moisture content of waterlogged archaeological wood is related to the degree of wood degradation (Grattan 1987) and is one of the traditional

Table 3. General chemical composition (%) of Jebu shipwreck No.1, No. 2 and recent wood, *Pinus* spp.

		Extractives			Holocellulose	Lignin	Ash	Holocellulose: Lignin
		Hot water	1% NaOH	Ethanol-Benzene				
Jebu shipwreck No. 1	Outermost layer	18.4	30.3	3.2	12.3	61.5	18.8	0.2 : 1
	Innermost layer	9.5	27.4	4.7	15.0	62.9	19.5	0.2 : 1
Jebu shipwreck No. 2		6.8	20.6	1.6	37.9	51.2	8.3	0.7 : 1
Recent wood		2.5	15.4	3.8	79.0	26.9	0.1	2.9 : 1

methods used to measure the degree of degradation of waterlogged archaeological wood (Jensen and Gregory 2006; Kim *et al.* 2004). The maximum moisture content of the Jebu shipwreck No.1 was 594% in the outermost layer, and 531% in the inner layer. As there was no significant difference between the moisture contents of the outer and inner layers it appears that the deterioration is relatively uniform throughout the entire thickness of the hull timbers. According to De Jeog's (1977) wood degradation class system, the Jebu shipwreck No.1 conforms to ClassI (>400%). This classification system indicates that the wood is extremely degraded including the internal sections of the timbers. The maximum moisture content of the outermost layer of Jebu shipwreck No.2 was 401%, indicating that the outermost layer is significantly degraded.

Chemical composition

Table 3 shows the analytical results of the chemical compositions of the timbers from Jebu shipwreck No.1 and Jebu shipwreck No. 2.

In the outermost and inner layers of Jebu shipwreck No.1, the ratio of holocellulose to lignin was 0.2:1 that of inner layer was 0.2:1 compared to that of recent pine 2.9:1. The timber from Jebu shipwreck No.2, had a holocellulose to lignin ration of 0.7:1. The amount of holocellulose in the waterlogged wood from Jebu shipwreck No. 1 and No. 2 had significantly decreased whilst there was a concomitant increase in the lignin content. These results indicate that the polysaccharides had degraded leaving the lignin fraction relatively un-deteriorated (Hedges 1990; Hoffmann and Jones 1990; Kim 1990a; Kim 1990b). The concentration of the alkaline extract increased in the waterlogged wood compared with the recent wood, indicating that the low molecular weight polysaccharides had decomposed. The decrease in organic solvent extraction also indicates that the resin component was decomposed. The ash content of waterlogged archeological wood is generally 10 to 20 times higher than that of recent wood (Giachi *et al.* 2003; Hedges 1990; Hoffmann and Jones 1990; Kim 1990a; Kim 1990b). The ash contents of the outer and inner layers of Jebu shipwreck No. 1 were analysed to be 188 to 195 times higher than that of sound wood, and that of Jebu shipwreck No. 2 was 83 times higher than that of recent wood.

FT-IR

The results of the FT-IR analysis are shown in Figure 1. The spectrum of the outermost and inner layers of Jebu shipwreck No.1 and the outermost layer of Jebu shipwreck No. 2 show similar tendencies despite differences in intensity. However, it can be seen that the hemicellulose represented by 1,730cm^{-1} were extinct in both the spectra of Jebu shipwreck No.1and Jebu shipwreck No. 2, indicating the decomposition of hemicellulose. In addition, 1,160cm^{-1}, 1,060cm^{-1}, and 870cm^{-1} representing holocellulose were completely extinct, and 1030 cm^{-1} decreased. In addition, lignin concentrations of 1,510cm^{-1}, 1,270cm^{-1}, and 1,223cm^{-1} increased rapidly. These results indicate the relative increase of lignin with the degradation of the polysaccharide (Kuo *et al.* 1988; Oron *et al.* 2016; Pizzo *et al.* 2015). Through the FT-IR analysis, it was discovered that the decomposition Jebu shipwreck No.1 and Jebu shipwreck No. 2 made considerable progress.

Figure 1 shows the results of the FT-IR analysis. The Jebu shipwreck No.1's outer layer and inner layer spectra have differences in intensity but are very similar in shape. However, the peak at 1,730cm^{-1} that represents hemicellulose is completely absent in the Jebu shipwreck No. 1 and No. 2 spectra indicating that all hemicellulose has degraded. Furthermore, the peaks at 1,160 cm^{-1}, 1,060 cm^{-1} and 896 cm^{-1} that represent holocellulose are also absent and the peak at 1,030 cm^{-1} was significantly reduced indicating significant degradation of the carbohydrate fractions in both shipwrecks. In addition, there was a concomitant increase in the peak heights at 1,510cm^{-1} and 1,270cm^{-1} that represent lignin. These results indicate a relative increase in lignin due to carbohydrate decomposition in the waterlogged wood from both shipwrecks. Based on the results of the FT-IR analysis, the wood from the Jebu shipwrecks No.1 and No. 2 is extensively degraded.

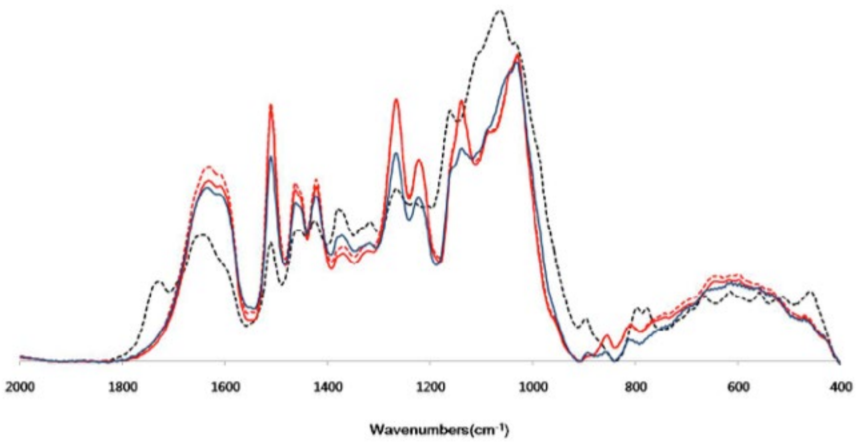

Figure 1. FT-IR spectra of recent and waterlogged archaeological wood. Recent wood hard pine—black dotted line; Jebu shipwreck No. 2—black line; innermost wood Jebu shipwreck No. 1—red dotted line; outermost wood Jebu shipwreck No.1—red line.

Monitoring

Jebu shipwreck No. 1 and Jebu shipwreck No. 2 are located in intertidal zones where they are submerged in seawater during high tide and exposed at low tide. The geomorphology of the surrounding sediment is a mixture of shell, clay and gravel.

Jebu shipwreck No.1 is located 1.4km from land, and the shipwreck is exposed only when the tidal range is less than 150cm during a month. The Jebu shipwreck No.1 is 11.2m in length and 4.2m in width.

The amount and location of the sediments around the timbers changed according to the monitoring period. Difference in the degree of exposure of the timbers was observed, and some timbers were partially lost. Additional research on the causes of changes in the amount and location of sediments, such as waves, tides and winds, among others, will be required. The brown algae that covered the exposed timbers in March when first surveyed was not present after three months (June). However, we were able to confirm that marine plants partially covered the site after three months. Six months later (September), we observed a barnacle dwelling on the guide sign.

Jebu shipwreck No. 2 is located on a beach 300m from shore. It is also exposed to seawater at the low tide every day. The size of the remaining timbers is 9.5m long, 5.2m wide and 30 to 40cm above the surface. The structure of the shipwreck was confirmed through trench investigation of the central part and the bow part of the ship. The shipwreck was located at the beach and only the safety net and the sign were installed around the shipwreck. It was confirmed that sediments piled up over Jebu shipwreck No. 2, and shellfish were fixed on some timbers.

Sediment, brown algae, marine plants and shellfish species were identified through monitoring Jebu shipwreck No.1 and Jebu shipwreck No. 2. However, it should be confirmed through continued monitoring whether these marine life-forms are seasonal or time-varying.

Conclusion

Jebu shipwreck No.1 and Jebu shipwreck No. 2 located in intertidal zones were confirmed to be made of hard pine. The maximum moisture content of Jebu shipwreck No.1 was 594% in the outermost layer and 531% in the innermost layer, and that of Jebu shipwreck No. 2 was 401%, indicating a significant degree of deterioration. These results were confirmed by the chemical composition and the relative increase in lignin following the decomposition of holocellulose determined by the FT-IR analysis.

Through the monitoring conducted three times every three months for a total of nine months, it was confirmed that the amount and direction of sediments and the habitats of brown algae and marine plants varied over this period of time for Jebu shipwreck No.1. In addition, sediments accumulated on the protective nets installed over Jebu shipwreck No. 2, and shellfish were observed in some timbers.

Our research institute will assess the viability of *in situ* preservation in intertidal zones by observing sediments, marine life forms, and damage to timbers by continuously monitoring Jebu shipwreck No. 2. We will

Figure 2. *In situ* monitoring of shipwreck No. 1.

Figure 3. *In situ* preservation and monitoring of shipwreck No. 2.

also systemise the methods of monitoring shipwrecks found in the intertidal zones.

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In Situ Preservation of the *James Matthews*: Past, Present and Future

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Abstract

The *James Matthews* became shipwrecked in 1841, near Woodman Point, south of Fremantle, Western Australia. The site has been identified as historically and archaeologically important not only because of its significance for early colonial trade in Western Australia but more importantly, it also remains one of the world's best preserved examples of a 19th-century purpose-built illegal slave trader. The wreck was fully excavated in the 1970s, documented, recorded and subsequently reburied *in situ*. The site remained stable until the late 1990s when changes in the natural near-shore sedimentary processes and increased industrial activity in the immediate area caused significant site exposure. Since 2000, a number of different reburial techniques have been trialled on-site and in 2009 the results indicated that the 'cofferdam' strategy was the most successful. However, funding was not available to implement the full-scale reburial programme until significant financial support was offered through the Australian Research Council Australian Historic Shipwreck Preservation Project (AHSPP). Hence, in November 2013 the full scale 'cofferdam' remediation strategy was initiated with the support of many local and interstate practitioners and volunteers.

This paper will highlight the results from this sixteen-year conservation management programme, and outline future research directions for the on-going *in situ* preservation of this historically important shipwreck site. The development of an Australian National Management Policy to assist heritage managers to better manage underwater cultural heritage sites at risk will also be discussed.

Keywords

In situ preservation, shipwreck, reburial, monitoring, management

Introduction

The *James Matthews* was a relatively small (approximately 25m x 7m x 3m), copper sheathed, composite vessel (wooden hulled with iron deck knees) constructed in France in the late 1700s. Originally known as *Voltigeur,* it was sold to a Brazilian slave trader in 1836 and registered as *Don Francisco*. This vessel operated in the illegal slave trade between Africa and the West Indies until it was captured by the British in 1837. At that time, captured slave ships were usually destroyed but this vessel was sold, re-registered and taken into general trading as the *James Matthews.* The ship sailed for the Swan River colony in Western Australia and arrived safely at Owen Anchorage on 21 July 1841. Unfortunately, the following night, there was a violent storm and the vessel was driven ashore after its anchor cable snapped, and it consequently sank (Henderson 1980).

The wreck site was rediscovered in 1973 and is located about 12km south of Fremantle, approximately 100m off shore at a depth of about 2–3m. The site was extensively covered with seagrass meadows and very little of the wreck was visible above the sediment with the exception of the windlass and a large mound of roofing slate. The *James Matthews* has been identified as historically and archaeologically important due to its significance to the early colonial history of Western Australia and, as most of these types of vessels were destroyed under the anti-slave legislation of the time, it is one of the world's best-preserved examples of a 19th-century purpose-built illegal slaving ship (Henderson 1980).

Four seasons of excavation were carried out by the Western Australian Museum between 1974 and 1977 (Henderson 1977). All associated artefacts were recovered and stabilised by standard conservation treatments appropriate for each material type. At the completion of each excavation period the exposed vessel remains were reburied by backfilling with the original overburden but some of the higher profile features, such as the windlass and iron deck knees, were not reburied to their original burial depths leading to considerable deterioration over time. Despite this oversight, the archaeological site appeared to be relatively stable (albeit devoid of seagrass) and remained buried for many years. However, in early 2000 it was observed that many areas across the site were exposed and were becoming severely degraded by marine borers. Therefore, determining the natural and/or anthropogenic forces causing this continuing deterioration was of paramount importance (Godfrey *et al.* 2005).

On-site conservation survey and coastal processes study

From August to December 2000 a comprehensive on-site conservation survey was conducted which consisted of dredging six ($2m^3$) test trenches at various positions on the site. This included a full corrosion survey of the exposed iron fittings; measuring the extent of deterioration of the timbers located in each test trench; and, physico-chemical and microbiological analyses of the sediments. The results showed that all exposed iron features were actively corroding (Heldtberg *et al.* 2004). The site had been previously exposed to a depth of approximately 30cm for an extended period of time; the exposed timbers exhibited active and extensive marine borer damage whilst timbers buried to a depth greater than 30cm were in good condition (Godfrey *et al.* 2005; Richards *et al.* 2009). Importantly, these results also provided important baseline information prior to the implementation of any reburial strategy.

Concurrent with the on-site conservation survey, another study was conducted, which examined the broader scale sedimentary processes affecting the site. It was concluded that anthropogenic impacts had altered the natural longshore processes and in combination with a significant storm event in the late 1990s, the net effect was sediment mobilisation away from the immediate area resulting in a significant overall reduction in sand coverage over the site. More importantly, the results indicated it was unlikely that significant sediment accumulation would occur naturally in the future (Winton and Richards 2005). Subsequent visits to the site at irregular intervals from 2001 to 2004 confirmed the results of the coastal processes study. It was observed that the site was becoming increasingly more exposed every year. It became clear that some form of remediation to alleviate or, at least reduce, the major physico-chemical and biological degradative forces acting on this site needed to be mobilised.

Experimental remediation strategies

Depth of burial is the key parameter controlling the degree of material degradation to changes in the local microenvironment. Past research has shown that the extent of degradation/corrosion of organics/metals, respectively, decreases significantly with burial depths greater than 50cm, and this is directly related to the reduction in dissolved oxygen concentration with increasing sediment depth (Björdal and Nilsson 2002; Gregory 1999; Nyström Godfrey *et al.* 2012; Richards *et al.* 2012).

All data showed that any proposed remediation strategy for the *James Matthews* site had to maintain sediment coverage of at least 50cm over the entire site in the long-term under sediment transport conditions that were counter-productive to this objective. The chosen technique could not adversely affect the wreck material and/or the local environment.

In April 2001, 500 canvas (cotton) sand bags were placed over the exposed sections of the site as a temporary protective measure while further long-term preservation options were investigated. The bags had totally disintegrated after six months and in 2003 the remediated areas were only covered with a very thin layer of sand. By 2004 the timbers were again exposed, confirming the results of the coastal processes study; the extent of degradation of the timbers had increased markedly from the initial survey (Godfrey *et al.* 2005). These areas were re-covered with UV stabilised polyethylene reinforced sand bags. Although the polymeric sand bags were an improvement, deterioration of the timbers continued (Richards *et al.* 2009). Clearly, the traditional sandbagging method could not be recommended for the medium to long-term preservation of this wreck site.

The most common form of *in situ* preservation is reburial often using dredged local sediment or dumping sand/sediment from another source. The need to maintain the integrity the surrounding seagrass beds negated dredging of large quantities of surrounding local sediment onto the site. Therefore, dumping of sand (either dredged from an off-site location or proprietary) was considered the best option followed by stabilisation of the reburial mound with geotextile fabrics or polymeric matting. The problem with this option is that as the dumped sand hits the seabed it is laterally dispersed so the resultant depth of coverage is significantly reduced. To gain coverage of greater than 50cm over the entire site, especially at the periphery where exposure was more extensive (>30cm), the reburial area needed to be significantly larger than the actual wreck (24m long x 7m wide), ultimately requiring import of massive volumes of sand.

It was obvious that some form of cofferdam surrounding the site was required to confine the deposited sand and minimise the reburial area and sediment mobilisation in the long-term. Cofferdams are usually constructed from timber, which would deteriorate rapidly in this

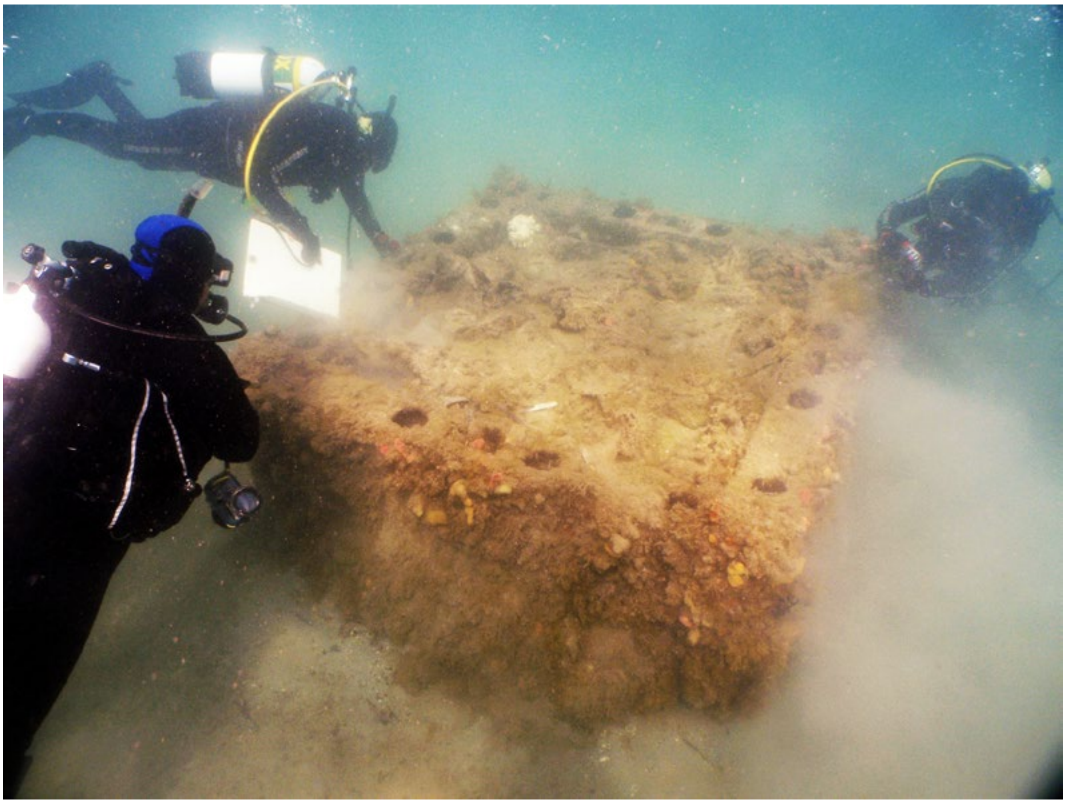

Figure 1. Test square adjacent to the *James Matthews* after four years (P. Baker, Western Australian Museum).

aerobic marine environment, or steel plate, which would corrode and adversely affect the delicate balance of the wreck ecosystem. Winton and Richards (2005) proposed the use of chemically and environmentally inert, interlocking medium density polyethylene 'road crash barrier' (RCB) units (2m-length, 0.9m-height). In March 2003, a field trial of a 'test square' consisting of four RCB units, joined together and filled with dredged surrounding sand to a depth of 0.8m was initiated on the *Omeo;* another local shipwreck site in a similar depth but subjected to greater wave loading than the *James Matthews*. After some initial deployment modifications, this pilot study demonstrated that the road crash barrier arrangement was structurally very stable, could withstand short period wave loading, did not result in significant changes to the local seabed topography and, with a shade cloth covering on the backfilled sediment inside the test square, maintained this depth of sand coverage over a two-year period. In early 2005, another 'test square' was deployed adjacent to the *James Matthews* wreck site and it remained stable for over six years (Figure 1) (Richards 2011a).

During this same period, it was decided to trial some more cost-effective *in situ* preservation strategies based on trapping suspended sediment in the water column and, thus, encouraging sediment accretion over the short to medium-term. The first method used an artificial seagrass mat (4m-length x 3m-width) made from polyethylene bunting anchored with cable ties to plastic garden trellis. After only three months, there was extensive algal growth on the fronds and, by 2009, they had totally collapsed and lay flush with the seabed rendering them totally ineffective. The second method used a mat of the same dimensions, made from 70% UV blocking proprietary shade cloth with fishing buoys attached to the upper surface to keep it suspended in the water column. After only one month, despite the use of the fishing buoys, the weight of the algal growth on the shade cloth had caused the mat to sink to the seabed and some toe scouring had occurred around the periphery of the mat. However, after two years the toe scouring had ceased and the mat was completely filled to its maximum capacity, which was about 1.5m above the seabed and by 2010 sediment had begun building up around the edges of the mat (Figure 2) (Richards 2011a).

Over the next five years the broader scale and localised seabed response, as well as any changes in the sediment micro-environment around and under the mats and in the test square, were monitored via a suite of physical, microbiological, chemical and geological analyses. Based on these results, the crash barrier cofferdam technique appeared to be the best solution for the *in situ* preservation of *James Matthews* (Godfrey *et al.* 2005; Richards 2011a; Richards *et al.* 2009).

Figure 2. Shade cloth mat adjacent to the *James Matthews* after five years (P. Baker, Western Australian Museum1).

However, due to the significant cost of this cofferdam strategy (approximately $25,000AUD for 40 RCBs, geotextile and polymeric sand bags), the Western Australian Museum did not have the budget to fund this full-scale reburial programme. Consequently, in 2010, the more exposed sections of the site were covered with shade cloth, which was economically more viable but resulted in undesirable toe scouring around some edges of the mats. The site continued to be visually monitored at irregular intervals over the next few years until funding was made available in 2012 through the Australian Research Council Linkage Grant (LP110200184)—Australian Historic Shipwreck Preservation Project (AHSPP).

The final decision to fund this innovative reburial programme was made strategically, and was based on a number of factors; the site had been archaeologically investigated in the past, had over 15 years of accumulated baseline data for longitudinal comparative analysis; and, the Western Australian Museum would continue to manage the site and fund the ongoing monitoring programme including sediment and materials analyses.

In situ preservation programme—cofferdam strategy

The initial plan was to deploy 40 RCBs in a semi-elliptical arrangement surrounding the site and then fill the cofferdam with clean, washed proprietary sand to a minimum depth of 50cm. Sacrificial wood, iron and copper alloy samples would be reburied during the process and recovered at regular intervals for *ex-situ* analyses. The same suite of analyses would be performed on the encapsulated sediment as was previously described for the reburial experiments. The results would then be extrapolated to those obtained during the initial conservation survey, which would enable the effectiveness of this cofferdam strategy to be quantitatively assessed.

This large-scale reburial programme was undertaken over five days in November 2013 with 22 personnel, including staff from the Western Australian Museum, UWA and and other local and interstate practitioners and volunteers (Richards *et al.* 2014).

All previous site stabilisation materials (i.e. anodes, sand bags and shade cloth) were removed and a rope guideline was placed around the periphery of the site to assist in the positioning of the RCBs as the in-water visibility was often poor. Each RCB unit and connecting pin was filled with 20kg and 5kg of aggregate, respectively, on board a rented dive boat. The floating RCB and pin were then transported upright to the wreck site using a small tender where three snorkelers sank the barrier via air displacement. Two divers received the RCB, which weighed approximately 15kg and physically manoeuvred the barrier into the correct position, inside the guideline and then locked it in place with the pin. Following this procedure 36 RCBs were deployed on-site before they were anchored in place with a minimum of 120kg of aggregate per barrier

Figure 3. *James Matthews* site surrounded by the cofferdam in November 2013 (P. Baker, Western Australian Museum).

(Figure 3). The gaps between the barriers were sealed with plastic roof damp coursing and anchored with zinc alloy 'tek' screws on the inside of the RCBs to minimise leakage of any deposited sediment.

Due to the shallow nature of the site there was only 1–1.5m of clearance above the edges of the cofferdam. Therefore a purpose-built sand barge had to be manufactured in order to fill the cofferdam with sediment to the required depth. The barge was loaded with clean, washed proprietary sand via 20kg sand bags from the dive boat (Figure 4). Using this method, 28 tonnes of sand was dumped inside the cofferdam, resulting in a 5–10cm sterile sand layer over the site. A further 230 tonnes were required to achieve the minimum sediment depth of 50cm, impossible with the equipment and personnel remaining after the fieldwork concluded. Therefore, in the interim, shade cloth was placed on top of the cofferdam to minimise loss of the previously deposited sand, prevent ingress of extraneous organic matter, and potentially trap sand suspended in the water column. After four months the barriers and shade cloth were totally covered with algae and the sediment in the cofferdam was grey in colour indicating a lower oxygenated, reducing environment, conducive to long-term preservation.

Unfortunately, in June 2014, before any further backfilling could commence, a meteorological tsunami ravaged the coast, destroying the shade cloth, damaging one of the RCBs and opening up the stern end

Figure 4. Dumping of sand from the custom-built barge on the *James Matthews* site (J. Carpenter, Western Australian Museum).

Figure 5. Breached cofferdam and exposed stern section of the *James Matthews* in June 2014 (J. Carpenter, Western Australian Museum).

of the cofferdam. Excessive water movement caused a tunnelling effect, transporting the deposited sterile sand and some original sediment towards the bow, totally exposing the structural timbers at the stern and the reburied sacrificial samples (Figure 5). The cofferdam was repaired in November 2014; replacing the damaged RCB and adding two extra RCBs to minimise stress on the cofferdam. Each RCB and pin was totally filled (~250kg) with aggregate and the wreck's interior covered with shade cloth to minimise further sediment loss and protect the exposed stern section.

From visual inspections of the site over the next year it was apparent that this interim remedial strategy had been successful in stabilising the deposited sand at the bow and slowing deterioration of the exposed stern section. Therefore, the research design has been altered and any exposed areas and new sacrificial samples will be reburied by dredging local sediment to a maximum depth of 5–10cm followed by a layer of shade cloth deployed flush on the surface of the redeposited sand. Once the site has stabilised, the monitoring programme will re-commence.

Development of National Protocols and Guidelines

The discovery of a new cultural heritage place whether submerged, coastal or terrestrial should at the outset prompt research into its archaeological, historical and contemporary importance to assist in developing an understanding of the significance of the site. In Australia, the accepted guiding document for establishing cultural significance and developing conservation management plans is the Australia ICOMOS *Burra Charter* (2013) (Australia ICOMOS Inc. 2013). The level of significance of the place should be a primary consideration when making management decisions but it has to be viewed in the context of relevant legislative and permitting requirements.

Further to this, the primary document widely utilised by Australian maritime heritage managers since the mid-1990s is the *Guidelines for the Management of Australia's Shipwrecks* (AIMA and ACDO 1994). This document defines principles for site; artefact and collections management; how management programmes should be implemented; and, funding and programme outputs. Basic guidelines were provided to inform and assist with meeting the principles. Within the document, Principle 1.2 (p. 10) relates to *in situ* preservation practices, requiring environmental assessment as part of management plans but does not describe how these should be conducted. The preservation of shipwreck material with minimal interference to the fabric as the primary conservation objective (point 2.6: 14) relates only to recovered artefacts. With changes in the approach to shipwreck management away from 'excavation and display' and more towards 'recording and *in situ* preservation', these guidelines should now be extrapolated to include the entire site and associated artefacts *in situ*.

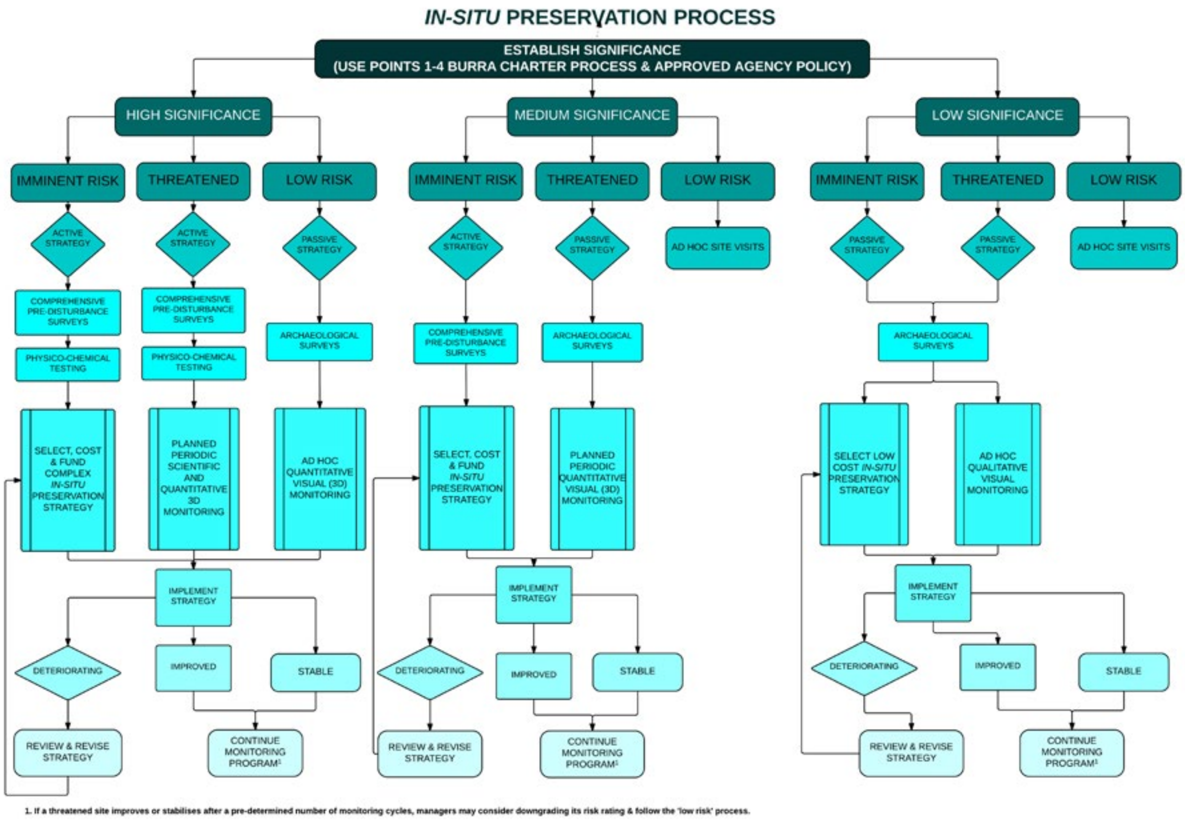

Figure 6. Flow chart for *in situ* preservation processes (C. Philippou, V. Richards and P. Veth, AHSPP).

In addition, the UNESCO Convention on the Protection of Underwater Cultural Heritage states that sites should be preserved *in situ* as the first option (Article 2.5 and Annex Rule 1). However, the Convention does not provide explicit guidelines on what activities fall under the umbrella of *in situ* preservation nor whether these activities should ideally be active or passive (UNESCO 2001). Consequently practitioners have taken this term to include a variety of preservation strategies, ranging from active interventions, such as reburying a site in its original location or relocating and reburying a site and/or its associated artefacts to simply monitoring the site's environment and physical remains at regular intervals, which is essentially a passive intervention.

The development of an Australian National Management Policy including *in situ* preservation protocols and guidelines based on past research and recent results from the *James Matthews* reburial project and the AHSPP, aim to further develop these conservation and preservation objectives.

In accordance with the previously mentioned documents and convention an idealised sequence of significance assessments of a site, threats and actions has been proposed (Figure 6). This could include reburial but may not specifically require intrusive management. Not all UCH sites or management situations require complex *in situ* preservation interventions. Following initial site assessment, guidelines should prompt managers to review the range of management options available to them and determine whether *in situ* preservation is the optimal strategy if the site is at risk. Methods for *in situ* preservation are varied, and must be assessed with reference to the constraints of the site type, its environment and availability of funding and personnel. Ultimately the measures taken will always be a moderation between the significance of the site, the expected effects of the *in situ* preservation strategy, the time span over which it has to be effective, the effect on the local environment and the resources required.

With this in mind an eight point protocol has been developed, based on the results from national and international UCH preservation programmes (Gregory 2010; Richards 2011b) to assist heritage managers in developing and implementing *in situ* preservation strategies for a particular site if required. The protocol is listed below:

1. Ascertain the extent of the site and likelihood of potential archaeological deposits;

2. Identify the major material types present at the site and the extent of their deterioration;
3. Assess the most significant physical, chemical and biological deterioration processes occurring on the site;
4. Assess the pre-disturbance local burial environment and the major factors affecting the long-term stability of the site;
5. Implement the optimal *in situ* preservation strategy to mitigate continued deterioration and stabilise the site long-term;
6. Implement a monitoring programme to evaluate the efficacy of the *in situ* preservation strategy;
7. Provide alternative plans and procedures if the implemented *in situ* preservation strategies are unsuccessful; and,
8. Provide resources for the reburial and/or conservation, storage and curation of any recovered artefacts.

Ideally Points 1 and 2 should be prioritised at the level of wreck inspection, in that site boundaries and content must inform level of risk and appropriate response. If this information is not available then more proactive interventions (such as reburial) should not be attempted. Points 3 and 4 are more complex processes and could be triaged, dependent on the risk and response outcomes based on the results of the initial site assessment, which includes Points 1 and 2. Furthermore, if the initial requirements of Points 1–4 are not met and an *in situ* preservation strategy is implemented due to the site being at imminent risk, then the monitoring programme (Point 6) must be conducted at more regular intervals. This will allow for a more rapid evaluation of the applied intervention so any deterioration of the site can be identified and ameliorated (Point 7). In such an instance, it is recommended that the applied *in situ* preservation strategy is simple and cost-effective to reverse, if Points 1–4 of the Protocol have not been met.

The guidelines are forthcoming, and these will expand on each of the eight protocols outlined above and provide more information on the fields, variables and attributes that need to be assessed and considered when selecting optimal *in situ* preservation methods and subsequent monitoring programmes for UCH sites.

Conclusions

There are still some questions and uncertainties surrounding *in situ* preservation of underwater archaeological sites. However, the information gained through national collaborative projects, such as the *James Matthews* and the AHSPP, will ultimately lead to a better understanding of the associated advantages and disadvantages of this process.

This work will be critical to the future development of national policy, protocols and guidelines for the successful protection and management of Australia's underwater cultural heritage.

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A Review of Waterlogged Wood Treatments in Slovenia and a New Approach to the Treatment of a Large Roman Logboat from the Ljubljanica River

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Abstract

The Institute for the Protection of Cultural Heritage of Slovenia (IPCHS) has a long tradition in conserving works of art. It has preserved many archaeological objects, but relatively few waterlogged wooden objects, in the last three decades.

Experimental studies of waterlogged wood conservation using the PEG and sucrose methods started in the 1980s at the IPCHS. The centre continued this waterlogged wood conservation and in 2012–2013 established a workshop dedicated to the preservation of organic materials from archaeological sites. In recent years, new methods, e.g. freeze-drying and the melamine resin method, were tested. The first large-scale conservation project involved a Roman logboat, excavated in July 2015 from the Ljubljanica River at Vrhnika, south-west of Ljubljana. The vessel is one of the five Roman logboats discovered so far in the Ljubljana Marshes. It is approximately 15m long and 1.40m wide and was found in several pieces with the biggest one about 7m long. The logboat was in use for a long time and has evidence of repair. In some cases, textile material soaked in tree resin was used to fill cracks in the wood. For conservation, melamine resin is being used as a relatively fast, inexpensive and—to present knowledge—a relatively long-lasting method.

Keywords

Slovenia, Celtic-Roman logboat, Ljubljanica River, waterlogged wood conservation, melamine treatment

Introduction

Slovenia boasts an extraordinary number of logboat finds, mostly from the Ljubljana Marshes. For millennia, and up to the very recent past, logboats represented an irreplaceable means of transport in watery regions, primarily lakes, rivers and flooded moors, where people could navigate small and agile boats with passengers and their cargo through clogged terrain. The settlement of the Ljubljana Marshes with a recognisable pile-dwelling culture, which has put Slovenia on the map of World Heritage Sites, could not have been possible without logboats. These boats symbolise the Ljubljana Marshes. New finds in the last 20 years confirm that the logboats were in use for a period which spanned more than 5500 years.

Due to the large number of finds of logboats, documented from the first half of the 19th century, their heritage could even be considered an emblem of this increasingly endangered landscape. With new discoveries in the last 20 years, the logboat's use in ancient times has been confirmed, as we have unveiled new time horizons (Erič 2014).

Particularly attractive is the logboat Vrhnika II (SI-60), which was found by Miro Potočnik in the 1980s. The first survey and initial documentation were performed by researchers from the Underwater Archaeology Division at the Department of Archaeology, University of Ljubljana, on 21 July 2001 (Figure 1). A logboat carved from oak (*Quercus* sp.) was lying under the right bank, 110m downstream from the Verd bridge near Vrhnika. Its trunk was broken into two parts; excavation was mostly confined to the more significant part of the trunk lying on the slope parallel to the flow. However, the smaller part of the trunk was extending perpendicular to the significantly larger trunk, and it was exposed 1m away from the bigger section. The AMS radiocarbon dating from the part of logboat exposed by the Ljubljanica River water stream, which was conducted in the laboratory of BETA Analytic, showed that the logboat is from the 1st century AD (Erič 2009; Erič *et al.* 2012).

Because of the proposed construction of flood controls, it was decided to examine the logboat, remove it from the site, conserve it, and place it in a nearby Visitor Experience Centre in Vrhnika. The research was

Figure 1. The Underwater Archaeology Division and Institute for the Protection of Cultural Heritage of Slovenia conducted a first examination of the Vrhnika I logboat in July 2001 (Jože Hanc-Joc).

conducted in summer 2015 as part of the project 'My Ljubljanica River' funded by the Norway grant under the leadership of the City Museum of Ljubljana. These studies have shown some surprising details, which have broadened our knowledge from 2001. Several samples, which had not been exposed to abrasion by the daily flow of water, were dated by several radiocarbon analyses. The parts of wood protected by thick layers of river sediment were surprisingly dated approximately 200 years earlier than the part of the wood dated in 2001 from samples exposed to the permanent water stream. Several AMS dates of logboat samples give us an average of the second half of the 2nd and the first half of the 1st century BC. Moreover, it became apparent that the logboat is at least 15m long and the broadest part of the boat exceeds 1.4m (Gaspari 2017).

Previous treatments and storage challenges

We have no existing written sources about methods of waterlogged wood conservation used in Slovenian museums in recent centuries. However, judging by the state of several wooden artefacts it can be assumed that some smaller objects did undergo a preservation process at the collection of the National Museum of Slovenia, known in the 19th century as *Krainisch Ständisches Museum* (Estate Museum of Carniola). We could not determine how the anonymous conservators in the 19th and the first half of the 20th century treated waterlogged wood artefacts, even though many wooden artefacts were brought into the museum, such as logboats, tread traps and other small artefacts. While logboats are enormous and the 19th- century management of the National Museum decided not to treat them, we do find smaller artefacts such as tread traps and other minor artefacts, which were treated and conserved, presumably with animal glue. The first article about waterlogged wood preservation in museums was published on 7 October 1927 in the Ljubljana newspaper *Jutro*. It described and documented the method of waterlogged wood conservation, mentioning a logboat from Matena (SI-08), which was treated with animal glue. However, even in this article, it is not entirely clear whether the logboat had been processed immediately after discovery when the timber was still waterlogged, or if the wood was first dried out and then treated with a solution of animal glue. We also have no evidence about how strong the animal glue solutions were, as no details of the method were described (Erič 1998). The logboat was exhibited in the National Museum in Ljubljana at various different times (Figure 2, top and middle). We have identified the Matena logboat and observed its condition; it is completely covered with transverse and longitudinal cracks between five and 30mm wide, with a length of usually more than 100mm, and depth of up to 80mm. Individual pieces of wood between the cracks have already fallen away. In this condition the logboat has only a few years of 'life' left. The National Museum of Slovenia collected six logboats in the 19th and the first half of the 20th century in the Ljubljana Marshes in extremely bad conditions. The preservation process to protect the wood from drying out during the transport was at that time quite innovative. Here the 'Staroleški' logboat is transported in 1946 from the fallow Stara lesa (SI-19) to the National Museum of Slovenia (Figure 2, bottom).

Figure 2. The logboat from Matena at National Museum of Slovenia (S.Habić) and 'Staroleški' logboat at National Museum of Slovenia (unknown).

Historical progress of wood conservation

In the early modern period, the '*Holland in Not*' ('Holland in Need') conservation idea gradually formed with the help of scientific evidence. Artisans and scientists at work in wood acquired new experience. In 1718, Germany introduced the first commercial product to protect wood called '*Holzbalsam*'. That is a solution of copper sulphate, at that time called vitriol. Sometime later, in 1791, it was patented in England as a wood preserving agent. The butcher's guild in England in 1838 applied for a '*Boucherie*' patent, in which they suggested preserving wood with the help of Belgian blue vitriol, which removes excess water from it. However, the big tragedy regarding wood 'protection' in the 18th century was the Dutch experience. In a report published in the Netherlands in 1731, the authorities described problems because of the deterioration and disintegrated of artificial river embankments. Their wooden components were only a few years old but had been virtually destroyed by the action of a parasite. In northern European countries, this event led to the saying '*Holland in Not*'. However, one of the most felicitous procedures for the destruction of these parasites is described in Zedler's *Universal Lexicon*: 'fight against woodworm with pepper, bay laurel, and myrtle in wine, but also with cattle hair and vinegar' [pepper (*Piperaceae*), bay laurel (*Laurus nobilis*), myrtle (*Myrtus*)] (Unger and Unger 1988: 157).

Under the Austro-Hungarian Empire, the protection of cultural monuments was increased in all provinces. With the founding of specialised conservation schools in Vienna, different methods of wood preservation were discovered, such as mixtures of animal glue, damar gum, shellac resin and rosin. These methods consolidate the biological (bacterias, worms etc.) and chemical (decay by the changing composition of organic materials) deterioration and damage to wooden artefacts. Therefore, we can suppose it was in the middle of the 19th century that the method of conserving severely damaged dry wood was developed in the region of Kranjska (Carniola). However, no reliable records exist of how the previously recovered collection of logboats was conserved and there were no resources available to analyse and determine what methods had been used in the past. We can only guess whether they knew about the latest method of waterlogged wood conservation with potassium alum, which was developed in 19th-century northern Europe.

Contemporary developments in Slovenia

At the end of the 1970s, when many waterlogged wooden artefacts were discovered near the Late Antique water reservoir at Ajdovski Gradec settlement above Vranje near Sevnica in Slovenia, the fellows of the Restoration Centre of Slovenia prepared to preserve them. The Centre created a project in 1981 to produce two baths, a smaller one of 1.5m and the second with a maximum length of 14m. They would heat a solution of polyethene glycol (PEG), which would be fed with the aid of pumps. The smaller bath was completed the same year (Curk *et al.* 1981; Nemec 1982).[1]

The first waterlogged wooden artefacts in Slovenia to be conserved in the bath using PEG treatments were finds from Ajdovski Gradec. The wooden roof-beams, shingles, ceiling gutter, a bucket for drawing water, ladders, wooden pegs, sticks and some unrecognisable objects were recorded and saved by the team of archaeologists, led by Peter Petru (Petru *et al.* 1978). Some of the finds at the beginning of 1982 were protected in the Centre. In 1982 when the heating bath for waterlogged wood by the PEG method was finished, around 270 wooden artefacts from Ajdovski Gradec were treated (Figure 3).

The standard PEG method was used, with some minor variations that are closest to the laboratory procedures of the British and Danish National Museums (e.g. Brorson Christensen 1970a; Organ 1959: 96–105). Conservation was begun by a gradual warming of a water solution of 10% Polidiol 4000 (PEG factory Teol) at 60°C. Into the solution, a one percent mixture of boric acid (H_3BO_3), and borax ($Na_2B_4O_7$ 10 H_2O) at a ratio of 7:3 were added as a biocide. Wood treatment lasted for 18 months. During this time, the solution was enriched every few days (2–4) with a few percent of PEG (below 5%). Upon completion, the concentration of PEG solution of 75% was reached. Bearing in mind that this procedure was adapted from the expected documented results, it should extend the conservation time.

Waterlogged treated artefacts were brought together in 1982 at the National Museum. They were kept there until the last phase of the work in 1993, for a reconstruction of the bigger, broken artefacts. The artefacts were washed with a minimum cover of 5mm in warm or hot water to remove excess PEG from the surface to reflect the natural structure and colour of the wood. This process is fast because PEG should not be exposed to water for too long. When the artefacts were dried after washing, they had the natural colour of the old seasoned wood. On the surface of the wood, traces of application, scars and damages were noticeable, which could lead to an in-depth analysis of its manufacture, and the tools used.[2]

[1] Ivo Nemec was the first conservator working in the Restoration Centre of Slovenia in recent times who has studied waterlogged wood conservation. In 1985 he carried out analysis of the usability of waterlogged wood protection in Slovenia: Workshop for a preservation of archaeological wooden artefacts and other organic material. Unpublished: Internal documentation of the Restoration Centre of Slovenia, Ljubljana.

[2] Treatment Report: Erič, M. 1994. Vranje nad Sevnico, Ajdovski gradec, Vodni zbiralnik - Poročilo o restavriranju lesa. - Internal

Figure 3. Wooden artefacts in a water reservoir at the Late Antique settlement on Ajdovski Gradec, above Vranje near Sevnica, after archaeological excavation, at National Musem of Slovenia (unknown).

As with the wooden artefacts from Ajdovski Gradec, the same treatment was used with the artefacts from the pile dwellings at Parte. Tatjana Bregant and Zorko Harej conducted excavations at Parte on the Ljubljana Marshes (Harej 1987). The objects that had been treated were washed and assembled. A re-examination of the treated artefacts showed that they had shrunk slightly, which has resulted in damage to glued joints, which do not stick anymore. All items are stored in the City Museum of Ljubljana. Among them, the most interesting are a '... carefully designed, comfortable and elegant paddle ...', which Harej supposed was a kitchen tool or perhaps used in the process of burning clay (Harej 1981: 46). Like all other artefacts from the pile dwelling at Parte, the paddle was restored; it was cleaned of excess PEG with water, ethanol, and toluene, and assembled with dowels made of nickel plated pins. At the end, all objects were protected with Paraloid B72 (acrylic resin). Another, smaller paddle was found in 1976 during the excavations conducted by Tatjana Bregant (Harej 1978: 71, fig. 1). The wood was well preserved. During the excavations, a spear was found in poor condition. A large scoop was found as well. It is poorly conserved but Zorko Harej judged that this artefact was a spoon. These objects have been well restored but handled unsuccessfully. Reviews and assessments on the effectiveness of these treatments should be conducted in the near future.

In the City Museum of Ljubljana, there is also a well-restored partially hollowed-out tree trunk, which had been used as a kind of kneading-trough or wooden vessel, along with smaller pieces of wood that could be used as weaving shuttles. However, Tatjana Bregant notes that some of the artefacts no longer exist.[3] Large quantities of smaller pieces are mixed together, and the record is not complete. Wooden finds in the City Museum of Ljubljana should be checked again to recognise them.

archive of National Museum of Slovenia.

[3] Personal information by Milena Horvat from Department of Archaeology, Faculty of Art, University of Ljubljana.

Figure 4. Medieval wooden pipe elements from a plumbing system in Koper were for the first time in Slovenia experimentally treated by a sugar solution ((left) Regional Museum of Koper; (right) Miran Erič).

It is also worth mentioning that the method of conservation with sucrose was tested in Slovenia. It proved to be a relatively inexpensive process with good results. During the 1985 archaeological excavations in Repič street in Koper (Župančič 1986: 188) the medieval plumbing system was discovered, the main components of which were wooden pipes. Such wooden plumbing pipes were also discovered in 1994 during excavations at Prešeren Square in Koper. All five tubes were kept submerged in water tanks in the Regional Museum in Koper. One wooden plumbing pipe, more than 2m long, from the first excavations in 1985, was used to perform pioneering experimental analyses of conservation with sucrose (Figure 4).[4] The water content of the wood was between 113 and 464%, with longitudinal shrinkage from 4 to 6%, and tangentially from 0 to 15% on samples of untreated waterlogged wood when it was air-dried. Treatment of samples began with a 5% water solution of sugar, with the addition of 1% boric acid and borax to protect the wood from microorganisms. Every 14 days 5% of sugar was added to the water solution, and after 70 days the concentration was increased to 7% every 14 days. After 175 days it was increased to 14%. The saturation of the water solution by white sugar reached 54%. Moreover, after 70 days, another 15% of sugar was added. After the next 70 days, the sugar saturation of the solution was 82% and it stabilised at that level. As the process was conducted at or below room temperature (between 18 and 22°C), a fully saturated solution could not be reached. Measurements after drying the wooden pipe stood at ASE 100% in longitudinal and tangential shrinkage. Before and during the conservation process, biocidal protection became necessary. During the preparations, mould growth was detected in some areas. Therefore, one percent of Boric acid and 0.5% of Borax was added before treatment. For this procedure, 181kg of sugar was used (Table 1).[5] The years after treatment in 1992 until our inspection of it in the Regional Museum in Koper in July 2016, the treated wooden plumbing pipe had been in the loft of a museum, mostly in the dark and packed air-tight into builders' hard polyethene foil. It was concluded that the plumbing pipe had not change dimensionally or in colour and that the wood is in excellent condition. Compared with other methods, here the only expenses were sugar and some polyethene foil lining for the treatment tanks.

A recipe for wood protection,[6] which is composed of one part ether, one part turpentine, 5% of damar lacquer, 5% of rosin and 3.3% of beeswax, has been developed in Slovenia. The solution is applied to damaged and

[4] Experimental conservation was conducted by Ivo Nemec from the Restoration Centre.

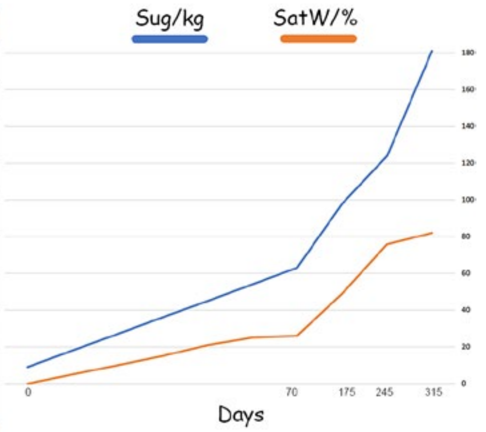
[5] Personal notes by Ivo Nemec: never published.

[6] My deepest gratitude to my colleague, wood-preserving specialist Ilonka Hajnalova from the Sergej Mašera Maritime Museum in Piran who in 1992 entrusted me with many conservation recipes for preserving dry, damaged wood, the recipe mentioned above, among others.

Table 1 Using incomplete working notes created from 1992 by Ivo Nemec, Restoration Centre of Slovenia, who conserved wooden objects using white sugar, the table and graph were reconstructed. It can be seen that the kinetics of the impregnation process approximate a diffusion controlled process. Diffusion processes are generally linear with the square root of time.

Days	SolW/%	ConW/%	SatW/%	Sug/kg/m3
1	5%	0%	0%	0
14	10%			
28	15%			
41	20%			
54	25%			
67	30%			
70		7%		
175	54%	14%		
245	69%			
315			82%	181kg/10,70m3

SolW/% = Water Solution of Sugar in %; ConW/% = Concentration of Sugar in Water in %
SatW/% = Saturation of Sugar in Water in %; Sug/kg/m3 = Kilograms of Sugar in Mass of Water in m3



delicate parts of the wooden objects at the museum. It is designed for artistic, historical and ethnological objects, not for waterlogged timber. This conservation method has not previously been used in the preservation of waterlogged wood in Slovenia, but it is very similar to the alcohol-ether resin method described by Brorson Christensen (1970b) from Denmark. Parts of the objects were restored and stayed soaked in the solution for so long that the cell walls of the wood were impregnated with solid substances in the mixture. A similar recipe (proposed for processing the logboat from Matena) is also used in the restoration workshop of the National Museum in Bern, Switzerland. Wood preservers used a mixture consisting of one part ether, 20% of Batavia damar lacquer, 10% of rosin, 5% of castor oil (obtained from *Ricinus communis*; Kostić and Kostić, 1980: 535), 5% of Dienol (an organic compound with atomic group [CH = C (OH) -]) and 2.5% of PEG.[7]

Using documents and the preserved parts from the Regional Museum in Murska Sobota, a reconstruction of a wooden crate was made, which had served as the base for a water fountain in the Bronze Age archaeological settlement of Dolnji Lakoš. It is exhibited in the permanent collection of the museum along with the original parts, which are desiccated and significantly deformed, with a crumbly surface. Attempts had been made in the Regional Museum to preserve the plank walls of a crate and barrels, which had been found during excavations in the village of Rabelčja vas near Ptuj. They were laid on a styrofoam bed wrapped with soft wet paper intended to prevent drying out, and an airtight polyethene foil applied. On revisiting in 1991, we found that the wooden artefacts, which were being kept in the basement of Ptuj Castle in which the Regional Museum is located, were in very poor condition. The polyethene foil was torn into several pieces, and the paper and wood in the cover had completely dried out. The wood was partly covered with algae, mould and mildew, and was very fragile.

The ancient wooden parts of the bridge over the Sava river near Črnuče (Ljubljana, Slovenia) were also partly explored by Karel Pick and Walter Schmid. In the basement of the National Museum, we found that timbers from the bridge were installed in a masonry niche with a glass wall. Unfortunately, the glass wall is in contact with walls of up to 1cm wide, but the 'chamber' has no device for humidifying the air. Due to differences in air pressure between the chamber and outdoor spaces, air circulated rapidly resulting in the timber mounted in the chamber drying out even more quickly.

A crucial consideration in protecting wooden artefacts after the conservation process is relative humidity (RH) control in the museum's exhibition spaces and depository. Severe fluctuations of RH lead to rapid degradation even of dry wood.

Proper conditions for exhibiting wooden artefacts

Due to the physical properties of wood, we must provide museums with a means of preventing dynamic and long-term changes of RH and temperature (Plenderleith

[7] Dr Niklaus Oswald from the National Museum of Bern visited the National Museum of Slovenia in 1992, where we examined the possibilities for conserving the Matena logboat. One option was to use the recipe mentioned above, which is similar to the recipe of Ilonka Hajnalova.

and Philippot 1960: 253). The fracture of weakened cell walls (low elasticity) is due to the high reception and transmission of water to and from the cell walls, and anisotropic properties and sorption effects. The process is repeated so that the water is continuously condensed into cells swelling them and then evaporates away. Heterogeneity in the process of shrinkage and swelling generates internal tensions, which weaken the elasticity of the walls, so the deterioration of wood cells is faster. The preferred RH of the wood due to its physical characteristics, in particular its flexibility due to the water in the cells, is from 55% to 65%.[8]

For best protection and storage in appropriate circumstances, objects should be in a museum or some form of controlled environment. Preserved wooden objects should be stored in suitable facilities which maintain their RH and temperature, separate from objects made from other materials like stone, pottery or metal. These materials require different RH and temperature conditions.[9] If the conception of the exhibition requires objects of various materials to be in one place, we should install wooden artefacts separately to more effectively provide temperature (temp. 15-18ºC) and RH (55%-60%) environmental conditions.

These strict climate requirements are justified; the fluctuation of RH and temperature in the National Museum of Slovenia provides an example. Measurements were captured from autumn 1990 to summer 1992, which showed that the air circulating around the woodwork was unsuitable. At that time fluctuations in humidity and temperature were high in the museum, especially in the central museum depository, the corridor of the basement, the foyer on the first floor and the permanent collection, where the wooden artefacts are stored. Over an extended period, RH fluctuated from 25% to 95%. Over shorter periods in the central repository, the humidity dropped 45% in just one day (from 85% to 40%) and later increased from 40% to 80%. After three days the RH again fell from 87% to 40% (Erič 1998: 117, figs 52–55, 56 and 57). The cell structure of wood can be stressed from much lower fluctuations in RH and temperature. In 1995 and 1996 no sudden fluctuations were recorded, but the wood was still not being kept in proper conditions.

When we examined the locations where they keep the wooden artefacts, they all showed RH of 15% to 25% which is acceptable only for stone and metal artefacts. As has been said, this percentage of humidity is extremely inappropriate for storing woodwork, since it causes a complete drying out of the wood leading to brittleness and breakage. These fluctuations were due to a reconstruction of the museum premises and, unfortunately, could not be avoided.

Roman logboat: conservation workshop and treatment

A Roman logboat was the first larger object brought to the recently established Department of organic material conservation at IPCHS. Previously, smaller objects were conserved with melamine resin (a prehistoric child bow and a wooden buoy), with tests carried out on pieces cut from a prehistoric pillow. Due to the lack of any heating tanks and the speed of the consolidation, this method was chosen as the most appropriate for such a large object. The main concern was the size of the object, particularly as it turned out much longer than expected before the excavation. Pieces ranged from several centimetres to about 7m long and up to 1.4m wide. The largest pieces weigh several hundred kg, which necessitated the use of a crane. The deterioration of the wood is classified as middle severe (2nd class), and due to their size, the larger pieces of the logboat especially were prone to breaking. During the excavation, the archaeologists prepared temporary supports for the largest objects, made of rubber for the smaller pieces and scaffolding pipes for the largest piece. The latter also served for transportation and storage at the conservation department, whereas the smaller pieces did not need support when put back into the water. Parts of the logboat were stored in water inside custom-made containers of aluminium plates, reinforced with iron tubes. To prevent leaking, for smaller containers pond foil (sheets of ethylene propylene diene monomer [EPDM] rubber of 1mm thickness) was used, whereas the container for the biggest piece was sealed like a swimming pool (Figures 5 and 6).

To enable the handling of the pieces longer than 0.5m, which could easily break during the conservation process, custom-made epoxy capsules reinforced with fibreglass and aluminium tubes were prepared. The capsules were made directly on pieces of logboat, protected by polyethene foil to prevent damage and staining to the wood. The technology used for preparing the capsules was the same as that used by conservators to make moulds for making replicas. To support the pieces of logboat during work and to limit the shape of the capsules' clay, insulation materials and window foam were used. These were all removed when the object was turned to make the second half of each capsule. Capsules were perforated with a drilling machine when polymerised to allow the exchange of substances during the conservation process. The holes are about 12mm in size and cover approximately

[8] In the exhibit hall of the famously known royal ship Vasa in Stockholm, for example, the temperature is maintained between 18-20°C, with a relative humidity of around 55%. Viewed 9 February 2017, <https://en.wikipedia.org/wiki/Vasa_(ship)#Conservation>.

[9] Stone: RH 10%-20%/temp. 15-25ºC; Pottery: RH 30%-40%/temp. 18-22ºC; Metal: RH 15%-25%/temp. 18-22ºC; Glass: RH 15%-25%/temp. 18-22ºC; Bones: RH 40-45%/temp. 15-18ºC.

Figure 5. Before the conservation process started, all necessary analysis of wood conditions was performed to determine the conservation strategy at the Department for organic material conservation at IPCH.
(Photo and microscopy images Katja Kavkler).

Figure 6. As the logboat was huge in at least three parts, important technical details had to be resolved, Department for organic material conservation at IPCH (Katja Kavkler).

one third of the surface of the capsules. The capsules should serve as protective layers throughout the whole conservation process. Before the wood is reinforced with the melamine resin, it is very fragile due to the deterioration of cellulose. In the first parts of the process the capsules offer support to prevent the wooden pieces breaking. Pieces of logboat can then be moved with minimal risk of damage. The capsules will then play a major role during the drying process. Due to its deterioration, waterlogged wood is prone to cracking and deforming while it is drying. The capsules should prevent the wood from deforming.

At the time of writing the experimental focus is cleaning the wood. After lying in the river under sediment for about 2000 years, the wood needs to be cleaned of occluding mud and from water soluble salts and acid deterioration products, which were not removed by 'hard' water in the river. Achieving near neutral conditions is essential to keep the melamine resin at basic pH in order to prevent polymerisation occurring too quickly (Cesar *et al.* 2017). An acid environment or higher temperatures promote the polymerisation process of the melamine resin. If cured too quickly the resin will not penetrate the wood and might cure on the surface of the object. That would have structural and aesthetic consequences: the wood would not be reinforced thoroughly, and the layer of resin on the surface would spoil the appearance of the object.

Discussion

Archaeological finds of organic materials are relatively rare. They are usually preserved only in places where microbiota are rare and therefore deterioration is rather slow, such as underwater environments and especially deep underwater sediments. These (partially deteriorated) archaeological finds are mechanically weak and need to be reinforced—either by external support or with an internal consolidant. With objects of the size and properties of our logboat, the main concern is to prevent mechanical changes. Water, which fills the degraded cellular structures, makes the object rather heavy and more vulnerable because much of the original strength has been removed through the processes of decay. Work with larger objects is therefore very different from smaller objects, which are easy enough for a single person to handle. Working logistics need to be planned in advance, and several pieces of supporting equipment need to be prepared.

The wood treatment and then slow drying is only the first level of artefact protection, which in itself is not permanent. This transition from waterlogged conditions into a dry state allows the wood to be exhibited. From here, two things are important: firstly, an adapted microclimate for the wood's exhibition; and, secondly, 3D monitoring of the changes in the form and relative proportion of an exposed wooden object. Controlled microclimatic air environments are now standard operational equipment in a museum. Monitoring is also a standardised procedure and computers, which can log data on the temperature and RH, run many building management systems. Museums must use monitoring when exposing highly sensitive items to protect them when they are on display. The original objects can be replaced completely if necessary by using the latest 3D technology, instrumentation technology and printing of 3D models. However, the cost and practical realities of reproducing 15m-long wooden boats are prohibitive.

Conclusion: is it time to change how we think about protecting our wooden heritage?

We are witnessing tremendous innovations in the conservation profession in the second decade of the new millennium. This requires re-thinking on several levels. Firstly, we must reconsider the responsibility of scientific researchers of humankind's cultural heritage, then the conservator's profession and their processing of the artefacts, and ultimately the museum profession, with its educational content enabling access to cultural heritage. The reason for re-thinking is that computer science has developed a very large number of technical devices and software for accurate 3D data capture, extending to complete precision 3D modelling and reconstruction. Then, there is all the 3D printing technology. What even five years ago seemed completely out of reach and too costly, today is part of daily activities. Therefore, it is now possible to observe many projects that use 3D technologies. The conservation profession now has access to procedures we could not have imagined, such as a replica of the original artefact. A decade ago, the gallery and museum profession was committed to displaying original objects from organic materials because it could not plausibly present heritage in any other way. However, today this argument may not be as valid.

The logboat from Vrhnika, which during its preparation for treatment was recorded by 3D measuring devices, today could be fashioned in its actual size from an oak log. It could also be printed in its natural size from a variety of composite materials, or to different scales, and these models could become excellent educational tools or souvenirs. Therefore, the logboat from Vrhnika is considered by the authors to be one of the last significant wooden artefacts to be exhibited as an original in an exhibition.

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An Underwater Archaeology Lesson from Pioneers Echoed in the UNESCO Convention

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Abstract

Between the end of the 1950s and the beginning of the 1960s, Sicily became a veritable 'experimental laboratory' of underwater archaeology, attracting some of the world's most important international institutions. This paper focuses on the work of the pioneering underwater archaeologists, in the belief that their research in Sicily—in particular Siracusa and Marsala—has provided lessons for the entire Mediterranean Sea. The commitment of Gerhard Kapitän and Honor Frost to the very first research investigations and to the field-testing of new techniques and methods of excavation and survey in Sicilian waters translates into a lesson that is still relevant today. Remarkably, objectives of research remain essentially those laid down in 1958 by the *Mediterranean Institute of Underwater Archaeology* founded by Pier Nicola Gargallo at Siracusa, and by the *Centro Sperimentale di Archeologia Sottomarina* founded at Albenga in the same year under the direction of Nino Lamboglia. Today these very same objectives are echoed in the UNESCO Convention on the Protection of the Underwater Cultural Heritage adopted in Paris on 2 November 2001 and ratified by the Italian Government with Law no. 157 of 23 October 2009.

Keywords

Interdisciplinary research, science-based approach, protection, law, international cooperation

The year 1958 marks a milestone date for the history of underwater archaeology in Sicily and is connected with Gerhard Kapitän and Pier Nicola Gargallo, the former a professional underwater archaeologist trained in Germany, the latter the forefather of the *Mediterranean Institute of Underwater Archaeology* based in Siracusa (Castagnino Berlinghieri 2010).

In Italy, Nino Lamboglia instituted at Albenga the *Centro Sperimentale di Archeologia Sottomarina* (Pallarés 1997–1998: 21–56). In those days the state of research was still at its beginning but it felt already strongly the need to act towards the protection of the underwater Mediterranean cultural heritage, not yet recognised as a common asset of humanity.

The rationale that channelled the earlier underwater recoveries in the Mediterranean Sea, albeit cargoes of great value such as that of the famous wreck of Antikythera in Greece (1900–1901) or that of Mahdia in Tunisia (1908–1913), to name two of the most striking examples, was far away from a science-based approach, and even less from the perspective of safeguarding the cultural heritage as a common good of humanity. It was a time of an 'antiquarian' attitude conceived as a mere 'surgical operation', where the 'removal' was a sort of 'gift' used to satisfy the erudite curiosity of the intellectual world of that time.

Later, in the fifties, on the excavations on the wreck of Albenga or on the wreck off the islet of Grand Congloué in France, although conducted under the direction of eminent archaeologists such as Lamboglia and Benoît respectively (Benoît 1961; Long 1987; Taylor 1965; Tchernia 1991), experience was not enough—technical tools and methodology were still at their initial phase. At the end of the fifties, from the depths of Sicily, Pier Nicola Gargallo and Gerhard Kapitän in Siracusa, Honor Frost later in Marsala (Castagnino Berlinghieri 2011, 2012), as both 'scholars' and 'divers' with the support of the local Soprintendenza, took on underwater archaeological investigations in a systematic way, making an important contribution in terms of method and scientific research setting.

Professor Nino Lamboglia, whom the whole Italian scientific community recognise as the 'father' of Italian underwater archaeology, in his introductory speech at the 3rd International Congress held in Barcelona in 1961 does not fail to appreciate the new results achieved in Sicily in the field, stating that 'the Marquis Pier Nicola Gargallo, with the support of German diver Gerard Kapitän, ..., [it] is dedicated to exploring with good results especially on the east coast of Sicily, encouraged by the Superintendency of Antiquities of Eastern Sicily' (Lamboglia 1971: 12–13). Pier Nicola Gargallo and Gerhard Kapitän in Siracusa were the first in the field to propose some significant queries about questions of topography; they were ahead of their time, going far beyond the traditionally understood limits of archaeology and so opened a new chapter of research which had hitherto been only marginally taken into account—that of maritime topography, closely related to urban planning of the ancient city.

With their researches in the Great and the Small Harbours of Siracusa, Gargallo and Kapitän undertook, for the first time, underwater topographic survey and challenged themselves to draw a hypothetical reconstruction of the port system of the Greek period. Through the use of 'a special sonar instrument' invented by Harold Edgerton from MIT in Boston (Calcagno, 2012) and developed by the Council of Underwater Archaeology of San Francisco, the first underwater thematic map was drawn up. Each item discovered on the seabed was charted along with information on depth, dimension and typology, allowing them to frame the coastal and submerged morphology in the right scientific perspective to appreciate better issues related to the ancient maritime topography.

Pier Nicola Gargallo of Castel Lentini (1923–1979) was a Syracusan aristocrat boasting Greek origins on his mother's side; a keen enthusiast with a bold and generous character, he blended his own passions with the passion for research (Figure 1).

Gerhard Kapitän (1924–2011), a German and inflexible personality, navigated through Sicily with Teutonic rigour in inexorable contrast to the Sicilian *savoir vivre* (Figure 2).

Honor Frost (1917–2010) was English by blood and of Cyprus by birth; she combined within her inimitable personality both a strong British temperament and a deep Mediterranean passion (Figure 3).

These are the vital genetic components of our free-spirited protagonists—features that distinguish their respective and professional biographies that evolved at a very high scientific level—above and beyond any sort of academic label. For this reason, many still remember them as a little haughty, with their Spartan and tough manners. Others loved them enormously; others still would have celebrated them forever—almost literally according to the baptismal name of Honor Frost—like the honour and pride of underwater archaeology.

Underwater archaeology had, thus, found in Sicily fertile ground and ready minds open to experiment with systems, methods and techniques in a new chapter of archaeological research (Castagnino Berlinghieri 2012). In fact, they were flanked by the institutional pioneers: Luigi Bernabò Brea, at the time Superintendent of Antiquities of Eastern Sicily and adjacent islands (Figure 4); and Vincenzo Tusa, in the same position for Western Sicily. These veritable leaders, fully aware of the potential of the discipline, supported and promoted maritime archaeology with alacrity in the territories and seabed under their respective jurisdictions.

Figure 1. Pier Nicola Gargallo, portrayed in old diving equipment during underwater surveys undertaken in the Small Harbour of Siracusa (Efisio Picone).

Figure 2. Gerhard Kapitän drawing archaeological finds recovered from the seabed off South-eastern Sicily, location not specified (Historical Archive of the Soprintendenza Beni Culturali of Siracusa, illustration from 2012 exhibition).

Figure 3. Honor Frost (right) portrayed with Elena Flavia Castagnino Berlinghieri after a dive to the seabed off the island of Ustica, Sicily.

Even Ranuccio Bianchi Bandinelli (1960: 418) who wrote the 'Archaeological Exploration' entry in the *Encyclopaedia of Ancient Art*, does not fail to mention (in paragraph 5 dedicated to 'underwater') 'intense scientific activity promoted by the 'Mediterranean Institute of Underwater Archaeology' founded, financed and chaired by Pier Nicola Marchese Gargallo, which gathered in Siracusa a remarkable collection of anchor stocks and of lead equipment items' (Figure 5).

Pier Nicola Gargallo, who is almost unknown to the scientific community today, was recommended as *Honorary Inspector for Marine Antiquities* by the Soprintendente Luigi Bernabò Brea, who wrote about him that he was carrying out significant benefits not only with regard to the archaeological exploration itself, but also to impede the illegal looting which is particularly intense during the summer, for which his frequent presence on the nearby coast in Siracusa was a deterrent (Bernabò Brea 1960). EFCB

At the international level, attempts were made in the 1970s to improve the protection of the underwater cultural heritage in international waters.[1] The subject was raised in the UN Conference on the Law of the Sea, but it was regarded as a marginal matter. In the end the UN Convention (1982) has two unsatisfactory articles on UCH: articles 149 and 303. They were clearly never discussed properly and their wording is confused;[2] clearly the negotiators at UNCLOS III did not consider underwater cultural heritage to be an important subject.

In January 1977 the Council of Europe Parliamentary Assembly debated progress at UNCLOS III, and decided that the subject was important; so, it initiated a study by its Committee on Culture and Education. The rapporteur John Roper MP recommended a European Convention. The Parliamentary Assembly approved this; however, its Recommendation (Recommendation 848) did not, unfortunately, lead to an intergovernmental agreement, owing to bilateral disagreements between some member states. The regret on this of one of the authors of this paper is profound, since he served as archaeological adviser to the Committee. However, there is a direct line of succession, pursued for many years by the lawyers who had been the legal advisers to the Committee, Lyndel Prott and Patrick O'Keefe: this, through the work of the International Law Association to the newly created Scientific Committee of ICOMOS, which produced the ICOMOS Charter of 1996, which became an Annex to the UNESCO Convention of 2001. Reference to the underwater cultural heritage was added to the revised European Convention on the Protection of the Archaeological Heritage, Valletta 1992.[3] DJB

With this background, the importance of underwater cultural heritage coupled with the commitment assumed by UNESCO in this delicate sector produced, over time, opportunities for discussion in Sicily and especially in Siracusa. Such debate, in fact, produced a key legal instrument by making use of the contribution of the city of Siracusa, not only in historical terms and content but also in terms of contractual negotiations (Castagnino Berlinghieri, 2013).

It would be worth emphasising more that, under the Italian constitutional system, Sicily is one of the four regions in Italy that have legislative autonomy regarding protection of cultural heritage, and the only

[1] The authors should declare an interest, having personally contributed to the debate and to the negotiations: Elena Flavia Castagnino Berlinghieri was a Member of the Scientific Committee established by the Italian Ministry of Foreign Affairs (Rome), General Directorate for Cultural and Promotional Cooperation, and attended a period of the negotiation of the 2001 UNESCO Convention; David Blackman served as archaeological adviser to the Council of Europe Parliamentary Assembly for the Roper Report (see below).

[2] See Dromgoole 2013: 29-36; Blackman attended a period of the UNCLOS III negotiations, and saw the inadequacy of the Revised Single Negotiating Text.

[3] See Blackman 2013; Dromgoole 2013: 36-64. For Valletta 1992, see ETS 143, Articles 1-2.

Figure 4. The Soprintendente Prof. Luigi Bernabò Brea with divers from the Nucleo Carabinieri and Guardia di Finanza, portrayed with part of the cargo belonging to shipwreck 'F' found off Capo Graziano di Filicudi (Aeolian Islands) (Historical Archive of the Soprintendenza Beni Culturali of Siracusa, illustration from 2012 exhibition).

one to have a public agency with exclusive competence concerning the protection, management and valorisation for UCH, called the 'Soprintendenza del Mare'—the 'Superintendency of the Sea'. This agency works within the Regional Agency of Cultural Heritage, Environment and Education, and has competence on investigation, inventory, protection, monitoring, promotion and use of the archaeological underwater heritage in Sicily. Upon request of the Superintendency of the Sea, on 11 August 2010, the Sicilian Region issued a special Decree no. 36—setting out the 'Guidelines for the protection of UCH' in order adopt the principles present in the Annex of the UNESCO 2001 Convention, and directly implementing a successful control method through its officials, in coordination with Coast Guard and local trusted diving clubs. The Superintendency of the Sea's concession gives local diving clubs the right to practice cultural tourism on archaeological sites while, in return, the Regional Board requires constant control and monitoring actions by them (diving clubs) during dives.

In accordance with the UNESCO 2001 Convention, which encourages bilateral or multilateral agreements aimed at promoting UCH research, the Soprintendenza del Mare has started intense activity on deep-sea archaeological research thanks the involvement of two USA non-profit Foundations dedicated to Maritime Archaeology education and research. This is done by using advanced technologies through a variety of methods including deep-water excavation, dive survey, student fieldwork, and ROV investigation. These are the Aurora Trust Foundation, investigating the sea around Siracusa and around Panarea in the Aeolian Islands, and the RPM Nautical Foundation, committed to exploring ancient wrecks focusing in particular on the Battle of the Egadi seabed site off Levanzo Island where they recovered, among other things, a number of bronze warship rams and helmets. Other international projects show how the collaboration between experts and research centres of different states may strengthen the investigation and management of the UCH.

Among the cargoes of ancient shipwrecks that sank off Sicilian shores, the large marble-carrying vessel found near Marzamemi in the sixties by the pioneers Pier Nicola Gargallo and Gerhard Kapitän is now under investigation within the 6th campaign of the project entitled 'Marzamemi Maritime Heritage Project'. It is a multi-stage collaborative excavation, survey, and heritage management initiative encouraged by the Soprintendenza del Mare in agreement with

University of Stanford (USA), Università Suor Orsola Benincasa of Naples, Diving Centre El Cachalote and Brooke University, Pennsylvania. This started in 2012 and is focusing on the 'Marzamemi 2' wreck, the large Byzantine marble-carrying vessel and its stunning cargo, as well as the maritime landscape off the south-east coast of Sicily.

These few examples demonstrate the core approaches taken by the Soprintendenza del Mare to surveying and conducting multilateral UCH projects in systems that favour public openness to such legacy and the consolidation of research interests. Indeed, the role played by the Soprintendenza del Mare represents an excellent opportunity for enhancing forms of closer cooperation between research, protection of the environment and protection of cultural and natural heritage. The scenarios opened by the '*Dichiarazione di Siracusa*' strengthen the important linkages between cultural heritage and protection playing a special role in the increasing law-making activity carried out at the international or supranational level.

The Soprintendanza del Mare continues to make a positive contribution, starting for the first time a procedure, which is provided for in the 2001 UNESCO Convention. On its proposal the Italian government has notified UNESCO of the discovery of several highly threatened cultural heritage sites on the Skerki Banks, in international waters between Sicily, Sardinia and Tunisia; such notification will trigger the protection of these sites under the 2001 convention (see Blackman 2018).

In the last decade in particular, decisive international conferences and meetings have seen converging in Siracusa scholars, jurists, academics, researchers and experts in the various fields of expertise related to the archaeological heritage, that have engaged in the forefront of the protection of the UCH of the Mediterranean.

In the period between 2001 and 2012, Siracusa hosted three International Conferences:

- 'Strumenti per la protezione del patrimonio culturale marino' in 2001;
- 'Cooperation in the Mediterranean for the Protection of Underwater Cultural Heritage' in 2003; and
- 'The pioneers of underwater archaeology: Siracusa and Marsala from Sicily to the Mediterranean', coupled with an interesting original exhibition in 2012.

The conference that took place at Palermo and Siracusa in 2001 has, in fact, represented the first explicit interregional commitment in the matter (for the archaeological aspects, see: Tusa and Li Vigni 2002; for the legal aspects, see: Camarda and Scovazzi 2002).

In this international setting, the comparative analysis of three thematic areas—training, research and legislation—coordinated by the DGPC (Direzione Generale Promozione Culturale) of the Ministry of Foreign Affairs, has made it possible to compare national plans of each State with the commitment to reconcile the technical and scientific aspects (typical of a university) with the real needs of the territory in order to create a common policy based on close cooperation. The basic idea was to establish and/or strengthen a network of partnerships between 'training', 'research' and 'legislation' stemming from a common platform with specific goals and expectations.

In the negotiation between Member States of UNESCO towards the elaboration and adoption of a common standard for the protection of such heritage, again the role played by Siracusa has been vital, contributing not only by its pioneering activities relating to UCH but also in decision-making. On 10 March 2001, the 'Declaration of Siracusa' on the Submarine Cultural Heritage of the Mediterranean Sea (see Annex) was adopted during the International Conference titled 'Means for the Protection and Touristic Promotion of the Marine Cultural Heritage in the Mediterranean' held at Siracusa.

The 'Declaration of Siracusa'—also known as 'Declaration on the Submarine Cultural Heritage of the Mediterranean Sea'—adopted on 10 March 2001, defines the fundamental ground for the achievement of UNESCO in the definitive agreement reached in Paris with the International Convention. This was approved in November of the same year 2001, after nearly 60 years of international debate followed by 20 years of negotiation process aimed to confer lawful protection for UCH. In the meantime, the Convention has entered into force on 2 January 2009 and is binding on 31 States, including ten Mediterranean States (along with Italy, Croatia, Spain, Libya, Lebanon, Montenegro, Slovenia, Tunisia, Albania and Bosnia and Herzegovina).

One of the main cases that first raised a number of important legal and ethical issues in relation to the protection of UCH in the Mediterranean Sea and beyond occurs on the Italian continental shelf, about 20 nautical miles off the southern coast of Sicily. It was January 1955 when the little bronze statue, representing the Phoenician Cypriot divinity Reshef, known as Melqart of Sciacca, became fortuitously entangled in fishing nets and dragged by the vessel *Angelina Madre* flying the Italian flag. The subsequent court case debating the 'first-come-first-served' or 'freedom of fishing' principle to determine the ownership of the statue and the legal territorial intricacies involved, appears as a

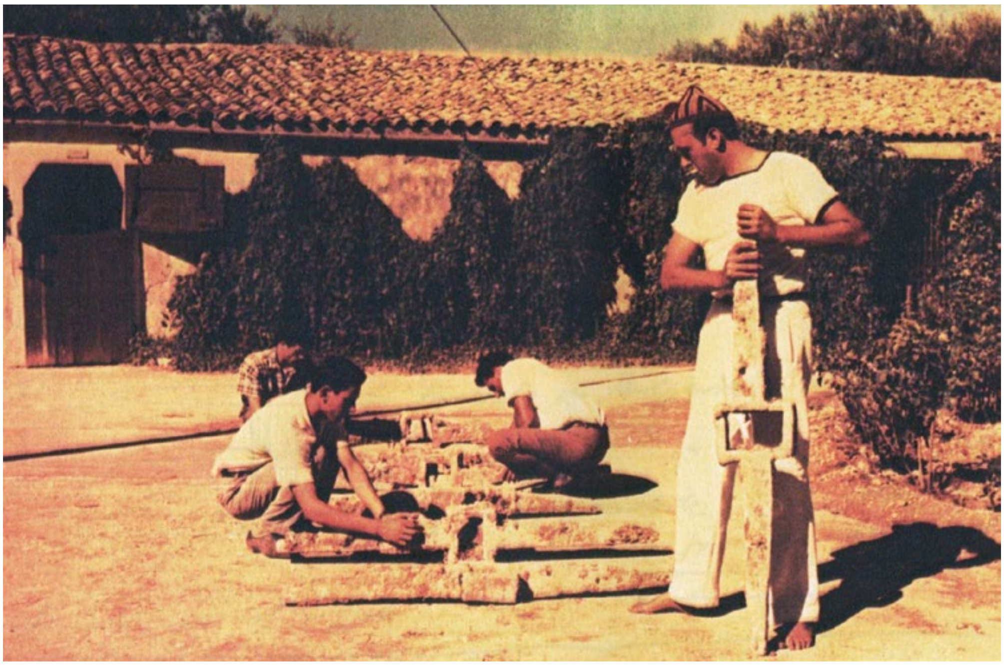

Figure 5. Pier Nicola Gargallo, with his remarkable collection of anchor stocks and of lead equipment items given to the former Superintendency of Antiquities of Eastern Sicily, based in Siracusa.

good introduction to the rules applied in Italy and the Mediterranean as a whole. Since January 1955, the case of the 'Melqart of Sciacca' has attracted considerable media coverage in Sicily, Italy, the Mediterranean States and internationally.

Again, in the waters between Sicily and Tunisia, 22 years later, another significant issue in the field arose. Relying on the 'principle of freedom of the high seas', Robert Ballard conducted his last expeditions (1997) at Skerki Banks, using a special research vessel *Carolyn Chouest*, supported by a nuclear-powered submarine of the United States Navy and an ROV-remotely operated vehicle (*Jason*). He proceeded to locate ancient shipwrecks and removed more than 150 manufactured objects including amphorae, glassware, anchors and other objects from the seabed.

These two cases can definitely be described as ground-breaking circumstances which could certainly be regarded as corner-stones of the history of the legal protection of UCH because they set the scene for studies in this field that were later officially steered by the Council of Europe Parliamentary Assembly through its Culture and Education Committee between 1976 and 1978, although this Committee drafted a Convention that was never adopted (see above). However, it led to the 1994 International Law Association (ILA) Draft Convention adopted at Buenos Aires; in turn, two years later, the 1996 draft of the General Assembly of the International Council of Monuments and Sites (ICOMOS) was adopted in Sofia, which broke through the impasse; and, lastly, at the 1997 UNESCO General Conference, States parties agreed to elaborate an international convention focused on the protection of the UCH.

Although the 'Mediterranean draft' could be seen as only a preliminary text, subject to all the improvements and adjustments resulting from the dialogue held in Siracusa on 3–5 April 2003, and further reflections by the countries concerned, it anticipated some of the future main principles and methodological practices that would be introduced into the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage, when it later entered into force in January 2009. In this setting, the draft Agreement projected even more advanced measures of protection and cooperation; for example, entirely excluding the claim of Salvage Law and Law of Finds; proposing the development of 'Specially Protected Areas of Mediterranean Cultural Importance'; and, recommending the establishment of an International Museum of Mediterranean Underwater Cultural Heritage.

Objective 3 of the Declaration concerns the cooperation and information sharing among states parties: 'The Mediterranean countries have a special responsibility to ensure that the submarine cultural heritage they share is made known and preserved for the benefit of humankind'. This is better-emphasised by Part II. Principles, 7: 'without prejudice to the rights of the coastal State, consultations on how to ensure the appropriate investigation, effective protection and, if they are not preserved *in situ*, final destination of the objects belonging to the Mediterranean submarine cultural heritage should be held between the countries having a verifiable link with the objects in question'.

In terms of protection, one of the most important objectives of the UNESCO Convention, widely discussed in Siracusa in 2001, concerned the regulation of UCH outside the possible area of archaeological jurisdiction of coastal States (maximum 24 nautical miles, an area of jurisdiction not covered by the 1982 United Nations Convention on the Law of the Sea). The latter, known as UNCLOS 1982, while laying down specific rules for the archaeological area (coinciding with the contiguous maritime area, article 33) and for the international area (over 200 miles, article 149), neglected to regulate the area that extends between 24 and 200 nautical miles. This gap had to be filled above all in the light of the fact that in article 303, para. 1, the same UN Convention provided for the obligation of States to protect archaeological or historical heritage 'wherever found at sea' and invited them to cooperate to this end; it also, in para. 4, provided for the possibility of integrating the existing protection regime for archaeological and historical assets with 'other international agreements and rules of International Law'.

A further commitment on cooperation, legal protection and scientific research in the Mediterranean coastal countries came in Siracusa in April 2003, when the diplomatic representatives of the governments of the countries bordering the Mediterranean—distinguished jurists and eminent archaeologists—pursued effective dialogue on the multiple aspects of protection and enhancement of UCH. From a legal perspective, the objective was to analyse and plan international regulatory instruments for the purposes of the entry into force of the UNESCO Convention (which required at least 20 ratifications) but also to propose, on the Italian side, a draft Mediterranean Regional Agreement, integrating the same Convention, pursuant to its art. 6, on strengthening the protection system of our underwater archaeological heritage.

Thus, while it briefly discussed international legal instruments concerned with the issues of protection of UCH, the draft Regional Agreement, known as 'Mediterranean Draft', integrated the rules with those fundamental key-points that represented, in fact, an added value to the 2001 Convention itself and in particular:

- The application of the Law of Salvage and the Law of Finds should be completely excluded;
- In the case of state vessels and aircraft located in internal waters or territorial sea, closer cooperation should be sought between the coastal state, the flag state of the wreck and other states having a verifiable link with it;

Figure 6. Use of one of the first airlifts on the seabed off Marzamemi while excavating the so-called 'Church wreck' (Historical Archive of the Soprintendenza Beni Culturali of Siracusa, illustration from the 2012 exhibition).

- The possible establishment of Specially Protected Areas of Mediterranean Cultural Importance;
- The establishment of an International Museum of Mediterranean Underwater Cultural Heritage;
- The organisation of periodical training courses; and
- In order to stress the special responsibility of Mediterranean states, only those states which are parties to the future Mediterranean Agreement, or which agree to cooperate with the parties in applying the measures established by it, are granted the right to engage in activities relating to the Mediterranean's UCH (Scovazzi 2010).

This background, with its rich repository of history from which we can learn useful lessons, explains the

Figure 7. Entry panel of the exhibition 'Storms, War and Shipwrecks: Treasures from the Sicilian Seas', Ashmolean Museum of Art and Archaeology in Oxford (2016). From left: A. Sofroniew, D. Blackman, P. Roberts, E. Castagnino Berlinghieri, M.T. Fidone.

special commitments that Italy, from Sicily, has given to the UCH legislation today. After the pre-existing 'salvage law' and the 'law of finds', the 'Declaration of Siracusa', thus, embodied one of the early responses of the international community—given by major representatives from governmental, academic and legal bodies of the countries bordering the Mediterranean—to improve the legal and operational protection of the underwater cultural heritage. Two years later, the final roundtable of the International Conference 'Cooperation in the Mediterranean for the Protection of the Underwater Cultural Heritage' was held again in Siracusa on 3–5 April 2003.

On this occasion, Italy presented a Draft Agreement, known as 'Mediterranean Draft', resulting from the discussion on the protection of the UCH including some fundamental key points, which were later integrated in the final 2001 Convention. Later, on 22 June 2012 the Soprintendenza ai Beni Culturali of Siracusa, under the aegis of the Italian National Commission for UNESCO, the Nautical Archaeology Society and in collaboration with other regional bodies, re-opened one of the earliest chapters in the Underwater Archaeology family album, reliving that extraordinary time when pioneering divers, oceanographic engineers, archaeologists and geologists, draughtsmen and photographers contended for the great prize of securing the first major underwater archaeological discoveries in the Mediterranean Sea. As a tribute to Pier Nicola Gargallo, Gerhard Kapitän and Honor Frost, and as a tangible expression of appreciation for their scientific investigation in the field of maritime archaeology in Sicily, the Soprintendenza dedicated a special event to their work in Sicily, under the title 'The pioneers of underwater archaeology: Siracusa and Marsala, from Sicily to the Mediterranean'.

Through this event—including an international symposium, an exhibition, a children's cartoon and a documentary film—the Soprintendenza intended to honour the huge and pioneering achievements made in underwater archaeology in Sicily, in the belief that Siracusa is once again ready to take the lead in continuing and deepening the work of Gargallo, Kapitän and Frost, as well as pioneering exciting new research in the Mediterrranean.

The exhibition was held in summer 2012 in the 'Caravaggio Hall' inside the historic headquarters of the Soprintendenza of Siracusa, located on the island of Ortigia. It was conceived as a 'small treasure': through rich thematic routes it was possible to explore a selection of unpublished testimonies, handwritten letters, drawings, and first-hand research reports, together with the very first underwater black and white slides, all belonging to the Historical Archives of the Soprintendenza of Siracusa. It makes it possible to relive the years of experimentation of the first scientific survey systems conducted with exemplary methodological rigour in Sicily. Also, the production of a short documentary film and a cartoon contributed to arousing a strong awareness in younger generations about the importance of the UCH seen as a cultural issue of highest value for humanity.

The 'Education for Sustainable Development UNESCO Week' organised by the Italian National Commission for UNESCO in 2013 at the national level was inaugurated in Siracusa on 18 November 2013 with the conference 'Protection of the Underwater Cultural Heritage. The UNESCO Convention of 2001, five years after its entry into force: current status, legal and technical-scientific perspectives'. It was held in the main Hall of the Marine Protected Reserve of Plemmyrio with many stimulating contributions. Among other panelists, Prof. Tullio Scovazzi, Professor in the Law Department of National and European Institutions at the University of Milan-Bicocca, explained that the event has allowed us to review the implementation of the UNESCO Convention of 2001 and, simultaneously, made it possible to reopen the international debate to propose and evaluate new prospects for work in the hope of opening in Siracusa an educational interdisciplinary centre in the field of maritime archaeology.

In 2014, it was the turn of the exhibition 'ARCHAEOMARIS. Discovering the seabed by surfing the Memory: History, Archaeology and Research for Sustainable Education', by which the Superintendency for Cultural and Environmental Heritage of Siracusa celebrated the '2014 Sustainable Education Edition' promoted by the Italian National Commission for UNESCO. The exhibition aimed at rebuilding the strong linkage of the younger generations with the city and its sea, in order to raise awareness of the common framework for the preservation and enhancement of the UCH in harmony with the UNESCO guidelines.

In 2016 the exhibition 'Storms, War and Shipwrecks: Treasures from the Sicilian Seas' (21 June 2016 to 25 September 2016) at the Ashmolean Museum of Art and Archaeology in Oxford (Figure 6), again conveys the extraordinary story of the island at the crossroads of the Mediterranean, through the discoveries made also by Gerhard Kapitän and Honor Frost in the depths of waters off Sicily. It was the discovery of the 'Flat-Pack Church' of Marzamemi Wreck, revealed and investigated by Gerhard Kapitän and Pier Nicola Gargallo on the seabed under the jurisdiction of the Superintendency of Siracusa (Figure 7), that proved one of the most interesting and fascinating sections of the display. Moreover, a series of side-events, organised by the Department of Antiquities of the Museum, also made it possible to devote more attention to the subject of the Byzantine 'flat-pack church' discovered by Kapitän, considered a masterpiece among the most extraordinary treasures ever found around the Mediterranean (Castagnino Berlinghieri, 2017: 117–20 with previous references).

All this rich background, here very briefly reported, definitely represents a source of great pride for Siracusa and seems to open new perspectives on the future of underwater archaeology, whose scientific premises, not surprisingly, trace their historical and cultural roots precisely in Siracusa.

After many years of consideration, the UNESCO Convention on the Protection of Underwater Cultural Heritage seems to embody the same full picture that in 1958 had already inspired Pier Nicola Gargallo in his duty to act—in order to study, preserve and safeguard the underwater archaeological heritage in the common interest by establishing the 'Mediterranean Institute of Underwater Archaeology' based in Siracusa.

Today these very same objectives are echoed in the UNESCO Convention on the Protection of Underwater Cultural Heritage adopted in Paris on 2 November 2001 and ratified by the Italian Government with Law no. 157 of 23 October 2009. EFCB

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Annex

Siracusa Declaration on the submarine cultural heritage of the Mediterranean Sea

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Siracusa, 8-10 March 2001,

The experts of several countries bordering the Mediterranean Sea, attending the International Conference 'Means for the Protection and Touristic Promotion of the Marine Cultural Heritage in the Mediterranean', held in Palermo and Siracusa, Italy, on 8-10 March 2001,

concerned by the fact that the submarine cultural heritage is threatened by activities of uncontrolled exploration and appropriation not respecting the need for conservation and research, increasing commercialization of the objects discovered, damages resulting from other marine activities,

looking forward to the early conclusion of the negotiations at UNESCO for a Convention on the protection of underwater cultural heritage,

acting in their personal capacity,

adopt the following

Siracusa Declaration on the submarine cultural heritage of the Mediterranean Sea

I. Objectives

1. The Mediterranean basin is characterized by the traces of ancient civilisations which flourished along its shores and, having developed the first seafaring techniques, established close relationships with each other.
2. The Mediterranean cultural heritage is unique in that it embodies the common historical and cultural roots of many civilizations. It is also an integral part of the cultural heritage of humanity and an important element in the history of peoples and societies.
3. The Mediterranean countries have a special responsibility to ensure that the submarine cultural heritage they share is made known and preserved for the benefit of humankind.

II. Principles

4. Activities directed at the Mediterranean submarine cultural heritage should take place only if full respect of the fundamental principles of scientific archaeology ensured, as reflected in the 1996 ICOMOS Charter and other relevant instruments.
5. Objects of any kind belonging to the Mediterranean submarine cultural heritage should not be acquired, sold, bartered or exploited for commercial purposes or private benefit. Economic use of sites and objects belonging to the Mediterranean submarine cultural heritage should be conducted only under strict public supervision.
6. States should avoid the dispersal and fragmentation of components of archaeological contexts.
7. Without prejudice to the rights of the coastal State, activities directed at the Mediterranean submarine cultural heritage should be carried out ensuring prior information and the possible involvement of countries having a verifiable link with the objects in question.
8. Without prejudice to the rights of the coastal State, consultations on how to ensure the appropriate investigation, effective protection and, if they are not preserved in situ, final destination of the objects belonging to the Mediteranean submarine cultural heritage should be held between the countries having a verifiable link with the objects in question.
9. Activities directed at submarine cultural heritage should avoid any damage to the surrounding environment and, when necessary, environmental impact assessment and measures for restoration should be undertaken.

III. Consequences

10. In view of their special responsibility, the Mediterranean countries should cooperate in protecting the submarine cultural heritage from natural and man-made risks. They should study the possibility of adopting a regional convention that enhances cooperation in the investigation and protection of the Mediterranean submarine cultural heritage and sets forth the relevant rights and obligations.
11. Mediterranean countries should promote the conclusion of bilateral or multilateral agreements incorporating the objectives and principles of this Declaration and relating to specific components of the Mediterranean submarine cultural heritage, such as wrecks or single objects.
12. Mediterranean countries should establish submarine protected archaeological sites or parks. They should consider means for the establishment of a list of submarine protected archaeological sites or parks of Mediterranean importance. Appropriate measures should be taken to protect submarine archaeological sites from dangerous activities.
13. The establishment of a network of museums where objects of Mediterranean submarine cultural heritage are conserved and displayed should be encouraged and properly publicized.
14. Mediterranean countries should exchange information on, and cooperate in, the training of marine archaeologists.
15. Mediterranean countries should encourage the cooperation of their competent authorities with local governments, scientific institutions, non-governmental organizations, associations of fishermen, seafarers, divers and other professions in the protection and promotion of submarine cultural heritage.

Siracusa, 10 March 2001

Documentation of a Hermitage Submerged in the Reservoir of Buendia (Spain) as an Example of Collaboration Between Divers and Institutions for the Protection of UCH

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Abstract

In October 2013, three recreational divers reported a chance discovery in the waters of the Buendía reservoir (Castilla La Mancha, Spain) to the National Museum of Underwater Archaeology of Spain. It was a human-made cave carved in sandstone, with an access door, a window and several engravings similar to those recorded in some hermitages in the area.

In June 2015, a campaign was conducted to inspect, document and assess the site. After initial historical and archaeological documentation, we did an underwater and terrestrial survey of this site and other nearby caves connected with hermitages.

The National Museum of Underwater Archaeology of Spain has a great scientific interest in this site for various different reasons. Documenting this site, a possible hermitage found in inland waters, is a pioneering research project in Castilla La Mancha and a milestone for the whole country of Spain, where few surveys of reservoirs have been done and even fewer corresponding to this historical period. In addition, this would also be an excellent example of collaboration between recreational divers and institutions in the Protection of Underwater Cultural Heritage.

Keywords

Inland underwater archaeology, cave hermitage, cross engravings, recreational divers, UCH protection

Introduction

Accidental discovery and official notification

In October 2013, three recreational divers made a chance discovery in the Buendía reservoir, located between Cuenca and Guadalajara, two provinces in Castilla La Mancha, an inland region of Spain (Figure 1).

The site is a human-made cave carved in sandstone, with an access door and a ventilation window, both with watershed and at least one door intrados engraving. Near the cave, the divers found other structures: a row of holes carved in the rock and a small dry-stone structure.

When the divers returned home, they checked the website of the National Museum of Underwater Archaeology–ARQVA (Cartagena, Spain) and found the SOS campaign: 'If you have any information which might be useful, please call us at 968–121166. Let's work together to preserve our shared heritage.'

On the first working day after the find, the divers reported their discovery to the museum by phone and later by email, sending further data and photos to the ARQVA archaeologists.

Divers and archaeologists kept in contact to proceed with the administrative process. As the finding was located in a different region, the official authorities

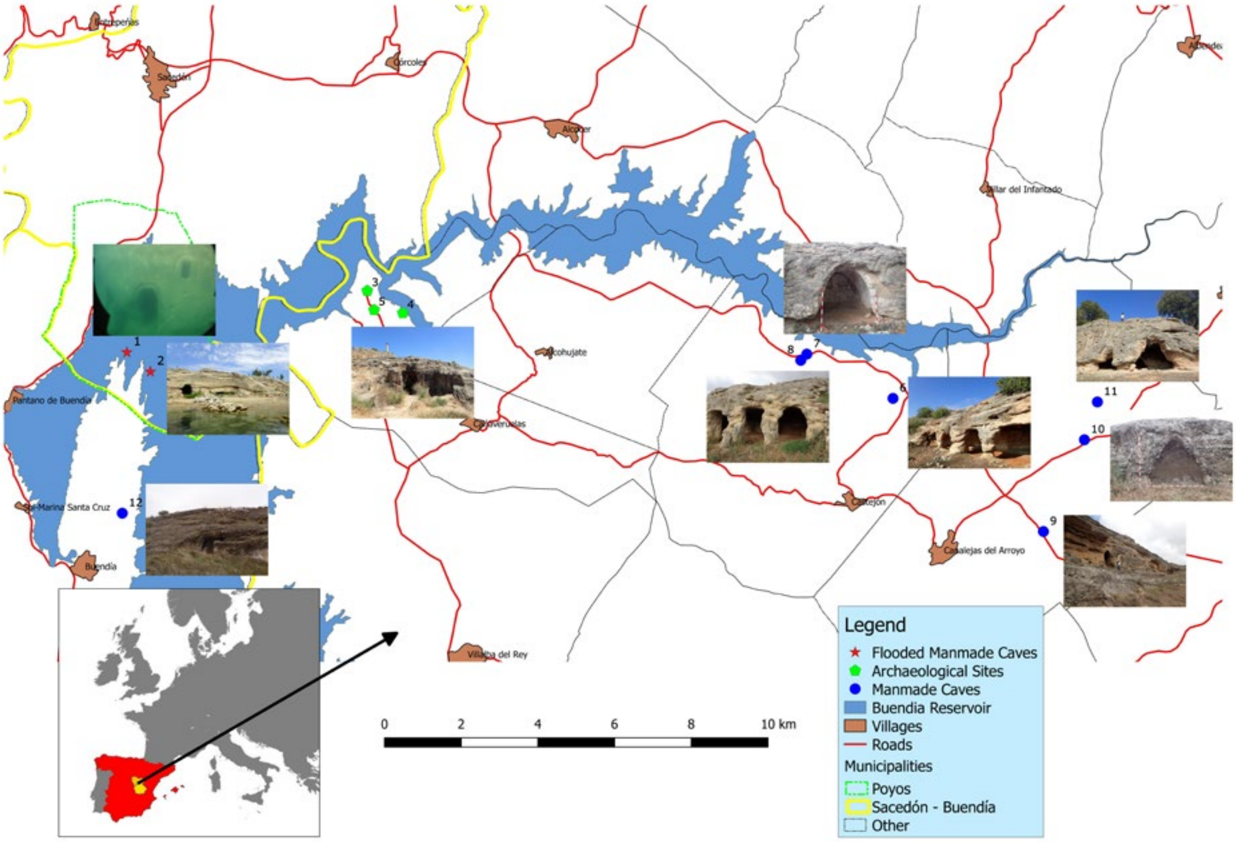

Figure 1. Map of human-made caves and archaeological sites. 1,2: Site 1 and Site 2. 3: Ercávica, Arcávica. 4: *Servitanum* Monastery. 5: Crypt of abbot *Donatus*. 6,7,8: Caves at Castejon. 9,10,11: Caves at Canalejas. 12: Cave at Buendía (Map and composition: Dr. Rogelio de la Vega-Panizo; Photos: Ángel M. Tobar-Escudero and M. Elena Labrandero-Pulgar).

of that area—the Department of Culture of Castilla La Mancha—needed to be informed. The divers authorised the Museum to make the notification on their behalf, which they did, sending all the pertinent information.

Museum public awareness campaign

In 2005 Spain ratified the 2001 UNESCO Convention of on the Protection of Underwater Cultural Heritage (UNCPUCH). This document dedicates its Article 20 to Public Awareness: 'Each State Party shall take all practicable measures to raise public awareness regarding the value and significance of underwater cultural heritage and the importance of protecting it under this Convention.'

The National Museum of Underwater Archaeology—ARQVA—is located in Cartagena and depends on the Spanish Ministry of Education, Culture and Sport. The museum is the institution responsible for raising public awareness of the Underwater Cultural Heritage of Spain, promoting its conservation and, thus, enhancing its use and enjoyment. Its objectives are the study, evaluation, research, conservation, promotion and protection of Spain's Underwater Cultural Heritage (UCH).

The ARQVA has different activities to encourage public awareness of UCH such as conferences, visits and campaigns like SOS. The goal of the SOS Campaign is to sensitise the public to accidental underwater archaeological findings. This campaign started in 2009, within the framework of the ArchaeoMed European project, in the western Mediterranean area. Several countries participated from Malta to Portugal. In Spain, four underwater centres are involved: Catalonia, Valencia, Cartagena and Cádiz. All publicise the SOS campaign via posters, brochures, stickers, talks and their websites.

In order to transmit to the public that the 'Protection of UCH is the task of everyone', ARQVA spread the SOS campaign through conferences mainly aimed at divers and fishermen, and through its website (http://www.culturaydeporte.gob.es/mnarqua/en/patrimonio-cultural-sub/campana-sos.html, viewed on 28 April 2020).

The campaign encourages citizen participation using simple slogans and establishes the steps that a diver should follow:

1. If you find an occasional underwater finding of archaeological interest, please leave the remains on the site; do not touch or remove them from the water; take photos and notes, leave only bubbles; and pinpoint it with GPS, queues or any geographical references.
2. Then, call the nearest Museum or underwater centre, the Ministry of Culture, the Civil Guard or Police.
3. Finally, if possible, take technicians to the site.

In this way, with your help, the natural and archaeological context may be conserved and any archaeological and historical 'clues' will be preserved without any alteration.

The Buendía Project

After the divers' initial report to the Museum and subsequent meetings, the 'Buendía Project' was born. It consists of an interdisciplinary team made up of two underwater archaeologists, two diving instructors/photographers, a GIS specialist and the recreational diver who discovered the site.

The team has carried out the following tasks: in 2014, prior research was carried out on historical and archaeological documents; in 2015, an underwater and terrestrial survey was conducted, after receiving authorisation from the regional Culture authority of Castilla La Mancha. The objectives were to inspect, record and assess the underwater site and document other nearby caves on lands connected with hermitages. In 2016, further investigations continued.

Previous Research

Historical and archaeological context

The Romans conquered the Celtic settlement of Ercávica in 179 BC. The Roman city of Ercávica maintains its Celtiberian name although it changed location. The new site was urbanised, granted the status of municipality and started to coin money. The city reached its peak in the first and second centuries AD. After the crisis of the 3rd century, an irreversible decline caused the gradual abandonment of the city during the 4th and 5th centuries AD.

Subsequently, Ercávica came to be known as Arcávica, a Visigoth settlement located southwards. This site has been identified with the nucleus that arose around *Servitanum* Monastery, founded in the second half of the 6th century AD by abbot *Donatus* and lasting until the 9th century AD. At this point, we should stop and analyse the 6th century AD in detail.

In the first years of the reign of Liuvigild (AD 568–586), several groups of monks fled to Hispania to escape the religious persecution in North Africa. Among them, there was a group of 70 monks led by abbot *Donatus*. This group arrived in 571 with a shipment of books and codices and founded *Servitanum* Monastery near the old Roman city of Ercávica (Visigothic Arcávica). Abbot *Donatus* had eremitical training and his cenobitic community probably followed the Augustine Rule (Barroso Cabrera *et al.* 2014: 264). It is known that Arcávica was a bishop's see since the 6th century because its bishop participated in the Second Council of Toledo in 527. Another of Arcávica's bishops participated in several Councils of Toledo (Barroso Cabrera *et al.* 2014: 262).

Servitanum Monastery was important because abbot Eutropius (disciple of abbot Donatus) was tutor to Prince Recared (younger son of Liuvigild) and probably an agent for his conversion to Catholicism. Until Liuvigild reigned, the king and his Visigothic subjects were Arian Christians and his Hispanic-Roman subjects were Catholic. When Recared became king of Spania (AD 586–601), he renounced Arianism for Catholicism at the 3rd Council of Toledo in 589. From the time Recared reigned until the end of the Visigothic kingdom at the beginning of the 8th century, there was only one religion in Spania—Roman Catholicism (Barroso Cabrera and Morin de Pablos 2003: 9).

The archaeological remains of Ercávica and *Servitanum* Monastery are near Buendía reservoir (Figure 1). Both sites have been excavated since 1972. Between them, there is another archaeological site known as the crypt of abbot *Donatus* (Barroso Cabrera *et al.* 2014: 257)—a human-made cave carved in soft sandstone. This cave could have been the initial church of a *lavra* for the monks, who made caves outside of this construction to live as hermits. After the death of Abbot *Donatus*, around AD 580–584, the original semi-rock church was transformed into an oratory and funerary crypt, becoming a place of worship and veneration. A necropolis *ad sanctos* arose, with 50 tombs excavated in the rock in radial disposition around abbot's tomb (Barroso *et al*. 2014: 265–66).

The caves discovered in the Buendía reservoir are near (10km) these archaeological sites (Figure 1). They represent two of nearly 30 human-made caves around *Servitanum* Monastery. These artificial caves have had different uses throughout the years. Some of them have carved Christian signs and they may have been used as hermitages. Abbot *Donatus* is known to have had eremitical training (Barroso Cabrera *et al.* 2014: 264). From the 4th to the 7th century, there was an evolution from eremitical to cenobitic monasticism.

UCH in continental waters in Spain

The Underwater Cultural Heritage (UCH) located in the continental waters of Spain is not very well known. The first finds were fortuitous: in 1923 there appeared more than 300 bronze objects in the Ría de Huelva; and, in 1938, a Greek helmet was found in the Guadalete River (Jerez, Cádiz). In 1958, an underwater survey was carried out in Las Lagunas de Almanera (Castellón), in search of a Roman port, a pioneering work in Spanish inland waters (Blánquez and Martínez 1993: 49–50). From the middle of the 20th century the massive construction of reservoirs left many archaeological sites submerged, although occasionally surveys or excavations were made and a few major monuments were transferred to dry land. Fortunately, in the last few decades, UCH located in lakes, rivers and reservoirs have begun to be the focus of research and protection projects.

In 1990 the Neolithic settlement of Draga was discovered in Banyoles Lake (Girona, Catalonia). Since then it has been excavated and investigated by a multidisciplinary team, being the subject of numerous scientific publications. It is the only lake site of prehistoric chronology documented in the Iberian Peninsula until now. Its location in a permanently wet area, partially covered by lake water and the water table, has led to the extraordinary preservation of organic remains—construction elements, artefacts, food remains, vegetables and animals (Bosch, Chinchilla and Tarrus 2011).

In Andalusia, this type of site has been included in its archaeological map since the end of the twentieth century. It is also the Spanish region that has granted more legal protection, as Assets of Cultural Interest in the categories of Archaeological Zone (AZ) or Archaeological Easement Zone (AEZ) with less protection (García and Alzaga 2012: 264). The 2009 declaration included: eight AZs in well-known underwater sites located in reservoirs or in rivers (Córdoba, Jaén, Sevilla, Cádiz and Huelva); and six AEZs in underwater archaeological reserves such as the Guadiana and Guadalquivir rivers, marshlands and estuaries.

In Extremadura there are some studies on archaeological sites flooded by reservoirs. At the end of the twentieth century nine sites were documented on the verge of disappearing in Valdecañas (González 1999: 533). Later, several flooded sites were included in a doctoral thesis on the Copper Age in Upper Extremadura (González 2012). Recently, a specific doctoral thesis has been defended on the UCH in the Extremadura Basin of the Tagus River, where 66 underwater archaeological sites have been cataloged (Matamoros 2016: 230–33). In addition, an interesting Model of Damage and Risk to Heritage Flooded by Reservoirs (known as MARPASE) is proposed to calibrate factors that affect UCH deterioration in reservoirs and make proposals for the protection and preservation of these underwater sites (Matamoros 2016. 272–73; Matamoros and Cerrillo 2016: 460–62).

Additional current research is the Amallutx project being developed in the Gorg Blue reservoir on Majorca (Balearic Islands). Before the construction of the reservoir in 1970-71, some sites were documented but in the drought of summer 2011 additional ones were discovered. Since then, during the months the reservoir is at its lowest level, systematic surveys and excavations have been carried out. The documented archaeological sites provide evidence for a continued occupation from prehistoric to recent times. The location of an important Islamic rural settlement is highlighted, and it is considered the most important site from Islamic times on the Balearic Islands. However, the reservoir's oscillations are contributing to site deterioration and increasing the chances of plunder (Deya and Galera 2013: 241).

In the rest of Spanish regions, more than 70 UCH sites in reservoirs are known, some of which are inventoried but not the subject of research projects.

Underwater and Land Survey

In 2015 the Museum got the funding and the time to carry out the verification and documentation of the accidental discovery. The ARQVA archaeologist created an archaeological project that was authorised by the Department of Culture of Castilla La Mancha on May of 2015.

This action was funded by the Office for the Protection of Historical Heritage under the Spanish Ministry of Education, Culture and Sport.

At the beginning of June 2015, the team met in Buendía to record the site discovered by divers in October 2013, and to survey the surrounding area. During those days, another site was discovered on the banks of the reservoir and documented. Other similar sites on land were also recorded.

Later, in September 2015 and March 2016, a few members of the team went back to the first site to check site status, particularly with regard to water level.

Site 1

When we went to the site in June 2015, we realised that the site environment had changed. The cave could be reached just by swimming, since it was only half a metre deep, instead of the previous six metres when discovered in October 2013 (Figure 2).

Figure 2. Site 1: the human-made cave, the holes carved on the rock and the dry stone construction, between 2013 and 2015 (Image composition: Dr David Munuera-Navarro; Photos M. Elena Labrandero-Pulgar and Ángel M. Tobar-Escudero).

The level of water in the reservoir had decreased, so the different colour of the stone and the traces of the different levels of water could be seen, outside and inside the cave. The engravings on door intrados were also out of the water.

As there was little water, site recording was quicker than expected. We were able to establish the relationship between the cave and the nearby holes that were not at the same level. We took coordinates with GPS, carried out measurements, sketches and took numerous general and detailed photographs, particularly of unique elements (access door, ventilation window, watershed and engravings on door intrados).

Furthermore, the team made a short underwater inspection, with just one dive, to record the small dry-stone construction. This structure was at a depth of 3m, instead of the previous 9m-depth. Measurements were taken and its location recorded using a GNSS (Global Navigation Satellite System) device, adapted for underwater jobs. In our case, the GNSS device was placed into a waterproof housing, attached to a surface antenna-buoy, in the vertical of each point positioned. From the reservoir surface, we observed that this stone construction was in front of the holes carved on the rock, very close.

A few months later, in September 2015, part of the team came back to the site. They noticed the lower reservoir water level: the entire site was exposed above the water and the cave was 6m above the water level. This situation gave us an overall spatial vision that we could not achieve underwater.

It was easier then to notice how the different elements were connected. We observed that the position of the line of holes was at the door's mid-height level and not at the top of the cave, as we had assumed when we dived because we had seen that at a land site. We also came to understand the relationship between the holes and the stone structure, which were very close to each other.

We also uncovered the construction method of the dry-stone structure, how the stones adjusted to the slope of the site. Additionally, we discovered new remains: several crosses engraved in the rock, between the holes and the stone structure, and a few stairs on the way from the cave to the water (Figures 2 and 5).

The last time we visited the site was in March 2016. After the rains of autumn and winter, the water level of the reservoir was up and the cave was only 1m above the level of the water.

Figure 3. Site 2: the quarry, the human-made cave, the enclosure from the top cave and an overview of the site (Image composition: Dr. David Munuera-Navarro; Photos: Ángel M. Tobar-Escudero and David Fernández-Sánchez).

Site 2

During the 2015 survey, we discovered and recorded another accidental finding. The new site was discovered by kayak and had three elements: a cave, an old quarry and a big enclosure (Figure 3).

Cave 2 is carved in sandstone, has an access door with watershed and a triangular engraving outside the door. The interior of cave 2 is bigger than cave 1 and has numerous engravings: several crosses of different types and a niche possibly for offerings or lighting (Figure 5).

At the top of the cave, on its roof, there is a ventilation hole and various watersheds to prevent rainwater from coming down over the entrance to the cave and into the cave interior through the ventilation hole.

This second cave is connected to an old quarry and a big enclosure. The quarry has at least three areas where it is easy to see traces of the mining system used to extract blocks, make large quarry cuts and various blocks themselves. The quarry is probably prior to the cave and the enclosure.

The enclosure is a big dry-stone construction connected to numerous holes in the rock, maybe used to support a possible cover or porch. This structure is near the cave, and perhaps it was later built to keep animals (related to grazing).

Other sites and hermitages

When survey in the reservoir was completed, we conducted a survey on land to visit and record surrounding sites similar to the ones we are investigating (Figure 1).

Firstly, we visited the main archaeological sites: Recópolis, an exceptional site founded in the Visigothic period, located 30km from our research area; then, the Roman city of Ercávica only 10km away; and finally next to this, the Visigothic remains of Arcávica, the *Servitanum* Monastery and the oratory-crypt where the abbot *Donatus* was buried in at the sixth century AD. It is a cave carved in rock. Nowadays, it has a half-ruined door, two rooms, and several signs engraved on its inner and outer walls, with some crosses, one of them similar to those documented in Site 2.

Moreover, we located and documented nine of the 30 known sites around the *Servitanum* Monastery (Figure 1). All are human-made caves carved out of rock, but only one has a door with a watershed similar to Site 1. Some of them have carved Christian symbols and they may have been used as hermitages. Nowadays, these caves display a much-deteriorated state of preservation, clearly worse than new Sites, 1 and 2.

Further investigations

Since 2016 our research continues along three main lines: an archaeological inventory, a spatial study (geographical and hydrographic analysis) and historical and archaeological research.

Archaeological map of Castilla La Mancha

We requested information about both the sites, which we recorded in Buendía reservoir, from the Department of Culture of Castilla La Mancha to see if they had been previously registered and known before the construction of Buendía reservoir.

Both sites are located on the shore of a small terrestrial peninsula inside the reservoir, in an area that only has access from the town of Buendía (province of Cuenca). However, we found out that in the past this area belonged to the municipality of Santa María de Poyos, an abandoned village flooded with the waters of the Buendía reservoir since 1956 and integrated into the municipality of Sacedón (province of Guadalajara) in 1967.

For this reason, we consulted the Archaeological Map of Buendia (VVAA, 2013) and Sacedón (VVAA, 2014). Fortunately, both maps had been updated recently and included some underwater sites. However, to our surprise, the two underwater sites that we documented were unknown and not registered. So now we are handling their inclusion into the Archaeological Map Inventory as a cultural heritage site to grant them protection.

There are other underwater sites registered in Buendía reservoir or its banks. The most famous one is the Los Baños de La Isabela site, built in 1801 although cited since the 11th century for the quality of its medicinal waters. Contemporary construction remains submerged under Buendía reservoir and sometimes it emerges when the water level drops in time of drought. The rest of the sites in Sacedón are covered partially and occasionally by the reservoir waters: Cabeza Negra, a Paleolithic site, covered by the waters of the reservoir at times; La Isabela-Molino, a necropolis of the Iron Age and Roman times, half of which remains within the flood plain of the reservoir when the level rises; and the medieval necropolis of the Isabela, a site bathed by the waters of the reservoir. There are two sites in Buendía municipality, only occasionally submerged: Valzorita, an archaeological site from the Bronze Age, which may be flooded occasionally; and the El Puro necropolis, which is covered with water only when the reservoir reaches its maximum capacity level.

Even an island in the middle of the reservoir, The Castillejo, was registered on the Archaeological Map, although it was not possible to survey it at that time. It was included as it shows all the signs of the possible presence of archaeological elements, such as toponymy, orientation, location etc. For this reason, it was granted a basic prevention scope to guarantee its subsequent study and, if necessary, preservation.

At this point of analysis, we were surprised by the fact that the sites documented in our project were unknown, even though the archaeological map had been updated recently. In our opinion, two factors converged: firstly, its location on a peninsula accessible only from Buendía, although it is actually under the jurisdiction of Sacedón after having been transferred from Santa María de Poyos; and secondly, both sites were probably submerged when the terrestrial survey was conducted.

Spatial study

A spatial study was carried out, analysing aerial photo series, the reservoir storage level and the changes in territorial distribution due to reservoir construction. Two aerial photos series were analysed. The first, taken in 1946 and prior to reservoir construction, shows that Site 1 and Site 2 were on land away from the river. In the second aerial photo, taken in 2013, both sites were lying on the waterline. For this reason, they can be submerged, semi-submerged or dry depending on the water level of the reservoir.

We also made an analysis of the reservoir storage level in Buendía Reservoir, inaugurated in 1955 reaching 90% of its capacity in 1960 for the first time. The fluctuations in water level in Buendía Reservoir, starting in October 2013 and continuing until March 2017 (Figure 4), show the variations in flooding experienced by Site 1 during this period: Site 1 was underwater when discovered in October 2013, semi-submerged during our survey in June of 2015, totally dry in September of 2015 and close to being submerged again in March 2016.

The impact on preservation of the archaeological sites due to these changes in reservoir water level should be thoroughly analysed, especially regarding rock degradation, preservation of engravings and human impact when dry.

For the study of the changes in territorial distribution due to reservoir construction, we checked the maps of the Servicio Geográfico Nacional Sheet Nr. 562, from 1943, prior to the construction of the reservoir.

The main conclusion of this analysis is that the former municipality of Santa María de Poyos, where Site 1 and Site 2 were located, was placed in the jurisdiction of Sacedón, but access by land was only possible from

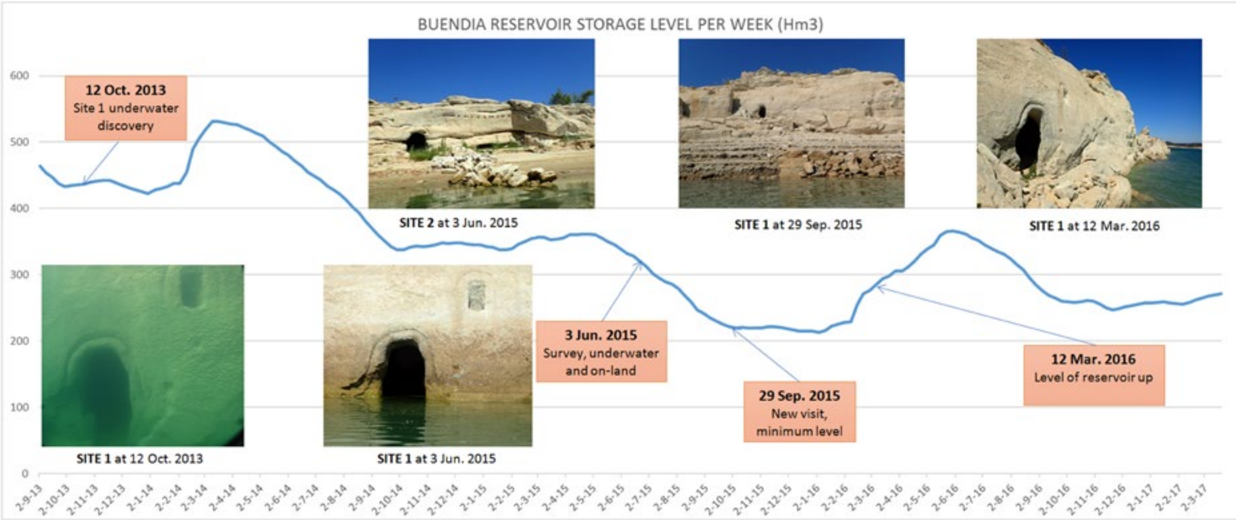

Figure 4. Different aspects of the sites depending on the storage level variation in the reservoir over time (Graphic and composition M. Elena Labrandero; Photos Ángel M. Tobar-Escudero and M. Elena Labrandero-Pulgar).

Buendía municipality. As mentioned before, this could be one of the reasons why these sites were not included in the Archaeological Map of Sacedón.

Historical and archaeological research

Historical and archaeological research are being carried out, with the aim of looking for typological identification and chronological assignment in order to reach a preliminary conclusion.

Firstly, at these two new sites, the following typological elements have been identified:

- **Human-made caves**: these kinds of structures, excavated in rocks, are located in isolated rural settings, although close to water resources (rivers, springs, streams, etc.) and communication routes, as the new two sites are. These human-made caves have had different uses over time. From pre-Roman times, they were used as housing, spiritual, religious and funerary structures. Later, these sites were reused with the same purpose or different ones: some hermitages became troglodyte churches, others continued as housing and many have been used as shepherd's shelters, small pens, stockyards, etc. They were modified throughout the years as uses changed and now it is very difficult to establish the exact age of the original buildings. They also do not usually exhibit archaeological remains, except some engravings, so they are additionally more difficult to date.
- **Enclosures and porches**: these dry-stone constructions are associated with wooden porches leaning on the rock and perhaps they were part of semi-rock constructions. They appeared often near the hermitages or small troglodyte churches, although they could be contemporary or later or both. Later, they were often used as enclosures or livestock pens.
- **Quarries** have been made use of from Roman, or even pre-Roman, times to contemporary times. The quarry at Site 2 may be Roman with possible connections to the Roman city of Ercavica or it could be from medieval or modern times. This issue will be researched in the future.

Secondly, in this paper, we are focusing our research on the analysis and search for parallels both of the hermit caves and of their engravings.

In the Iberian Peninsula, caves artificially excavated for housing are documented from Iberian and Celtiberian cultures. In Roman times, there were numerous tombs excavated in the rock and even a troglodyte city (*Tiermes*). With the fifth-century invasions, the population dispersed and took refuge in caves. In Late Antiquity, there was a proliferation and massive use of artificial caves by Christian monks, and even later some churches were still dug into the rock. From the medieval period the artificial caves were still used for housing, a traditional Spanish cultural practice that remained until the mid-twentieth century and which persists in some towns of Granada even today (González 2014: 24–25).

Nevertheless, despite the extended use of these artificial caves, it is necessary to underscore their relevance in Late Antiquity and the Early Middle Ages in the Iberian Peninsula. Between the 6th and 11th centuries, the rock phenomena proliferated a great deal. At that

Figure 5. Engravings at Site 1 and Site 2: figurative motifs (1a, 1c and 2a); general view (1c and 2b); simple crosses (1d and 2c); double cross (2d); and cross on a triangular foot (2e) (Image composition Dr David Munuera-Navarro; Photos Ángel M. Tobar-Escudero and David Fernández-Sánchez).

time, these rupestrian structures were used mainly as places of Christian worship or burial areas (López and Martínez 2014: 10).

As we explained earlier, in the area of our investigation around the *Servitanum* Monastery, there are nearly 30 human-made caves, including the two new sites that we discovered. Some of them have carved Christian symbols and they could have been used as hermitages. At this point, although these sites are commonly identified as hermitages from the Visigothic era, caution should be applied until the scientific investigations and doctoral theses in progress are published. In the meantime, no generalisations should be made and it is necessary to study carefully the scarce existing evidence such as the engravings.

When analysing the engravings documented in the new sites, we observed different motifs (figures, symbols and writing) carved probably at different times. Some of them are figures: on the door intrados of cave 1 there is at least one figurative engraving, very schematic and difficult to interpret, that might be an anthropomorphic figure (Figure 5.1a and 5.1b); and, outside of the door of cave 2, we recorded a triangular geometric representation engraved on the rock (Figure 5.2a). However, most of the documented engravings are crosses of at least three types:

- **Simple engraved crosses** made with two simple transverse lines, corresponding to a Simple Latin Cross and interpreted as marks or signs of Christ (Cruz 2014: 222 and 309, fig. 47 A-1). These types of crosses were employed at all times and places, as boundary markers, as testimony to the Christianization of pagan places or as simple marks of faith (Fernández y Lamalfa 2005: 259). We found these simple crosses outside of cave 1 under the line of boreholes (Figure 5.1b), inside cave 2 (Figure 5.2c) and in other nearby hermitages.
- **A double engraved cross** made with two double transverse lines, that is very similar to one found in Arcávica, outside the oratory-crypt that is dated to the 6th century (Barroso and Morín 1996: 174 and 193, fig. 3.A) and to those documented in the hermitage of Castejon. We recorded one of these double crosses inside cave 2 (Figure 5.2d).
- **A double cross on a triangular foot** corresponds to the triangular standing cross or Calvary silhouette cross interpreted as a symbol of the

Figure 6. The team at Site 1 during the 2015 campaign. Up: Dr. Rogelio de la Vega-Panizo. Down, from left to right: Rocío Castillo-Belinchón, Ángel M. Tobar-Escudero, M. Elena Labrandero-Pulgar and Dr David Munuera-Navarro (David Fernández-Sánchez).

Stations of the Cross (Cruz 2014: 223 and 309, fig. 47. B-2). This type is also denominated the Cross of Calvary or Cross of Golgotha and dates from the 17th to the 19th centuries (Fernández y Lamalfa 2005: 261), although there are references from the 16th century. It was documented outside Arcávica hermitage (Barroso and Morín 1996: 174 and 193, fig. 3.A) and at Canalejas hermitage. We recorded three examples of this type inside cave 2 (Figure 5.2e).

Conclusions

The Buendía project is research in progress, carried out by a multidisciplinary team (Figure 6), with more questions than answers, currently. At this stage of the research, based on the previous facts and as a preliminary conclusion, we consider that these remains will be difficult to date. The only clear evidence is the presence of Christian symbols, maybe as marks of faith. Some of them are similar to crosses documented at the Crypt of *Donatus* dated to the 6th century, but others are dated between the 17th and 19th centuries. However, the proximity of *Servitanum* Monastery, leads us to propose as a preliminary hypothesis the possibility that both caves could have been used as hermitages in Late Antiquity and the High Middle Ages, a period in which the hermit phenomenon greatly expanded in the Iberian Peninsula.

Finally, we would like to note that the National Museum of Underwater Archaeology of Spain has a great scientific interest in this project for various reasons. We have been allowed to document two possible hermitages found in inland waters. Not only is this a pioneering underwater research project in Castilla La Mancha, an interior region without sea but with several rivers and reservoirs, it is also a landmark in Spain, where few surveys have been done on reservoirs and even fewer corresponding to this historical period. In addition, it is an excellent example of how recreational divers and institutions can work together on protecting Underwater Cultural Heritage understood as the Heritage of Humankind, whose preservation is a task for everyone.

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Balancing Safety and Significance: The SS *Dicky* Shipwreck

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Abstract

How do you manage a popular and beloved shipwreck that has suffered progressive deterioration to the point that it is regarded as a public danger? This is the case of SS *Dicky*, a dilapidated iron shipwreck that grounded in the intertidal zone of Dicky Beach, Caloundra, Queensland, Australia, over 120 years ago. SS *Dicky* is the first intertidal historic shipwreck in Australia where modern health and safety issues as well as strong local sentimentality have been at the forefront of immediate and ongoing management.

In 2014, Sunshine Coast Council approached Cosmos Archaeology Pty Ltd to preserve heritage elements of SS *Dicky* while reducing safety risks. Cosmos Archaeology brought together a team of specialists to develop methods for the removal, conservation and interpretation of the shipwreck that led to the excavation and partial removal of the upper remains.

Keywords

Shipwreck, conservation, management, interpretation, Australia

Introduction

Long-term management of the SS *Dicky* wreck has been debated since the 1980s. Situated within the intertidal zone of a sandy surf beach, the remains were regarded as potentially hazardous to swimmers and beach-goers alike. The wreck of SS *Dicky* originally formed a large and formidable feature at Dicky Beach, Caloundra, however, the remains had been subject to alteration and deterioration that resulted in extensive loss of fabric. Despite this, the landmark value and tourist attraction of the SS *Dicky* wreck had not diminished. In 2013, Sunshine Coast Council (Council) approached Cosmos Archaeology to prepare management planning documentation for preserving heritage elements of SS *Dicky* while reducing safety risks. This paper details the planning stages undertaken to ensure that the SS *Dicky* shipwreck was managed at a high heritage standard before, during and subsequent to removal.

History of the vessel

SS *Dicky* was constructed in 1883 at the shipyards of the Howaldt Brothers in Kiel, Germany (Australian Register of British Shipping 1888). The 225 tonne, clinker built, iron-hulled vessel had two decks and measured approximately 30m (98ft) in length. Two inverted compound surface-condensing engines powered a single propeller. The vessel was registered and operated in Hong Kong from 1886 before being registered in Sydney in 1888 and then in Brisbane in 1889 (Australian Register of British Shipping 1889).

SS *Dicky* serviced the smaller outports of southern Queensland as part of the fleet of Brydon Jones and Co (Mann 1985: 9). It had a quite uneventful working life before Captain John Beattie took the vessel out to sea in February 1893 and encountered a storm considered the worst to lash the south Queensland coast in decades. While en-route from Fitzroy River to Brisbane, SS *Dicky* was driven ashore by the storm and grounded at Caloundra on the Sunshine Coast in Queensland. No lives were lost. Four attempts at re-floating the vessel failed and eventually, in February 1894, the vessel was run ashore and officially salvaged (Mann 1985: 27–28).

From the time of wrecking, remains of SS *Dicky* have been an attraction for both locals and tourists. The beach, later named Dicky Beach, is popular for surfing and swimming with the Surf Life Saving Club located just inland from the wreck. SS *Dicky* has been extensively photographed by beach-goers, capturing a timeline of its collapse and providing a rare opportunity to view the progressive deterioration of a shipwreck site over a century (Figure 1). Over the next 123 years, wave action, corrosion and scavenging would have a severe effect upon the wreck causing progressive alteration. Instead of a large imposing structure on the beach, it would be reduced to a few elements protruding from the seabed.

Collapse of the wreck

The earliest images after wrecking show the intact hull, albeit with holes appearing in various places. SS *Dicky* maintained its integrity into the 20th century with

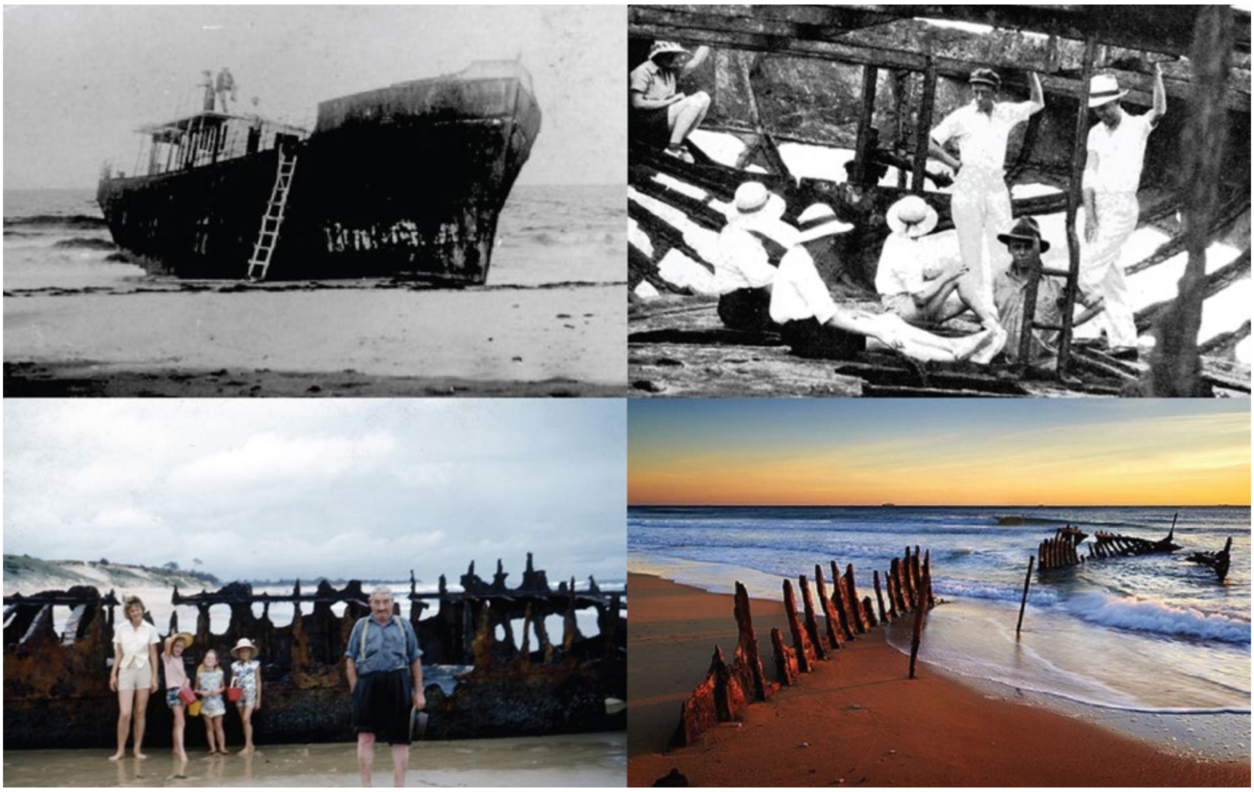

Figure 1. Photographs of SS *Dicky* from 1900, *c.* 1938, 1961 and 2012 showing its collapse over time (Anon *c.* 1938; Lean 1961; Voller 1900; Zajac 2012).

the most visible damage being the loss of hull plating at the bow (Cosmos Archaeology 2008: 19–20). While relatively complete, the wreck was used as a changing place for swimmers. Early photographs depict people standing on the remains, either on the edge of the hull or on the deckhouse.

SS *Dicky* experienced a significant change sometime in the early 1920s, possibly after a major storm, with the collapse of the deckhouse, forecastle and most of the hull-plating forward of mid-ships. The next collapse event occurred sometime in the mid-1930s when the main deck beams and bow crumpled into the lower deck (Cosmos Archaeology 2008: 21). The counter stern also fell away leaving the rudderpost standing proud of the wreckage. SS *Dicky* underwent its second-to-last major change before World War Two including the collapse of the stem post (Cosmos Archaeology 2008: 22).

In 1963, the propeller was removed and mounted on a specially erected stone cairn near the site. The North Caloundra Progress Association sponsored the removal and mounting and the plaque on the cairn was researched and paid for by the Queensland Women's Historical Association. During the late 1960s, a large section of the upper parts of the hull at midships were likely to have been deliberately removed, possibly to allow passage by 4WD vehicles along the intertidal area where the sand is more compact.

In 1985, the then Landsborough Shire Council approached the Harbours and Marine Department to remove the wreck due to complaints from beach users that it was becoming a hazard. The North Caloundra Surf Life Saving Club supported this, arguing that the wreck endangered young children who were jumping off the wreck into shallow waters or who could be swept into the wreck by strong waves. The local community opposed the removal of SS *Dicky* based on the site's uniqueness—it was believed to be the only known recreational beach in the world named after a wreck and where the wreck was still visible.

More recently, there has been increasing awareness of the heritage value of SS *Dicky* and its longevity as an attraction. In 2006, after conservation advice was sought from Dr Ian MacLeod of the Western Australian Museum, the wreck was purposefully exposed and given a fish oil treatment as a means of slowing down corrosion. It does not appear that the interior was uncovered down to the bilge.

2007 management plan

Council has again been negotiating strong conflicting concerns from the community regarding management of the SS *Dicky* wreck. Key aspects included the potentially hazardous nature of the wreck verses its landmark value and tourist attraction, as well as the cultural heritage significance of the wreck itself. In 2007, Council (then Caloundra City Council) approached Cosmos Coroneos, Director of Cosmos Archaeology, to produce a management plan for the wreck.

A number of heritage guidelines were utilised in the preparation of a management plan to ensure that management of SS *Dicky* met the best standard of practice. This included *The Burra Charter: Australia ICOMOS Charter for Places of Cultural Significance* (Burra Charter) (ICOMOS, 1999), the UNESCO *Convention on the Protection of the Underwater Cultural Heritage* (UNESCO, 2001), the *Guidelines for the Management of Australia's Shipwrecks* (Australasian Institute for Maritime Archaeology and Australian Cultural Development Office, 1994), and additional requirements from the Queensland Department of Environment and Heritage Protection (DEHP) (then the Environmental Protection Agency).

The key principles of these documents, with relevance to SS *Dicky*, include that the cultural significance of a place—as embodied in its physical fabric, settings, contents, use, associated documents and its meaning to people through their use and associations with the place—should be preserved. Conservation should involve a cautious approach of changing as much as necessary but as little as possible with respect to the existing fabric, use, associations and meanings. Also, preservation *in situ* should be considered as the first option before engaging in activities directed at this heritage place, and activities must use non-destructive techniques and methods in preference to recovery.

The *Guideline for the Management of Australia's Shipwrecks* details specific issues regarding shipwreck management (Australasian Institute for Maritime Archaeology and Australian Cultural Development Office 1994). It states that all activity that does cause disturbance to a shipwreck site should be guided by a management plan containing a detailed assessment of the significance of the shipwreck and that management should focus on conserving its cultural significance. Strategies to control environmental and human impacts are suggested to include site stabilisation, rescue archaeology, relocation and recovery of part or all of the remains.

Cosmos Archaeology's (2008) management plan assessed the significance of SS *Dicky* based on the concepts of cultural significance as defined in the Burra Charter. It determined that the wreck had, at that time, moderate aesthetic significance as a shipwreck archetype. Its context in a picturesque beach provided contrasts and tensions between culture and nature that had drawn photographers since its wrecking. It has also been a prominent part of Caloundra society. Having been present since before the town was settled, many have fond memories of playing in the wreck as children and interacting with it in their leisure time, lending to its high social significance. The accessibility, context and easy identification of SS *Dicky* also turned it into a static, self-interpreted display about shipwrecks and the story of collapse as a robust cultural feature slowly giving way to nature (Figure 2). The management plan found that the significance of the SS *Dicky* lies in its excellent ability to convey the story and meaning of shipwreck through its present form and context. It is a much loved and perhaps even revered cultural landmark of the Sunshine Coast. (Cosmos Archaeology 2008: 80)

From an archaeological perspective, the remains of SS *Dicky* could be considered very rare in an Australian context as one of only two known German-built iron-hulled steamers from the 1880s wrecked in Australia. The highest archaeological potential of the wreck was determined to be the lower areas, specifically the bilge and any deposits it may contain, which have experienced less exposure and degradation compared to the upper remains that afford SS *Dicky* moderate archaeological significance. The continual and incidentally well-documented collapse of the wreck also lends to its moderate scientific significance as an example of the diachronic formation of iron wreck sites. There are also no ship lines or models for SS *Dicky* so the remains were considered of moderate technical significance as a potential source of information about the original form of the ship. Its moderate historical significance is derived from the events of its wrecking, in one of southern Queensland's best remembered storms and floods, as well as the involvement of the Premier of Queensland in the unveiling of the mounted propeller in 1963.

The management options provided to Council in the management plan included the ongoing application of fish oil, cathodic protection and a physical support for the leaning rudderpost in order to prolong the shape and form of the wreck. Interpretation options were also suggested. Relocation was considered undesirable, as the gains of salvaging the material would cause immense loss of cultural significance. Instead, Cosmos Archaeology assessed that it would be better for the remains to decay slowly in their present location (Cosmos Archaeology 2008: 82).

Unfortunately, slow decay was not to be a reality. An inspection report by the Queensland Heritage Branch in 2013 determined that SS *Dicky* had suffered advanced degradation since Cyclone Oswald in January that year, dramatically effecting the wreck's appearance and heightening safety concerns. The increased rate of degradation was a catalyst for Council to take further action.

Figure 2. SS *Dicky* in the early morning, taken during site inspection (Cosmos Archaeology 2008).

A new proposal

In 2014, Council approached Cosmos Archaeology with the proposal to preserve key heritage elements of the SS *Dicky* wreck as well as reduce safety risks by removing hazardous elements. In order to undertake these works, Council applied for a permit from the DEHP under Section 91 of the Queensland Heritage Act 1992 to disturb the site. The permit was awarded conditionally, in part, on acceptable archaeological mitigation strategies being implemented before, during and after interfering with the wreck. DEHP required a Heritage Impact Assessment (HIA), Conservation Management Plan (CMP) and an initial Wreck Interpretation Plan (WIP). These documents assessed the proposed impacts and planned the ongoing mitigation measures to minimise these impacts. An archaeological test excavation was first required to assess the condition and structural integrity of the wreck in order to determine appropriate excavation and relocation options.

April 2014 test excavation

The objective of the April 2014 test excavation was to expose a small area down to the keelson to determine the construction and integrity of buried and previously unrecorded elements. Despite being below the waterline, excavation managed to uncover and identify two parallel floor plates extending in a continuous line from the starboard to the centreline keelson. The floor plates appeared to abut the keelson indicating that the keelson was, arguably, a centre-through-plate type i.e. a continuous longitudinal member. One of the floor plates appeared to have broken at its juncture with the keel, indicating a high probability of other points of damage and/or weakness throughout the vessel. It was also likely that the wreck rests or has sunk into a hard substrate of stiff clay, creating a suction bond to the hull (Cosmos Archaeology 2014: 27, 33).

Remains of timber ceiling planking were also identified. The interior of the bilge on the starboard side of the wreck had been exposed to wave action and it was unlikely that any bilge deposits remained intact in the starboard midships area of the wreck. Observations indicated that the wreck was heeling over approximately 12 degrees to the port side meaning that there was a higher potential for more deeply buried ceiling planking to survive on the port side, thus sealing and protecting under floor bilge deposits (Cosmos Archaeology 2014: 27–28).

The remains of SS *Dicky* also demonstrate basic principles in iron wreck site formation processes (Ward *et al.* 1999). Ongoing corrosion had resulted in the weakening of the remaining structural integrity of the wreck. Differing rates of corrosion could be easily discerned, with rates depending on the 'thickness' of elements and their location on the wreck. Those areas towards the stern, at the seaward end, were unable

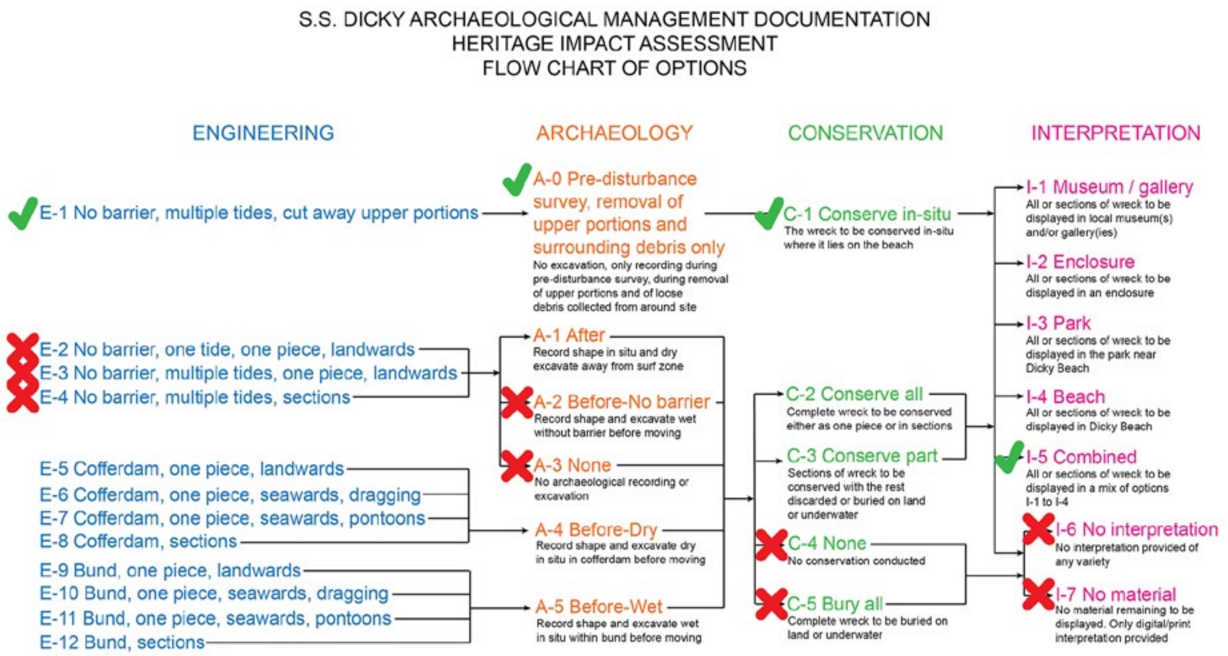

Figure 3. Flow chart of options presented in the HIA report (Cosmos Archaeology 2015a: 68).

to develop protective corrosion product due to their larger exposure to mechanical wave damage and were, therefore, corroding at a faster rate. Despite this, the rudderpost was the thickest and most durable element and thus far had remained the most prominent aspect of the wreck. The lower elements of the wreck had constant or sporadic protection of sand cover and were in relatively better condition (Cosmos Archaeology 2014).

The test excavation provided a realistic idea of the integrity of the SS *Dicky* remains. It also demonstrated the physical and logistical challenge of excavating a wreck site in the intertidal zone of a dynamic beach. It became apparent that accessing the entire wreck, let alone lifting it as one piece and in one tide, was impossible. The question now was to work out what could be done to preserve key heritage elements and reduce the safety risk.

Heritage impact assessment

Cosmos Archaeology prepared a HIA report to identify a wide variety of options that could both fulfil the Council's requirements and protect the heritage significance of the site (Cosmos Archaeology 2015a). The process was broken into four elements:

1. Engineering: the physical removal and relocation of all or sections of the wreck;
2. Archaeology: the examination and recording of the remains;
3. Conservation: preserving any recovered remains; and,
4. Interpretation: the display and interpretation of SS *Dicky*.

Each of these elements had a number of possible options and a number of viable combinations connecting the options, as summarised in the flow chart (Figure 3). The combinations ranged from 'do nothing' to an extensive excavation within a cofferdam. An assessment was made of each option including the requirements, risks, heritage impact and acceptability of each from a heritage perspective (Cosmos Archaeology 2015a).

Specialists were engaged by Cosmos Archaeology in order to present these options and assess their viability. Geoff Hewitt (Principle, Geoff Hewitt Archaeologist) assisted with the Engineering options; Vicki Richards (Research Officer, Department of Materials Conservation, Western Australian Museum, Shipwreck Galleries) and Jon Carpenter (Conservator, Western Australian Museum, Shipwreck Galleries) assisted with the conservation options; and Peter Tonkin (3-D Projects) with the Interpretation aspect.

The options were presented to Council who selected a combination referred to as the 'Cut and No Cover' approach. This approach entailed removal of the upper portions of the wreck for conservation, storage and an outdoor display while the majority of the wreck remained buried *in situ* beneath natural beach sand deposits. The option also included the provision for ongoing removal of loose wreckage as it becomes exposed in the future (Cosmos Archaeology 2015a).

Measures were presented to mitigate impacts to the SS *Dicky* wreck including archaeological, conservational and interpretive mitigation. Archaeological recording would be undertaken before, during and after removal with the establishment of management protocols if the remains become exposed after storm events. Conservation was to include the treatment of recovered objects for the outdoor display and an assessment of the *in situ* remains to determine if any additional measures would be required. Initial interpretation would focus on the installation of an outdoor display in a nearby park overlooking the site to provide an above ground representation of the wreck. There was also the potential for *in situ* wreck remains to become intermittently exposed, thus, maintaining its presence at Dicky Beach.

The proposed works were assessed to have a substantial impact to the moderate aesthetic significance of the SS *Dicky* wreck, however, natural processes would have caused continued corrosion and mechanical damage until the wreck was reduced to sand level. In effect, removal was an acceleration of this process whilst retaining material for interpretation (Cosmos Archaeology 2015a: 90). The moderate archaeological and technical significance of SS *Dicky* would be impacted in a minor way by the removal and recovery of structural elements. This would be minimised by recording all objects and the conservation of select items, while also enhancing the moderate scientific significance of the wreck by increasing our understanding of iron wreck deterioration processes (MacLeod 1989). The outdoor interpretive display for SS *Dicky* would enhance the moderate historical, high interpretive and high social values of the wreck by providing extensive information and a physical representation of SS *Dicky* (Cosmos Archaeology 2015a: 90).

A full recording methodology, excavation methodology and details for the management of the wreck before, during and after removal of the upper portions were provided in a detailed CMP (Cosmos Archaeology 2015b). Before completing the CMP, a number of crucial questions arose in the process of preparing the methodology that required a second test excavation.

April 2015 test excavation

The April 2015 test excavation's key objectives were testing cutting equipment above and below water and exposing the port side at midships to observe what remained of the hull and framing. A thermal lance was successfully tested on a frame that was exposed beneath the water level. It took approximately 20 minutes to cut through a single frame and was proved to be an inefficient means of cutting, likely due to the amount of concretion and corrosion leaving minimal pure steel to slice through. A circular saw was tested against remains exposed above sand level and took approximately six minutes to cut through a frame almost three times the size. The excavation also revealed that the hull on the port side was significantly buried, below that of the bow remains, and there was little chance of it becoming an exposed hazard (Cosmos Archaeology 2015c).

The results of the April 2015 test excavation provided useful insights into the actual extent of buried hull remains of the SS *Dicky* wreck and guided the ideal location for cutting. On the starboard side, the only upright sections were the exposed hull towards the stern. Fortunately, there was part of a side keelson on this section of hull that was only intermittently exposed above sand level. Cutting the hull above this side keelson would provide a stable horizontal surface. As determined by the April 2015 test excavation, there were no upright remains of the port side hull at midships, with the bow remains already presenting as a horizontal surface. The only unknown at that stage was the port side hull towards the stern.

As the most conspicuous feature of the wreck, the stern assembly was not considered much of a safety risk, however, this feature was assessed to be facing imminent collapse that could tear and de-stabilise the entire stern area and open up the interior of the wreck to damaging mechanical forces. Thus, it was preferred to remove the stern assembly in a controlled manner as part of the works. A similar approach was to be taken with the exposed stanchion. Its structural stability would be examined as part of the excavation and it would be cut away if assessed to be in imminent collapse. With the cutting locations now planned, the CMP could be completed.

Conservation management plan and undertaking the removal

The methodology for the removal of the upper portions were divided into four stages including: 1) Pre-Main Works; 2) Main Works; 3) Post-Main Works; and, 4) Ongoing Site Management (Cosmos Archaeology 2015b). Once the CMP was completed, all the planning documentation was submitted to DEHP to obtain a permit for excavation. The stages of the CMP are detailed below as they were undertaken (Cosmos Archaeology 2015d).

Pre-Main Works

Pre-Main Works involved photographing exposed features of the wreck prior to disturbance as well as a metal detector survey to delineate the buried wreck remains and identify any other potential buried

Figure 4. Photographs showing the cutting, removal and recording of SS *Dicky* during the Main Works (Cosmos Archaeology 2015d).

wreckage nearby (Cosmos Archaeology 2015d). The exposed elements of the wreck had already been recorded by DGPS survey in the 2014 test excavation to create an accurate site plan.

Main Works

The next stage was the big event: the excavation, cutting and removal of the pieces over two days. All the pieces were carefully transported to the Council depot for storage and further recording (Cosmos Archaeology 2015d). Once the features had been cut and removed, the *in situ* remains were recorded using photography and DGPS (Cosmos Archaeology 2015c). Prior to start of works, a crowd of locals began to grow with many people taking their last photographs of the SS *Dicky* remains. This crowd developed throughout the first day and the excavation process also attracted media attention.

Works on the first day concentrated on the starboard and stern areas of the wreck that had been previously recorded extensively and were the largest sections to be cut. As intended, the exposed starboard hull was removed down to the side keelson and the stern assembly was removed down to the narrow section above the floors (Figure 4). The works proceeded smoothly and to plan, working from the bow end of the wreck towards the stern end as the tide receded, and then finishing works just after the tide turned (Cosmos Archaeology 2015d).

The second day focussed on the bow and port side of the wreck. An area around the stanchion was excavated to assess its integrity but, unfortunately, the stanchion was clearly unstable and had to be cut away (Cosmos Archaeology 2015d). The majority of the port side remained below water level and there was no evidence of upright sections requiring removal (see Figure 5). However, the two days of excavation did uncover loose pieces of the wreck nearby and these were tagged and collected for further recording (Cosmos Archaeology 2015d).

Post-Main Works

Following up the Main Works was additional recording, an assessment and implementation of conservation measures as well as the development of the wreck interpretation. While an interim WIP was supplied to Council and DEHP by Cosmos Archaeology with the other planning paperwork, all interpretive aspects of

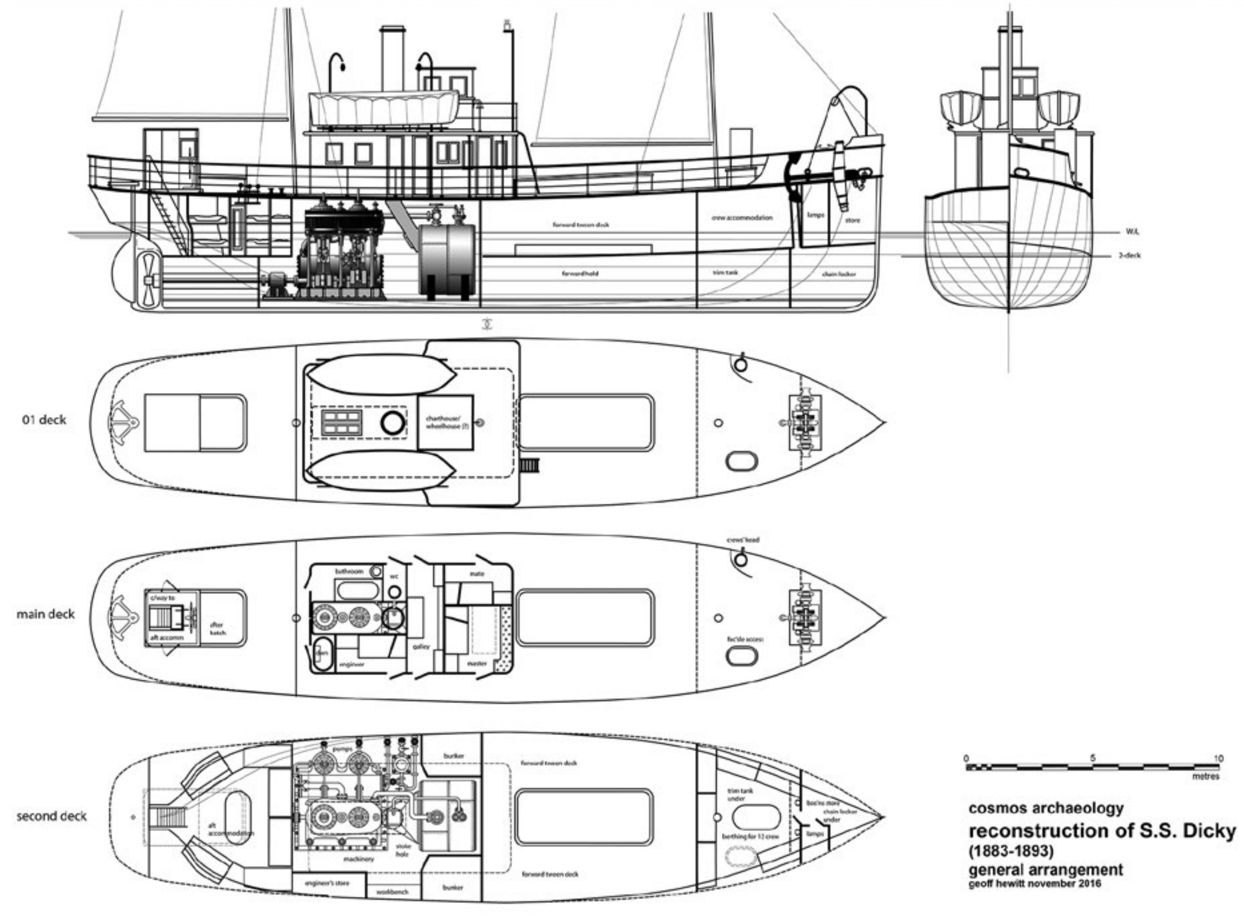

Figure 5. Internal arrangement of SS *Dicky* (Cosmos Archaeology 2016).

this project have been taken up by Council and will be discussed separately below.

All the items removed from the site were individually photographed and recorded, as were other pieces that Council had previously collected during the 2005 fish oil treatment. This collection of material includes three large pieces of hull, two stanchions, part of the rudder and numerous pieces of frames. The hull pieces also have evidence of stringers, deck knees, deck frames and even some timber caulking used between the stringer and the hull plating. A selection of the material was noted for continued storage at the Council depot while the rest could be discarded, however, at the time of writing, it appears that Council have yet to dispose of any material (Cosmos Archaeology 2015d).

Recording of the material collection has added to knowledge of how SS *Dicky* was constructed. For example, the frames are formed of two angle irons riveted back-to-back to form a straightened 'Z' shape, with frames spaced approximately 540mm apart. An additional angle iron was attached to the lower portions of the frames to secure bulkheads to the hull plating (Cosmos Archaeology 2015d: 40–41; Reed 1869: 222–23). The transitions between frames with and without the additional angle iron were perfectly captured in the cross sections formed by the cuts of the circular saw. The side keelson is a 'T' shape, originally thought to be back-to-back angle irons but a clean cross section by the saw revealed it to be made of one continuous piece. Hull plating is in the form of alternating raised and sunken strakes with the gap between raised strakes and the frame filled by an additional flat 'liner' piece. The strakes were of a length to stretch across five frames. Butt straps were also present, including the rectangular butt straps for the raised strakes and longer butt straps with trapezoidal ends for the sunken strakes (Cosmos Archaeology 2015d: 42, 50–53; Reed 1869: 183, 191, 207).

Jon Carpenter inspected the wreck remains stored from 2005, as well as the propeller removed in 1963 for mounting in the nearby park. Carpenter assessed the condition of the remains stored outside compared to those stored inside and found that the former were in surprisingly good condition (Carpenter and Richards 2015: 11). Natural rainfall had performed a washing action that had evidently removed salts in the metal

Figure 6. 3D digital animation of SS *Dicky* based on the ship lines (Cosmos Archaeology 2017).

for these pieces to retain better integrity than the flaking pieces stored inside. Carpenter's advice was to store the recently removed artefacts in the same manner. Carpenter also provided advice on the method of conservation for pieces that were to be used in the interpretive park display, however, no pieces have yet been selected for incorporation (Carpenter and Richards 2015). Unfortunately, the fibreglass coating on the propeller prohibited an effective assessment.

Ongoing site management

A number of procedures have been put in place to manage the *in situ* remains of the SS *Dicky* wreck as well as the material stored in the Council depot. Part of these is monitoring of the material collection in the Council depot as well as the *in situ* remains. The procedures include initial recording methods and the details of persons to contact if elements become exposed. It also guides the assessments to undertake if the exposed elements pose an ongoing risk to public safety and need to be removed.

If further wreck material is required to be removed, there are two procedures in place depending on whether the material to be removed is loose or attached to the wreck. The recording method for loose material is basic, however, the procedure for cutting fixed material mirrors that detailed in the CMP for the Main Works and must be undertaken by an archaeologist with approvals from DEHP. Thus far, only one instance of exposure has occurred and this lasted no longer than one day before being naturally reburied by sand.

Interpretation

Another major part of ongoing work is interpretation. From the initial pre-disturbance photographs, Kevin Edwards (Tempus Archaeology) has produced some initial models of the wreck. Cosmos Archaeology has also been working again with Geoff Hewitt to recreate the ship lines and plans of SS *Dicky*. This began with a rigorous search of resources within Australia and Germany to locate any original plans and, failing that, plans of similar vessels (Cosmos Archaeology 2016). Fortunately, there are many historic photographs of the wreck in various stages of collapse and these provided excellent insights into the vessel's construction and details. Hewitt also reproduced the internal arrangement of SS *Dicky*. Edwards then turned these plans into a 3D digital animation (Figure 6).

Council have released draft concept design plans for the park display as part of the Dicky Beach Precinct Plan (Sunshine Coast Council 2016). At the time of writing, these were currently open for community feedback via the Council website. Council's designers have attempted to replicate the physical size and presence of SS *Dicky* in an interpretive boardwalk that frames the view to the wreck site. The boardwalk includes rusty steel frame elements mimicking the frames and deck beams of a ship, with interpretive signage displayed on angular projections replicating barnacles. These features are also replicated throughout the rest of the park, forming bus stops and interpretive panels. Council is also planning to integrate a smart phone application to visualise an outline of the former wreck with 3D animation from a key spot on the boardwalk. Council has shown a high regard for conserving local heritage and have gone above and beyond to maintain the presence of SS *Dicky* at Dicky Beach and in the local area.

Conclusion

The management of the SS *Dicky* shipwreck has been an exercise in balancing concerns for public safety with cultural heritage significance. It was the objective of Council, DEHP and Cosmos Archaeology to undertake extensive planning, assessment and mitigation to effectively preserve, or even enhance, the heritage significance of the wreck as much as could be achieved while reducing safety risks. The key outcomes of this project are that SS *Dicky* is still largely on site, buried *in situ*, and will become intermittently exposed to maintain a presence in the beach. While all the visible and iconic elements of the wreck have been removed, their aesthetic, interpretive and social significance will be maintained by physical and digital interpretation. Nevertheless, the removed pieces have been recorded and conserved. There are also procedures in place that will protect the *in situ* remains into the future. For 123 years, SS *Dicky* had been a prominent landmark at the beach at Caloundra and in the identity of the local community. Thanks to the extensive work, enthusiasm and dedication of Council, SS *Dicky* will maintain its presence in the landscape of Caloundra.

Acknowledgements

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Impacts and Issues of the Commercial Exploitation of the ˚land ‘Champagne Schooner’

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Abstract

This paper concerns the issue of the commercial exploitation of underwater cultural heritage (UCH) which professional archaeologists have long regarded as incompatible with the objectives and purpose of maritime archaeology. The particular point in question here relates to the kind of cultural heritage which will ‘go bad’ as time passes.

The case described is that of the ‘*Champagne Schooner*’ of the Åland Islands which are a politically neutral and entirely demilitarised region of Finland, consisting of an archipelago at the entrance to the Gulf of Bothnia. The region is almost entirely autonomous from Finland.

The world’s oldest champagne was found at a shipwreck site in 2010 and the legality of subsequent actions of the regional government and authorities are examined following an extensive complaint filed by the author to the Finnish Chancellor of Justice in April 2012.

The salvage and recording of the cargo (168 bottles of champagne and five bottles of beer) is described, as is the subsequent testing of the champagne and its partial commercial disposal by auction (ostensibly for charitable purposes). Finally, the current management system for cargo is described.

Keywords

‘*Champagne Schooner*’, Åland Islands, Finland, salvage, bottles, auction, champagne, beer, Veuve Clicquot, cultural heritage

Introduction[1]

Professional archaeologists have long regarded commercial exploitation of underwater cultural heritage (UCH) as incompatible with the objectives and purpose of maritime archaeology. Many legal battles have been fought against and between governments, companies and private individuals engaged in salvage operations and commercial exploitation of UCH.[2] But what happens when a regional government starts auctioning cultural objects—in this case the world’s oldest champagne—that are supposed to be protected by law? How should we manage this kind of cultural heritage that will ‘go bad’ as time passes?

The ‘Champagne Schooner’ of the Åland Islands is a perfect example of the professional ethics of maritime archaeology colliding with the commercialisation of UCH. Maritime archaeology can be defined as the scientific study of the material remains of humans and their activities relating to the sea. Is the commercialisation of this heritage ever justified, or should we always (or just) focus on the people and era behind the shipwreck, and what the site and objects on board can reveal? Are these aspects forever incompatible with each other, or are we able to respect both stances at the same time? Is a ‘middle way’ desirable and acceptable? Who should have the ultimate responsibility to decide—political authorities, international organisations, the general public, all these together, or someone else?

This case also raised other questions more specific to the Finnish context. For example, how was it possible that the regional authorities were able to engage in an operation that was not in accordance with local laws, international conventions, and good codes of practice or professional museum ethics? Furthermore, what are acceptable grounds for making and justifying these kinds of decisions, and how far can the definition of charity be stretched?

The Åland Islands are a politically neutral and entirely demilitarised region of Finland, consisting of an archipelago at the entrance to the Gulf of Bothnia. The region is almost entirely autonomous from Finland. The Åland Islands have their own regional government,

[1] LL.M. (University of Helsinki), Advanced European Scientific Diver (AESD), commercial and technical diver. This article is based on personal research done between 2012 and 2014 for the complaint filed to the Finnish Chancellor of Justice, 24 April 2012. The author would like to thank all who assisted and gave their expertise and time during the complaint process. The views expressed in this article, as any errors or omissions, are those of the author.

[2] Notable recent examples include the cases concerning HMS Victory and the Nuestra Señora de las Mercedes. Furthermore, in 2014, two UK-based divers were for example ordered to pay £60,000 after they had scavenged artefacts from shipwrecks, including cannons and propellors. In 2015, another UK-based diver was jailed for fraud after providing false information to the Receiver of Wreck.

ministers and parliament—separate from Finland. The region is entirely monolingual Swedish-speaking with a population of 29,000 inhabitants. The region is governed according to the Act on the Autonomy of Åland and international treaties, which must be independently accepted by the regional parliament.[3] Finland and the Åland Islands are not party to the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage. However, the region has very strict laws and regulations on the protection of heritage, including underwater heritage. According to the Act on the Autonomy of Åland, the Åland Islands have legislative powers over prehistoric relics and the protection of buildings and artefacts with cultural and historical value. As defined by the regional law to protect UCH,[4] underwater cultural heritage includes all underwater cultural material and shipwrecks that have been underwater for over one hundred years. A permit is required for all kinds of diving, and all dives must be individually reported to the regional authorities.

When the world's oldest champagne was found at a shipwreck site in 2010, the story spread like wildfire to different media agencies across the globe. This was no accident; for a small self-governed region of islands in the Baltic Sea, it became an opportunity to put their mark on the map and attract tourists and international media.

The legality of the actions of the regional government and authorities was subjected to judicial review following an extensive complaint filed by the author to the Finnish Chancellor of Justice in April 2012.[5] According to the complaint, the auctions and related actions of the regional government of Åland since summer 2010 violated the province's own laws and fundamental principles of good administration. The complaint outlined that the officials' decision to auction the champagne bottles resulted in explicit destruction of cultural heritage, as the bottles had been treated as consumer goods to be sold. The officials also acted without due consideration for the discovery, failing to ascertain the exact number of bottles, for example. This led to incomplete archaeological documentation and a hasty retrieval, which unnecessarily compromised the integrity of the site and the salvaged items. The complaint also invited the Chancellor of Justice to examine whether, through the auction of the bottles, the regional authorities had also violated the laws on the export of cultural goods. Further, the complaint questioned the regional authorities' promise to donate the proceeds of the champagne auctions to charity, as no surplus was ever made and tax revenues covered the costs. Before the complaint, the actions of the regional authorities had also been questioned in an open letter from the International Committee on the Underwater Cultural Heritage (ICUCH), as well as in a letter from the Baltic Sea Region Working Group on Underwater Cultural Heritage[6]—to no avail.

The discovery of the world's oldest champagne—and what happened next

In 2003, while conducting a multi-beam survey around the Åland Islands, the Finnish Maritime Administration (FMA) discovered an anomaly that could be a shipwreck. A few years later, in 2007, the local marine historical society, *Ålands Marinhistoriska Sällskap* (ÅMS), obtained a list of coordinates from the FMA. In 2009 ÅMS was planning to explore some of the new sites with Christian Ekström, a local diver and dive operator, but the plan never materialised (Näsman 2010a; Rosenqvist 2010).

During the summer of 2010, a group of Swedish divers led by Anders Näsman were diving around the Åland Islands. Their aim was to dive, find and document new wreck sites, and Näsman had been provided with a list of targets by Ekström. Among these coordinates was the location of what would come to be known as the 'Champagne Schooner'. On 13 July, Näsman's crew made the first dive at one of the sites on their list and discovered a wreck full of cargo, including a large number of visible bottles. Näsman informed Ekström who soon arrived at the site. After his arrival, Ekström called to report the find to the local maritime archaeologist, Marcus Lindholm. Lindholm, who was abroad at that time, was not available to attend the site but, as a first step, gave Ekström permission to remove one bottle for further research (Landskapsregering 2010a). After the permission was given, Näsman's team dived at the site with Ekström and lifted one bottle. To their surprise, the cork slid open and the team decided to taste the contents.[7] It was very sweet and, judging

[3] The current Act on the Autonomy of Åland (1991/1144) entered into force on 1 January 1993. An unofficial English translation is available online, at <https://www.finlex.fi/en/laki/kaannokset/1991/en19911144.pdf3>. A complete collection of regional laws is available online in Swedish, at <www.regeringen.ax/alandsk-lagstiftning/alands-lagsamling>. References to all online sources are accurate as of 30 April 2020.

[4] See further in Swedish, landskapslag (2007: 19) om skydd av det maritima kulturarvet, available online at ibid.

[5] See further (in Finnish and Swedish) the decision OKV/613/1/2012, 26 March 2014, available online at <www.okv.fi>. The Chancellor of Justice of the Government, along with the Parliamentary Ombudsman, is the supreme guardian of the law in Finland. The duties of the Chancellor of Justice are carried out by the Chancellor of Justice as well as the Deputy Chancellor of Justice who endeavour to ensure that the courts of law, other authorities and other persons or bodies assigned to perform public tasks comply with the law and fulfil their assigned obligations. For further information, see online <www.okv.fi/en>.

[6] The Åland Islands are also a party to the Working Group, which has adopted a Code of Good Practice for the management of the Underwater Cultural Heritage in the Baltic Sea Region (COPUCH), available online at available on file from the author.

[7] According to the regional government, the cork slid open on the boat deck, roughly 30 minutes after it had been brought up (Landskapregering 2012b, p. 6). According to Näsman the cork slid

from the bottle, probably champagne. And moreover, it was drinkable!

A couple of days later, the local newspaper *Ålandstidningen* (Granlund 2010) and the Swedish *Aftonbladet* (Stenquist 2010) broke the news about the find. According to Näsman (Näsman 2010a), the leak to the press happened unintentionally when a local journalist interviewed his crew. The news spread rapidly across the world to the ABC, CNN and the *Independent*, among many others. Ekström became the local face for the find and was quoted as the finder of the world's oldest champagne. Shortly after the news broke, ÅMS claimed (Rosenqvist 2010) that they had provided the coordinates to Ekström, while Ekström insisted that he had received them from a local fisherman.

Three days after the find was made public, the first diving restrictions were introduced. One week after the find, on 21 July, Ekström was commissioned by the regional government to conduct more dives and further research at the site, to determine how many bottles there were, and how to proceed. On 22 July it was confirmed that the lifted bottle contained champagne and was from a defunct champagne house called Juglar. The case was elevated to the Ålandic Minister of Education and Culture.

In late July, ÅMS informed the authorities that they had laid dive restrictions on the wrong place, and new restrictions were laid (Landskapsregering 2010a, 2010b). Meanwhile, despite the local regulations, an unknown number of dives had been conducted at the site. A local diver, who had visited the site after the first finding, observed that it looked like someone had been removing bottles and other objects from the site, since it had been open to everyone for two weeks due to the misplaced restrictions.[8] Ekström and Näsman made similar observations and reported them to the regional government.

On 30 July, a preliminary study and a plan for the salvage were presented to the authorities by Ekström, together with Näsman (Näsman 2010c). According to them, the salvage needed to be undertaken immediately, and would be very complicated. They estimated that there were approximately 70 bottles of champagne at the wreck site. After presenting the salvage plan with Ekström, Näsman handed in his tender for the salvage.

When the find had become public in July, Swedish champagne expert Richard Juhlin estimated (Granlund 2010; Stenquist 2010) that the street value of one bottle would be around €50,000. After the media coverage, the regional government made a quick decision to salvage the bottles and commercialise the find. Marcus Lindholm, the regional maritime archaeologist, opposed the commercial nature of the project and due to the lack of documentation in the project planning, he was quickly excluded from the decision-making process. From then on, the Minister of Education and Culture, Johan Ehn, made decisions, while the Permanent Secretary Rainer Juslin was preparing the matters for decision. On 17 August a decision to salvage the bottles was made based on the threats expressed in the preliminary study.

Pursuant to the *Act on the Autonomy of Åland*, the regional government must obtain an opinion from the Finnish National Board of Antiquities (NBA) before undertaking measures regarding non-movable relics, which includes all shipwrecks that have been sunk over one hundred years. On 18 August the regional government asked for the opinion of the NBA (Landskapsregering 2010c); the opinion was given on 25 August (NBA 2010a), and received by the by the regional government on 30 August. As their opinion, the NBA expressed that it had nothing against the planned salvage operation if the operation followed archaeological principles for documentation and that the salvaged items were handled as museum objects (NBA 2010a). In their response dated 2 November 2011 to the Chancellor of Justice, the regional government stated (Landskapsregering 2010b) that it had thanked the NBA for their 'valuable views' but the opinion did not give rise to any concrete actions.

The salvage

The salvage was planned entirely on the report made by Ekström and Näsman. The public procurement procedure was skipped completely and no further tenders were invited (Landskapsregering 2010e). The contract between the regional government and Näsman was made as a direct purchase and signed on Monday 23 August, and the salvage work began. The first lift was made on Thursday 26 August. The regional government claimed that the salvage had to be immediate, as the media coverage and price estimates provoked a danger of looting. Ironically, Näsman and his divers, who were hired for the salvage; had caused the media coverage and, the price estimates were made by Richard Juhlin, also hired by the regional government to assist in the project. The salvage started before the opinion of the NBA had even been received.

During the salvage, all efforts were taken to save the liquid in the bottles while archaeological documentation received little, if any, attention. The regional government claimed that together with its own employees, it had consulted outside experts. These experts involved in the project were: François Heutekeur (winemaker from

open when Ekström let go of the cork (Näsman 2010a).

[8] The original post has been made private and is no longer available online. Available on file in Swedish from the author.

Veuve Clicquot); Dominique Demarville (cellar master from Veuve Clicquot); Richard Juhlin (champagne expert); Anders Näsman and his dive team (avocational technical divers); Max Jahrehorn (wet material conservator); and Amorim Group (Portuguese cork producer) (Landskapsregering 2012b: 2). The regional government also established their working group for the wreck find (Landskapsregering 2010d). This group included five politicians from the marketing, administrative, trade and educational boards, and the head of the local museum bureau as the sole archaeologist, who was personally very supportive of the commercialisation and salvage.

The number of bottles was eventually reported as 168, instead of the predicted 70. This put additional pressure on the project: because Näsman's support vessel PAGI had a fixed schedule and had to return to Sweden, salvage efforts were doubled—there was no time for adjustments or surprises. The salvage operation was completed in seven days, while the whole salvage project lasted nine days. The rush had detrimental effects on the level of documentation. Marcus Lindholm wrote in his 2010 report (Lindholm 2010: 20) that the documentation was imperfect and inadequate, and only partly satisfactory. Nevertheless, the regional government and politicians were pleased with the results (Landskapsregering 2012b).

During the salvage, all bottles were tagged with an individual letter and a number, where the letter indicated the area of the wreck where the bottle was found. The salvage report (Näsman 2010b: 6) listed the areas where the bottles had been found and a small hand-drawn picture illustrated these areas. The regional government claimed that everything was done in accordance with archaeological standards, and that every bottle had been documented and their exact locations could be determined from pictures—although the list of places where the bottles were found also included 'X —unknown place'. One of the many issues was that the bottles were labelled and tagged at the lift basket on the seabed, after their removal from context. Thus, it became impossible to study, for example, which bottles were shipped together and how, and what their relation was to other cargo. After the salvage operation in September, the Permanent Secretary was reluctant to reveal the exact number of bottles because he did not want to compromise the future market value—months before the official decision to sell was made on 16 November 2010 (Landskapsregering 2010d). This suggests that an unofficial decision to sell had already been made.

Archaeological documentation was done by Näsman and his crew during ten days in 2011, after the bottles had already been removed from context and the site had been contaminated in 2010. A preliminary report was made in December 2011 (Näsman 2011) and the results were summarised in the 2012 auction catalogue (Artcurial 2012a). Small test trenches were made to study the remaining cargo on board and the wreck was mapped. It is now believed that the ship's destination could have been a town located on Finland's west coast, as the wreck was found near a historical maritime route between Sweden and Turku, Finland, in the Gulf of Bothnia. Most of the porcelain and ceramic found on board came from Sweden. Salvaged objects suggested that the boat was carrying a cargo of luxury products. The timber used to construct the boat was analysed, revealing that the ship was made from pinewood and fir, an indication of its possible northern origin. The analysis also revealed that the schooner had undergone important repairs on its mast, its tiller and prow. The identity of the vessel is still not known.

The auctions

On 17 November 2010, the regional government announced that they would host an international champagne auction, probably annually, and all profits would go to charitable causes such as maritime archaeology and marine preservation (Landskapsregering 2010e). Of the 168 bottles found, 145 were identified and dated by markings on their corks. These included: four bottles of Champagne Heidsieck & Co (founded 1785); 46 bottles of Champagne Veuve Clicquot Ponsardin (founded 1772); and 95 bottles of Champagne Juglar (a champagne house which disappeared in 1829 when it merged with Jacquesson). The best source for information regarding the finds is not any research publication, but the 2012 auction catalogue, which covered the known historical facts to promote the sale (Artcurial 2012a).[9]

In the end, all except five bottles were re-corked, and 79 bottles of champagne were found to be adequately preserved and drinkable (Artcurial 2012a). One bottle was opened and tasted when the divers found the wreck; two were tasted by media; five were beer bottles; two were impossible to identify; eleven were broken or could not be opened; three bottles leaked; and five bottles were kept in the museum collection. The bottle reconditioning was done in Åland in 2010 by Veuve Clicquot's cellar team. The standard archaeological practice would normally be to conduct an analytical investigation to provide insights into the winemaking practices of the 19th century, and into the find itself; however, no scientific evaluation or testing was done. It was not until five years later, in 2015, when an independent group of researchers (Jeandet *et al.* 2015)—not affiliated with the regional government—acquired

[9] For more information regarding the 2012 auction, see the Åland's Champagne Rendez-vous auction catalogue, available online at <artcurial.com/sites/default/files/pdf-catalog/2017-09/2215.pdf>.

samples from three bottles. Instead of scientific analysis, Richard Juhlin was hired to taste all bottles and rate them on a 100-point scale for commercial purposes (Artcurial 2012a). This was a lost opportunity, considering that all bottles and their contents—and their tasting notes—were unique (Jeandet *et al.* 2015:5893; Artcurial 2012a). All bottles were classified into two categories; champagnes in category 1 were the best and the clearest.

Two bottles were made available for purchase in the first auction that was held in Mariehamn, Åland, on Friday 3 June 2011 by Acker Merrall & Condit of New York. The decision to hold the auction was discussed earlier at the regional parliament. The minutes from the plenum of 27 April 2011 reveal that it was taken almost for granted that the income would be an estimated €100,000 for two bottles, and, therefore, that it was a good idea to sell: '[...] if we assume that one bottle could bring in €50,000, it means approximately a revenue of €100,000 from the forthcoming auction' (Lagting 2011).[10] The total revenue was €54,000 (€30,000 and €24,000 excl. buyer's premium and sales taxes)—half what was expected but still a world record.

The 2011 event was boldly titled 'The Tsar's Treasure: A Historic Shipwreck Champagne Auction'. At the time, there were only speculations that the cargo might have been bound for the Russian Tsar's court in Saint Petersburg. After the scientific analysis in 2015, it was noted that the relatively low sugar levels suggested that the champagnes were probably intended for customers in the Germanic Confederation; correspondence between Madame Clicquot and her agent in Saint Petersburg testified that Russian customers had demanded higher sugar levels—double what the found bottles contained (Jeandet *et al.* 2015: 5893).

In 2012 the government decided to sell eleven bottles as part of the celebration of 90 years of autonomy (Landskapsregering 2012d). Tenders were requested from Christie's, Sotheby's, Acker Merrall & Condit and Artcurial. The auction was held on 8 June, this time by Artcurial Briest–Poulain–F. Tajan of Paris as a direct purchase, after none of the auction houses replied to the tender request (Landskapsregering 2012e). The benefits were promised to charitable marine preservation funds and for continued marine archaeological work. The event was promoted by a substantial 48-page auction catalogue that went to great lengths to point out the archaeological and historical nature of the find for potential buyers. Despite the attempts, only eight bottles were sold; the remaining three did not achieve the minimum price and were withdrawn (Artcurial 2012b). The highest achieved price for one bottle was €15,000 (excl. buyer's premium and sales taxes) and the total income was €109,280.

The champagne and the beer

Veuve Clicquot has traditionally been one of the best marketers of champagne, and it is no surprise that this champagne house became heavily involved in the scientific and historic aspects of the discovery. Veuve Clicquot's archives enabled extensive research, thanks to a detailed legal brand document registered at the commercial court in Reims, France on 12 May 1841 when Mrs. Clicquot adopted the new burnt branding technique on corks. This knowledge revealed that the Veuve Clicquot bottles found on the wreck could not have been produced prior to May 1841. Remains of string were found on the corks, indicating that they were kept closed with string rather than wire muzzles. Wire muzzling was developed in 1844, and its use quickly spread over the Champagne area. The precise date of its adoption by Veuve Clicquot is unknown—although it cannot be any later than 1850 when wire became the market standard and string muzzling was abandoned. A more detailed history can be found from the auction catalogue (Artcurial 2012a).

Only five bottles of beer were found. The VTT Technical Research Centre of Finland was commissioned to analyse the contents of two bottles (A56 and C49), in part to help recreate the original recipe for modern industrial production. The results concluded that the analysed bottles contained two different beers, bottle C49 being more strongly hopped than the other, A56.[11]

The regional government entered into a contract with the local Stallhagen brewery, giving them exclusive rights for the recreation of the beers. Based on VTT's analysis, Stallhagen developed recipes in cooperation with Belgian master brewers and the KU Leuven University. In May and October 2014, two different beers were launched.[12] According the *The New Yorker* (Stayner 2015), the brew that matched the hoppier version of the original beers became known as 'Historic Beer 1842' and the second, smoother beer, became known as 'Historic Beer 1843'. The 1842 was a limited run of two thousand individually numbered, hand-blown replicas of the original bottles. While online sources have suggested that the 1842 was quickly sold out, the complete run was sold exclusively to an Åland registered passenger ferry company, Viking Line, and

[10] Translation by author.

[11] For a video from the analysis, see the YouTube video 'Shipwreck Beer / Hylkyolut', available online at <www.youtube.com/watch?v=RuSR04 goJK8>.

[12] For further information, see online <www.stallhagen.com/en/vrakol>. For promotional material and video clips from the salvage operation, see the YouTube video 'The discovery of Stallhagen Historic Beer — "The shipwreck beer"', available online at <www.youtube.com/watch?v=Y40POSGq3Pw>.

was only available on board.[13] The original price per bottle was €120, but recently the remaining bottles have been available for a discounted price of €99. The 1843 became the mass-produced market version, priced at €6 per bottle. At the time of writing no information was available on whether the 1843 is still in production.

Legal issues and official responses

While the legal issues received little attention, opinions were still expressed. On 29 April 2011, before the first auction, ICUCH approached the regional government with a letter (ICUCH 2011), warning about the far-reaching consequences and public confusion between legal and illegal action. ICUCH also condemned the sale as being against international standards, the International Council of Museums' (ICOM) Code of Ethics, good code of practice and local laws. ICUCH also expressed willingness to help resolve the situation. The letter was answered some eleven months after the first auction by the Permanent Secretary (Landskapsregering 2012a) who acknowledged the letter but stated that it did not give rise to any concrete actions. The Baltic Sea Region Working Group on Underwater Cultural Heritage also approached the regional government, but received no response (Bleile 2012).

During the review by the Chancellor of Justice between 2012 and 2014, the Finnish National Board of Antiquities was asked for an opinion. As already noted in their previous opinion, the NBA required that the bottles be treated as museum objects and documented according to current standards. In their response (NBA 2013) to the Chancellor of Justice, the NBA was against the sale of legally protected cultural heritage and pointed out that the purpose of the salvage was to prevent looting and the sale of UCH on illegal markets. By making these very objects available for purchase, regional authorities endangered the credibility of cultural heritage protection and made the sale of UCH look like a normal part of cultural heritage management. The Finnish Ministry of Education and Culture was also asked for an opinion. The Ministry was likewise (MINEDU 2013) against the sale of legally protected cultural heritage and considered the auctions to be against both the spirit of the Antiquities Act, and international conventions and museum ethics. The Ministry also pointed out that authorities have a special duty to preclude commercial exploitation, and make sure that all actions follow international standards and conventions.

In his verdict, the Deputy Chancellor of Justice drew the local authorities' attention repeatedly to the requirements of good governance and issued instructions concerning the proper legal procedure for future reference. The verdict concluded that by starting the salvage operation before the regional government had received the opinion of the Finnish National Board of Antiquities (as required by law), the Government of Åland had acted against the Administrative Procedure Act, the fundamental principles of good administration, and the Act on the Autonomy of Åland. By deciding to sell the champagne bottles, the Government of Åland acted against the object and purpose of the local laws governing and protecting UCH, and the Valletta Convention on the Protection of the Archaeological Heritage. In addition, the Government of Åland failed to obtain the information and accounts necessary for the decisions on the matter that were required by the Act on the Autonomy of Åland and the fundamental principles of good administration. The Permanent Secretary had also neglected his duty of service by not replying within a reasonable time to ICUCH. Based on the information available, the Deputy Chancellor of Justice held it obvious and self-evident that the Government of Åland had completely ignored the domestic and European legislation concerning the export of cultural goods.

After the verdict, the regional government analysed it in plenary, and noted that the Åland Islands had legislative powers over UCH and the actions were not against the law. It was also stated that the regional government had not started to salvage before the opinion of the NBA was received.[14] They concluded (Landskapsregering 2014) that the verdict caused no further actions.

Costs and charity

The charity angle—that all surplus would go to charitable causes—was something the regional government liked to refer to whenever the project was questioned or covered in the press or other media. However, the true contributions to charity were never made public by the government. Nevertheless, one observation is striking: the Permanent Secretary systematically denied the figures that were expressed in the media during the review by the Deputy Chancellor of Justice. Already in 2012, the Permanent Secretary questioned where the expressed numbers came from, claiming that they were simply not true; however, no explanation or counter figures were provided (Lanskapsregering 2012b). In 2014, when the regional treasury provided the list of expenses to the author, it was revealed that the numbers presented earlier by the media had been correct. Furthermore, most of the costs were already present in the regional budget with the

[13] See further 'The world's oldest beer has been recreated', available online at https://www.visitaland.com/en/mat-aland/the-worlds-oldest-beer-has-been-recreated/.

[14] The memo stated that the opinion had already been received on 25 August 2010. However, the materials the regional government sent to the Chancellor of Justice prove that the letter was received and stamped 30 August 2010. Nothing suggests that the NBA had actually been in contact with the regional government already on 25 August.

exception that some costs had been paid from multiple budgets, and not just from the budget that was created for the wreck and commercialisation project. All costs had been publicly available since the beginning of the project and could be easily determined from the official records. However, since the media frenzy was all about the auction prices, the actual expenses of the project were overlooked.

During 2010 the total costs were €196,627.76 without any income. These costs included the salvage (€98,949.74), the use of experts and research (€45,826.08), and storage and security (€24,342.43). During 2011 the total costs were €128,568.83, and the income from the auction was €86,935.62. The biggest individual expenses came from the use of experts (€74,448.90) and travel and accommodation costs (€22,742.57). During 2012 the total costs were €164,123.54 and the total income from the auction was €116,747.94. The biggest individual expenses were the use of experts (€67,783.02), salaries (€28,998.15) and a grant of €16,000 awarded to the finders. During 2013 the total costs were €38,206.93 without any income. The biggest expense was a €25,000 grant for PhD students, which is the only thing so far that can reasonably be categorised as charity. All in all, the net loss was over €300,000 in less than three years. However, it should be noted that the situation would have changed over time, if more bottles were to be sold. Despite this, the figures prove that estimated auction prices are not a suitable basis for the feasibility of a project such as this. Because of the costs associated with the management and auction arrangements, the result will almost undoubtedly be never more than a zero-sum game.

Final thoughts and the future

In 2013 the Ålandic Minister of Education and Culture Johan Ehn stated that 'actually, well these bottles are not, like cultural heritage. They are more like groceries and consumable goods' (MOT 2013).[15] This comment contradicted an earlier statement of the regional government claiming ownership based on the bottles being cultural heritage and, thus, protected (Landskapsregering 2012b). The bottles were considered cultural heritage as far as ownership was concerned but once they needed to be sold, they were artificially re-classified as consumable goods.

However, the Minister's comments raised an important point: How do we, and how should we, value cultural heritage, which has the potential to 'go bad' and can be consumed? In this case, the liquid in the bottles will spoil and vanish over time. It is inevitably something we cannot preserve. Therefore, keeping it in storage without giving the general public the possibility to enjoy or appreciate it in one way or another, will lead to its partial destruction with no clear benefit. But at the same time we should remember that all cultural heritage requires careful conservation and preservation. Nothing lasts forever, which leads to the question of what is worth preserving, and on what grounds should we make these decisions? What are we trying to achieve when we want to preserve and conserve objects? These questions require careful consideration, because a single incident can turn into a dangerous precedent.

If the conclusion is that we should sell, what would be the distinguishing factor between professional archaeology and commercial and/or illegal salvage, if both aim for commercial gain by selling cultural heritage? How do these choices shape and affect the awareness and opinions of the general public? We have a duty to protect UCH for future generations, but at the same time we should also have the right to enjoy it in a responsible manner.

Nevertheless, whatever the future brings for the legacy of the 'Champagne Schooner', it will always be affected by the choices that were made between 2010 and 2012. This also emphasises the importance of internationally accepted professional ethics and standards. If the salvage had been done in accordance with professional standards and archaeological principles, selling some of the liquid might be easier to justify. But the salvage operation and its results do not comprehensively differ from those of typical commercial projects where little or no regard is given to archaeology and documentation and, thus, the question of whether the sale of the champagne was justified is more complicated. In this case, the project resulted in losses to the archaeological record while the salvaged items were taken care of to the highest possible standards for commercial reasons. Thus, any kind of commercialisation will always be viewed in a negative light.

This leaves us to consider how the situation might be different had the project and its aims been compatible with professional ethics and archaeological practices. Under Article 4 of the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage, an exception could be made for edible or consumable finds and their commercial exploitation considered acceptable. This could be the case only if the project had been in full conformity with the Convention, and if the recovery of the UCH achieved its maximum protection. This time it did not, but in theory, it could have. However, this view requires careful consideration and further debate, which is beyond the scope of this article.

[15] This comment was made in a television special by the Finnish Broadcasting Company YLE, called 'The looting of the champagne schooner' (from YLE's investigative program 'MOT'). All translations by author.

In August 2016, after two years of silence, the regional government established a new working group (Landskapsregering 2016) to draft a future strategy for the handling of the champagne find, after it was concluded that the old group—consisting only of politicians—did not fulfil its purpose. The new Working Group has six members, including the new Minister of Education and Culture, Tony Asumaa; a representative of Visit Åland, Lotta Berner-Sjölund; the project leader of the 2012 auctions and commercialisation, Lina Dumas; the 'finder' Christian Ekström; the head of the Åland maritime museums, Hanna Hagmark-Cooper; and Rainer Juslin, the Permanent Secretary. In January 2017 the regional government extended the mandate of the new working group until the end of August 2017 (Landskapsregering 2017a). Soon after, on 14 February 2017, based on the recommendation of the Working Group, the regional government gave one bottle (A37) to Veuve Clicquot for further analysis (Landskapsregering 2017b). Only time will tell how things will progress but at least for the moment, there is hope that the future might depend more on careful consideration and analysis, rather than purely commercial aims and annual champagne auctions. The case was "closed" in a way after all bottles got spoiled. This was mentioned briefly in some newspapers. Afterwards the local government decided that all bottles would be added to the museum collection. Adding this new information with a reference would be useful. It could be mentioned briefly in a footnote.

For example: "After the original version of this paper was finished, the Finnish Broadcasting Company YLE published a small article on 10 August 2018 concerning the current state of the bottles. A never analysis had revealed (presumably based on the bottle A37 that was sent to Veuve Clicquot), that the contents had been turned undrinkable. As a conclusion the Minister of Education and Culture Tony Asumaa told the Åland Radio, that "Sure, it was champagne, but not of the quality that we wanted, so it is not worth it. From now own we will classify [the bottles of champagne] as museum pieces, not something to consume." See https://yle.fi/uutiset/osasto/news/worlds_oldest_champagne_discovered_near_aland_found_to_be_undrinkable/10450446"

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Global Database of Early Watercraft: Beginnings, Development and Future Plans

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Abstract

The management and presentation of cultural heritage over a given region requires a dedicated database which can store all relevant information (location, text, photography, 3D models, animations etc.) and an intuitive way of accessing this information (searching via different criteria such as geo-location, time-frame, type of find, state of preservation, etc.).

We decided to test a recently available open source platform, Arches 3.0, to construct a database of all known logboats and other early watercraft in the country of Slovenia: the Early Watercraft Database. The software platforms of existing inventories are mostly proprietary, expensive to maintain and difficult to interconnect and upgrade to new requirements. Existing database inventories are therefore difficult to combine and this makes the study of early watercraft finds on a global scale, independent of modern state boundaries, more difficult. By contrast, information stored in applications developed on the Arches platform can be easily merged.

The Early Watercraft Database application demonstrates the ability of the Arches platform to be employed for a wide range of applications; it can be used for small-scale solutions but it can also be extended to accommodate large-scale (global) inventory requirements. The Arches open source heritage inventory and management system is sponsored by the Getty Conservation Institute and the World Monuments Fund.

Keywords

Early watercraft, global database, Arches

Introduction

Early watercraft—logboats, reed boats, skin boats, bark boats, rafts and simple three to five-plank boats—are among the best known and oldest human inventions. The creation of early watercraft had far-reaching significance for navigation and led to a new form of human mobility, orientation and means of networking and communication, resulting in further migration and colonial expansion. This new mobility furthermore inspired and improved the development of other capabilities like trade, warfare or politics. Many types of early watercraft can still be found in use around the world (e.g. Arnold 2014, 2015, 2017).

The great story of water transportation, which is closely linked to humans' traditional coexistence with water and our life in aquatic environments, has a strong symbolic meaning (Erič 2014). Most people live near seas, lakes and rivers. In our current world heritage narrative of navigation, the vessel construction and watercraft typology of early watercraft have not been given the attention they deserve. But they represent the origins of humankind's navigational tradition, while also revealing that beneath an outwardly simple appearance lies a sophisticated example of design, construction and extraordinary cultural practices.

During the last two centuries, and particularly in the last two decades, the preservation and promotion of cultural heritage have advanced worldwide. Cultural tourism is increasing rapidly. The general public has a much greater awareness of the importance of cultural heritage and expresses a much higher demand for experiences related to cultural heritage. Well-preserved and correctly presented cultural heritage is becoming a valuable tool for obtaining extensive appreciation of the ways of life of different cultures, communities and their people. Working replicas of early watercraft are particularly suitable for providing the public with relevant first-hand experiences. The unique position and contribution of early watercraft to the development of our cultural heritage should be highlighted.

Background

The oldest archaeological evidence for early watercraft includes a logboat, aged around 8200 years, from Pesse, Netherlands, Europe (Van Zeist 1957); an 8000-year-old logboat from Kuahuiqiao near Hangzhou, China (Jiang and Liu 2005); and a 7000-year-old logboat from Dufuna, Zimbabwe, Africa (Breunig 1996). A petroglyph from Quobustan Milli Parki near the Caspian Sea in Azerbaijan, around 12,000y old, depicts a reed boat with 20 paddlers! Even without any material evidence of the craft used, anthropological theory and migration indicate that watercraft must have been in use by Homo sapiens for at least 60,000 years. The beginning of this period saw the colonisation of Australia from the Asia-Pacific region, and at nearly the same time South America was colonised from Africa over the Atlantic (Watanabe *et al.* 2008). Some anthropologists have even put forward the theory that Homo erectus may have used watercraft as early as 800,000 years ago (Bednarik 2016). The fact is that without the invention of early watercraft many key human inventions such as compass, navigation, etc. would not have been invented at all. We think it unlikely that the study of astronomy would have developed at all had it not been necessary for navigation.

Information about cultural heritage, as with practically all application areas, is now stored in various computer-based information systems. The databases where cultural heritage data is stored are often already in their second or third generation. For compatibility, many international standards were developed in this application area. However, on an implementation level, very different software solutions have been developed for these databases. That makes the interchange and collection of data from various databases much more complicated and time-consuming for the end users who would like to study the development of cultural artefacts on a larger scale and in areas that are geographically more appropriate. Modern national and state borders, which typically determine the scope of such cultural heritage databases, do not coincide with the geographical regions relevant for cultural development in the time of early watercraft.

The Early Watercraft Initiative—a global perspective on invention and development (EWI)

To address these methodological problems, a global initiative entitled ‘Early Watercraft—a global perspective on invention and development’ was established in April 2015. The initiative aims to establish a systematic research environment for studying the origins of navigation in general, with an emphasis on the invention of the earliest indigenous vessels (logboats, reed boats, skin boats, bark boats, rafts and early plank boats) along with fire, housing and simple survival tools—all of which should be considered the most important early human inventions. At present, the initiative consists of 67 ambassadors from 35 countries around the world (Bockius and Erič 2015).

So far, the initiative has been very successful in connecting individual professional researchers and scientists as well as institutions, universities, museums, natural and cultural parks along with local and regional communities where early watercraft are still in use for trading and daily living. Finally, local communities and enthusiastic individuals from regions where early watercraft originate, or such vessels are reconstructed and redesigned, should also get involved. In such regions, modern reconstructions of early watercraft could be used for contemporary educational, sustainable, promotional, sporting and cultural tourism activities.

One of the initiative’s initial objectives was to include all continents, i.e. without any modern geopolitical—local, regional, international and global—religious, ideological, economic, or any other divisions. From a scientific perspective, the broadest spectrum of views should be included. Early watercraft should be studied from different angles such as archaeology, anthropology, history, ethnology, art, geology, paleoenvironmental, physics, biology, geology, philosophy, computer and information science, technology, sociology, etc. The most significant long-term task of this initiative is to establish a framework for a permanently operating group of scientific researchers with the aim of researching one of the most important inventions of humankind and its early development. It has the following important goals.

The primary goals of the Initiative

To establish conditions for education and promotion of invention through an Early Watercraft Heritage Network of interconnected museums, heritage parks, tourism, sporting and other organisations responsible for the protection of cultural heritage as well as citizen scientists and amateurs active in reviving the tradition. All efforts should be directed towards an entirely new promotional format that would work uniformly across the world and at the local, regional and global level with organisational units across the globe.

Calls for various projects will be designed to target different fields, such as science, culture, heritage protection, IT development, rural community development, sustainable tourism, alternative sports, traffic and transport, art, etc. A principal objective would also be to include and register early watercraft into the UNESCO list of Intangible Cultural Heritage as the oldest human invention, which is still flourishing all around the world. A web portal and an International Journal for Early Watercraft Research should be jointly established. To start off with, the journal would be issued only in electronic format. Once established, one of the major scientific publishers (e.g. Elsevier, Springer, etc.) will be contacted to take the journal under its wings.

Unfortunately, we have no idea when, where and which group of people in the evolution of humankind was the first to appreciate the benefits of using the world's water network. Therefore, the task of the Initiative is to promote scientific research, educational campaigns and promotional activities across the globe. Examining all known data on human evolution and migration models would enable us to hypothesise where and when early watercraft could have been used 800,000 years ago.

To develop ideas and extend research on the phenomenon and its development, it would be necessary to use all possible research methods and techniques from a variety of disciplines; this should help to promote scientific research, education, promotion and maintenance of traditional knowledge all over the world. This is the only human invention that has not changed throughout the history of humankind and is still in use in its original form.

Some of the activities of the Early Watercraft World Research Institute should also be undertaken on a more symbolic level, once some at least of the above-stated goals have been achieved. For example, one goal of the Cultural Centre of European Space Technologies is to bring culture into space, picking up from the point where the 'Fallen Astronaut' left off. The basic idea of the programme is to enable artists and scientists to engage in various research projects involving human activities in space and to create an environment for modern and memorable in-depth intercultural scientific research. On a symbolic level, the logboat is a prime human invention; it has significantly contributed to the symbolic liberation of the human mind and to the understanding that, in a physical sense, the water network system of the earth is synonymous with its communication and transportation network. Until the 19th century, transportation by water was the fastest means of transport and travel, enabling humans to explore the unknown. At the same time, the logboat is an implement with increased carrying capacity that considerably exceeds the physical capabilities of a human.

From the Slovenian cases towards a worldwide inventory

Since the Ljubljana Marshes, with its high density of finds (Erič 2008), is a region that has significantly contributed to the development of this idea, one of the centres of the global organisation could be in Slovenia (with departments on all continents around the world). As data and knowledge on early watercraft exist in all possible local and regional variations, they should be collected on every continent. This knowledge should be promulgated with interactive presentation systems, based on holograms and other cutting-edge information technologies which would in future, for instance, enable virtual interactive rowing in the so-called I-pool (pool managed by artificial intelligence) and detailed virtual observations of early watercraft from all around the world. Scientific research work could be supported by other units and collections in the Heritage Park. The Institute would also be involved in the experimental reproduction of vessels.

The early watercraft that have been preserved are either kept in museum collections or remain *in situ*. Some of those that have had to be moved into museum depositories because of pressure on exhibition space should be made accessible to the general public for educational purposes.

Sharing knowledge about the importance of the invention of early watercraft for human evolution is vital. This process should bring together academic researchers and broader groups and communities to exchange ideas, evidence and expertise. Within the initiative, the primary targets are groups which could contribute to our understanding of heritage and consequently provide many cultural and environmental benefits to society. In practice, all knowledge exchange engages across these audiences. Knowledge-sharing should include worldwide organisation probably under the auspice of UNESCO (ICOM/ICOMOS). However, in addition to early watercraft instructors and experts, a broad scientific research institute network with institutional and individual members from all around the world, a network of heritage parks around the world, scientific conferences, heritage public festivals, journals and web-based communications on different levels, all benefitting from a single worldwide meta-database of early watercraft knowledge, are crucial for the achievement of these goals.

Today's practice of using polyethylene glycol or melamine in the conservation of waterlogged wooden finds is unsatisfactory (Erič 2014; Erič *et al.* 2018).

However, to meet all requirements for protection, safeguarding and presentation of a selection of original vessels, we should investigate the possibilities of developing so-called I-aquariums—cells with controlled, biologically steered hydrological climates and the possibility of indoor and outdoor display of chosen artefacts. This idea should be put into practice by an interdisciplinary team of specialists in woodworking, microbiology, hydrology, mechanical engineering, computer science, etc. Its purpose would be to prevent the decomposition of wood in the course of physical, microbiological and chemical processes. That could be achieved with the help of cutting-edge technology, cavitation systems, a thermo-hydrological balance and carefully implemented adjustments in the microbiological balancing of water plants and animals.

The collection could expand gradually, from year to year. The reconstruction of the oldest watercraft found so far could mark the beginning: the Pesse canoe from the Netherlands or another logboat more relevant to a particular region. New copies or reconstructions of prehistoric logboats could be made at annual festivals every year. In a couple of years, dozens of logboats could be carved and fabricated all around the world. These collections would be managed by local communities of the countries that have embraced the idea of global heritage parks. The new boats could be used to organise educational trips or ‘logboat treks’. In Slovenia they could, for instance, travel between Bistra, Vrhnika and Ljubljana. Each logboat would have a berth at Vrhnika, Podpeč or Ljubljana. The berths would be equipped with the data about the original boat: its discovery and the context in which it would have been used. Along the route, there could be places to stay. All logboats in the system would be equipped with high-tech navigational devices, enabling interactive ‘real-time’ monitoring from all over the world. One of the thematic collections in the heritage park would consist of originals, copies and reconstructions of typical watercraft from around the world.

In Slovenia, one could set up an exhibition of the earliest Roman barges made in the northern Mediterranean shipbuilding tradition, such as the Lipe ship and the Sinja Gorica ship. A minor permanent exhibition at the Visitor Information Centre could showcase miniature copies of Arles Rhone 2 from Marseilles, Yverdon 1 and Bevaix from Lake Neuchátel and Lipe. Full-size replicas of the vessels from Sinja Gorica and Lipe could be reconstructed. These could be used for tourist trips, cultural events and hiring. Next, an exhibition dedicated to the ‘*čupa*’, a typical Slovenian north Adriatic fishing outrigger logboat, could be prepared. It is little known that in the 18th and 19th century, Slovenes used to have the biggest fishing fleet of more than 400 *čupa* logboats in the Gulf of Trieste (Volpi Lisjak 1996, 2005). This exhibition would pay tribute to this fishing fleet. Finally, a collection of the expanded *Notranjski drevak* logboats of the Notranjska region could be exhibited. Local inhabitants used this type of logboat in the basin of the Ljubljanica River during recent centuries. The latest studies of ship construction in Sinja Gorica indicate that this shipbuilding tradition may have originated in Slovenia and not in the valley of the River Po, the region where this type of boat is generally taken to have originated (Erič, Jaklič and Paskali 2017). These boats have, interestingly, a construction almost identical to the vessels on the Suwa Lake, south of Nagano in Japan (Robertson 2013), and on Lake Lugu in Yunnan province in China (Thompson 2007).

Thematic trails in the Ljubljana Marshes and around the world where local communities want to organise Early Watercraft Heritage Parks, could be laid out. All locations where logboats were found in the Marshes, or regions where other types of early watercraft are still in daily use, should be equipped with public information boards with descriptions of these unique finds. Advanced computer technology would allow virtual visits to these locations. The boards could be linked to a computer game devised for this purpose, for instance, ‘Find the Early Watercraft discovery location’. The game format could be used to distribute bonuses/incentives for renting reproductions of early watercraft vessels in all parks around the world with available heritage facilities. Festivals organised by a worldwide team could also be used for promotion and education. They would include events for promoting early watercraft, e.g. an ‘Early Watercraft Regatta’, attended by celebrities, athletes, artists, scientists and accompanied by festivities. As an example, a 20km racing route could, for instance, be set up on the River Ljubljanica between Vrhnika and Ljubljana. These events could become a tradition, featuring workshops dedicated to the experimental reproduction of early watercraft. Sailing or paddling races could be transmitted to other continents, to locations with Early Watercraft Heritage Parks units. These centres would also be responsible for organising conferences and other educational activities. An early watercraft conference, early watercraft reproduction workshops or similar events should be held annually.

Future expectations and impacts of the initiative

One of the most important goals of the initiative is to create a globally integrated meta-database of all archaeological discoveries, anthropological and ethnological documentation relevant to traditional watercraft, reconstructions and copies of discovered watercraft which arise all over the world through the revival of the tradition of manufacturing.

One of the first challenges facing this initiative was to address the problem of the lack of transnational connection of cultural heritage databases. As an example, early watercraft seem a good test case. We implemented a web-based system Early Watercraft Database (EWD: EarlyWatercraft.org). EWD is aimed at the global level, to combine records of all archaeologically researched early vessels around the world, thereby documenting all typological phenomena of early watercraft. These vessels are often still a significant economic navigational aid in various environments around the world. EWD is also intended to document innovative tourism efforts for sustainable conservation of cultural heritage. Such a database will serve as the foundation and the starting point for comprehensive, multidisciplinary and in-depth scientific research into the invention of early watercraft.

The EWD enables the storage and management of all relevant data about the finds for the specialist but, at the same time, presents early watercraft to the general public, which is alas a less well known subject of cultural heritage. For the technical implementation of EWD, we selected Arches, an open source platform for managing and storing data about immovable cultural heritage developed by the Getty Conservation Institute (Figure 1).

Early Watercraft Database (EWD): the Arches platform

The origins of Arches go back to 2004 when the Getty Institute for the preservation of cultural heritage (GCI) and the World Monuments Fund (WMF) formed the initiative for the preservation of Iraq's cultural heritage (Iraq Cultural Heritage Conservation Initiative). As the political and security situation in Iraq at that time did not allow for progress in that particular geographical area, an organisation linked to the Jordanian Department of Antiquities stepped into the project so that in 2010 the project MEGA-Jordan was successfully devised and is still in progress today. As the development of MEGA-Jordan was underway, other organisations dealing with the protection of cultural heritage became interested in the project. That was the motivation for both sponsoring organisations (GCI and WMF) to decide to develop a general open source software system for managing spatial data for all types of immovable cultural heritage. The project was named Arches (Carlisle *et al.* 2017; Myers, Avramides and Dalgity 2013).[1]

Experimental study and existing state-of-the-art EWD

The Early Watercraft Database is at this moment an experimental project on the Arches platform to study its functionality as a virtual collection of data in one place. The final version of EWD should support a worldwide database of logboats, grass boats, skin boats, bark boats, rafts and their accessories as indicated by the archaeological evidence. Thanks to Lars Kröger from Deutsche Shiffahrtsmuseum, EWD will shortly (in November 2018) accept a database of up to 3500 dated European logboats collected by several institutions with all relevant information. The database will include all published discoveries in Europe from the beginning of the early 19th century, and at least twenty researchers,[2] archaeologists from all over Europe will make a database on a national or regional level. The existing EWD is based on the Slovenian logboat database (Erič 2008). EWD should also be extended to include archaeological evidence from around the world.

Another part of EWD should include all available evidence for the contemporary use of early watercraft around the world, providing a description of the specific local or regional characteristics of these types of watercraft.

One component of EWD will be the *Journal of Early Watercraft* which will enable peer-reviewed publication of research and short articles about watercraft. However, there may also be many other possible functionalities of the EWD platform which will emerge in the future.

The functionality of the Arches platform

Based on the experience gained with the development of the MEGA-Jordan project and with the cooperation of many organisations around the world, the following principles formed the basis for the development of Arches:

- Design standards-based: The system should be based on established international standards in the field of cultural heritage (Figure 2) and information technology, thereby encouraging the exchange of data and longevity data, which will be independent of technological progress.
- Universal Access: To ensure the widest possible access, the system must be accessible via the Internet, and its use as straightforward as possible.
- Economical: As an open source system, it must be free, and its users must be allowed to adapt it to different requirements for local usage of the system.
- Scalability: The system must be built in a modular fashion to make adjustments as simple as possible. Also, the system must be capable

[1] Chapter 'Early Watercraft Database (EWD): The Arches platform' based on an unpublished Masters dissertation (Kastelic 2015).

[2] Béat Arnold, Jan Lanting, Christian Hirte, Sean McGrail, Waldemar Ossowski, Lars Kröger, Miran Erič, Niall Gregory, Karl Brady, Ole Kastholm, Thijs Maarleveld, Davorin Vuga, Jason Rogers, and many others.

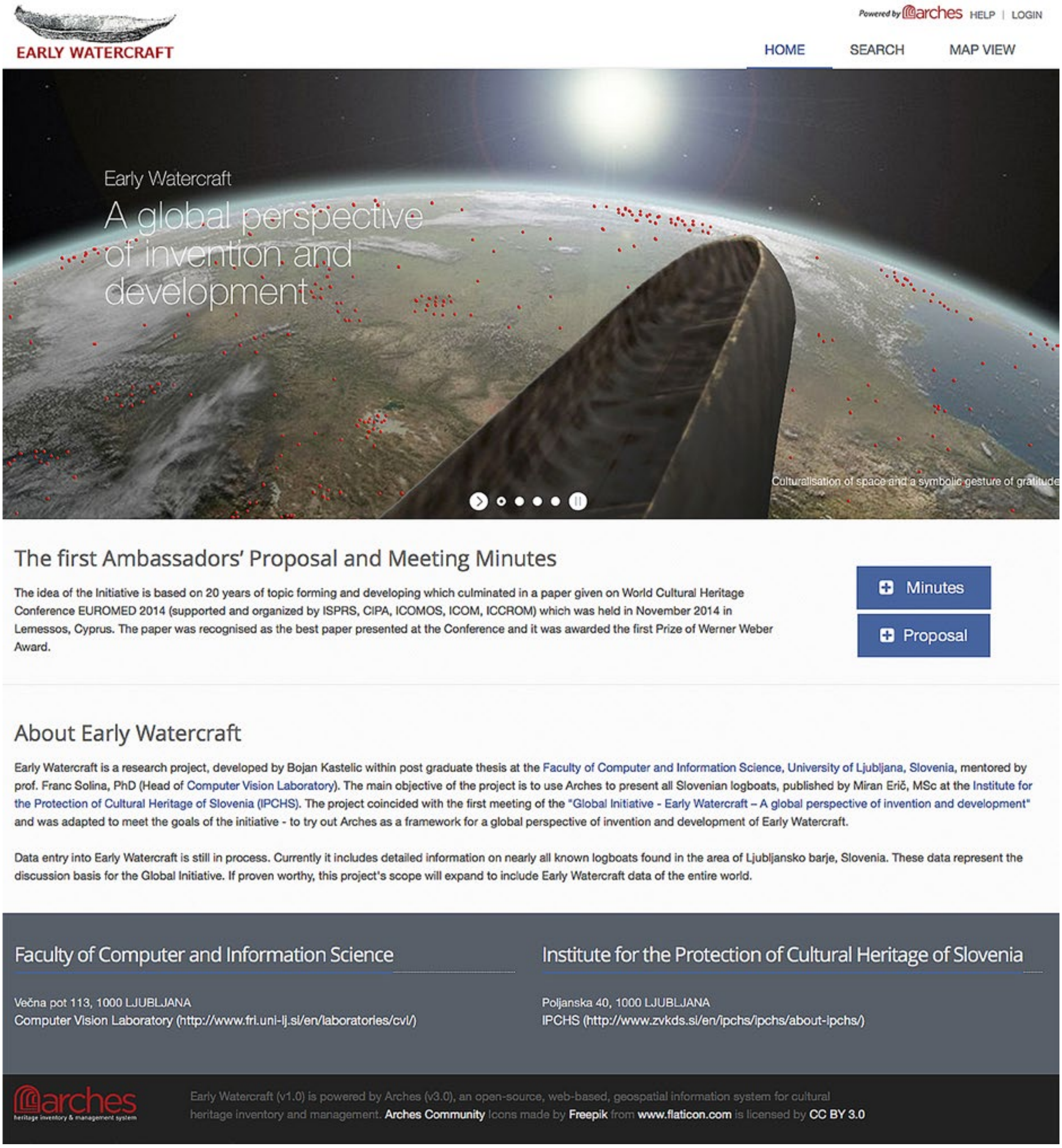

Figure 1. The entry page of EarlyWatercraft.org. At the moment the page based on Arches version 1.0 and does not work correctly. In 2019 it will be moved to the new version, Arches 4.0.

of multilingualism and being adapted for use anywhere in the world.

- Security: The system must allow any level of data protection—it can be fully opened to the public, completely closed or somewhere in between (a particular part of the functionality is open to the public, while another part is accessible only to users with appropriate rights).

The first version of the system Arches (1.0) was released in October 2013, and since then regular upgrades were undertaken. EWD is based on the third version (3.0) of the system, which was issued in April 2015.

Cultural heritage standards in Arches

From its very inception, Arches conformed to international standards in managing immovable cultural heritage. In particular, it is based on two CIDOC standards (DEF 2015): CDS (Core Data Standard), that covers the definition of data fields of the generic version of the Arches system, and CRM (Conceptual

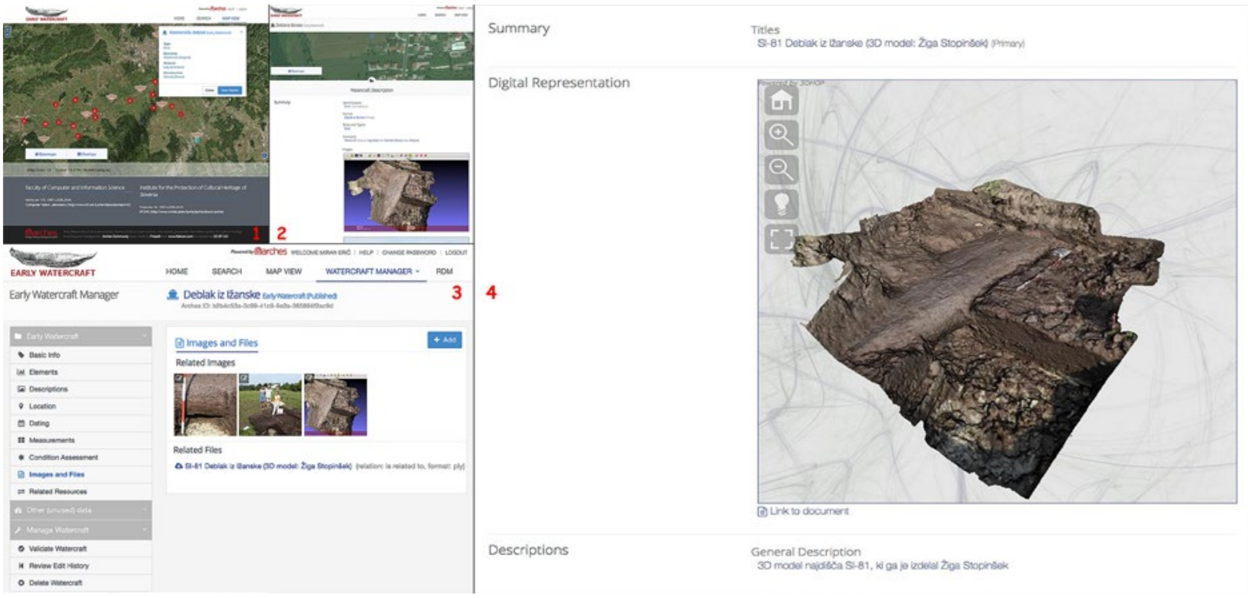

Figure 2. A public open map from EWD, showing a section from Ljubljansko barje, indicating positions where logboats have been found (1). A click on the logboat icon opens another window with all relevant data about the particular finding (2). Image 3 shows the administrator's working area for adding new finds where it is also possible to upload 3D models (4).

Reference Model), that covers the semantic framework of data usage. The CDS and CDI standards serve as the basis for a new international standard for essential data on archaeological and architectural heritage, which is currently in the final stages of preparation by CIDOC in collaboration with the international documentation council ICOMOS (CIPA).

As already stated, the CDS standard was used as a basis for the collection of data types for the first version of Arches. This collection of data types has expanded with subsequent versions of Arches. This integrates the set of original metadata (Dublin Core Metadata Element Set), which was proposed by DCMI from Dublin and is used for information resources used for storing digital as well as analogue data. The Dublin Core Metadata Element Set was also included in the ISO standard 15836-2009.

The CIDOC Conceptual Reference Model (CRM), which is also used in the Arches system, provides a basis for understanding concepts and how they are related; these are represented by data. CRM was initially designed as a tool for museums, libraries and archives, but could also be used in the context of immovable cultural heritage.

Arches includes the default mapping of its data into CRM classes and properties. In this way, different and distinct information can be represented and understood, while at the same time integration with systems using CRM is facilitated. CRM Special Interest Group developed CRM in the framework of CIDOC already in 1996 and in 2006 it was accepted as standard ISO 21127 (IAD 2006).

The use of Arches enables the free presentation of cultural heritage, which is not possible with standard databases since they usually require additional knowledge of implicit agreements. By enriching data with semantic content, CMR enables the generation of new apprehension from existing data and performing a powerful search, both inside the database, as well as among different databases. This allows easier migration of data to new systems and their preservation over time.

Although the CRM standard is comparatively complex and demands a steep learning curve, all implementation details in the Arches system are hidden from the end user. End users can communicate with the database using popular entry forms, which are also used in traditional relational databases.

IT standards in Arches

Arches also conforms to all key web and geospatial technical standards. For access and processing of geospatial data, Arches uses the open standard published by OGC (Open Geospatial Consortium), which ensures compatibility with all known GIS applications used in the area of cultural heritage and with the majority of web browsers and web maps currently in use. Arches also supports upcoming data formats such as GeoJSON and KML (Keyhole Markup Language) besides the currently standard GIS format (shapefile). Arches is also designed as an OGC web service so that it can be used in connection with other GIS applications such as ArcGIS or QGIS (Myers *et al.* 2012).

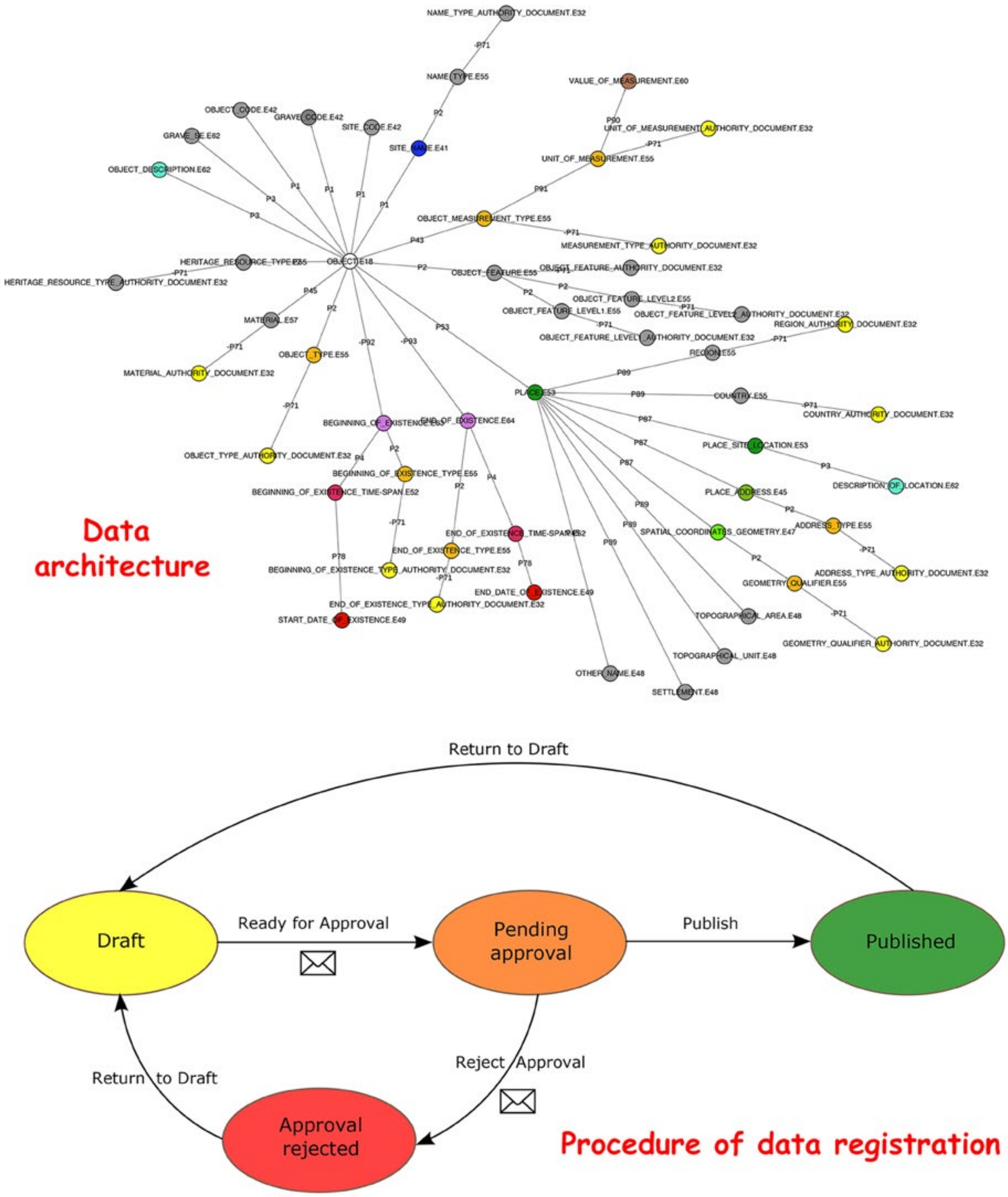

Figure 3. EWD based on all the latest standards for documenting Cultural Heritage (e.g. CIDOC and CDS) as well as on the latest information technology standards. It is possible to design and adjust the database architecture to any heritage, and create a more levelled control system for publishing.

Arches uses modern architectural concepts (Figure 3), based on RESTful interfaces and MVC patterns, so that data and their representation and processing can be independent. It is implemented in Python programming language in the open framework Django. For processing, Arches uses basic Javascript languages, such as Require.js, BackBone.js, jQuery and Bootstrap. PostreSQL is used as a data server (Myers *et al.* 2012).

Even in its basic configuration Arches enables all functionalities required for keeping the registers of immovable cultural heritage. However, its open source system permits straightforward upgrades and modifications to local requirements.

The data model consists of three parts:

1. Ontology data stores the data graphs that in the framework of CICOC CRM standards store the records of permitted data types and their interconnections;
2. Reference data stores the hierarchically designed dictionaries that serve for the loading of selection lists. In Arches, records in the selection lists are called concepts, which beside data also store their metadata and connections between them; and
3. Resource data stores the actual data of the immovable cultural heritage. This data is divided into entities that store records of immovable cultural heritage, business data that store data about individual types, and relations, that store links between different entities.

The open library that arranges drawing of maps is OpenLayers in JavaScript, which supports all the leading record types and mappings from any source with the help of OGC standards. That in practice means that Arches supports all well-known systems of maps: Google Maps, Microsoft Bing Maps, ESRI ArcGIS, and open source OpenStreetMap. In Arches 3.0 the default support is for Microsoft maps, but that can be changed. Arches can be installed under Linux and Windows operating systems.

Results

EWD is built on the Arches platform to make the most out of its functionalities, such as built-in search, display and presentation of spatial data, but we explored, in particular, the possibility of extending data types within the Conceptual Reference Model (CIDOC CRM).

For example, we found especially beneficial for the implementation of EWD the following possible extensions:

- Support of multilingualism in the import and display data;
- Support of new types of documents (sites, graves, objects);
- Advanced search options, such as the separation of search by type of records, multi-layered lists and limitation of dimensions of artefacts or locations; and
- The reproducible preparation process for data transfer from a central database, which operates in the MS Access environment in Arches.

Within the EWD platform we implemented some new functionalities that we found relevant for our application:

- We added support for the process of releasing data, which covers the status of processed documents;
- Ownership of data is unbundled, to restrict a particular user to edit only their data;
- Distinct icons were designed to indicate on the map separate types of vessels in different colours to signal different materials; and
- Display of 3D models of vessels where these are available.

EWD is, therefore, an illustrative case study, demonstrating the rich possibilities of the Arches platform.

Discussion

Arches is an advanced application platform for management of immovable cultural heritage since it is one of the first that applies the CIDOC CRM standard not only for the definition of data but also for storing data. The sample application HIP, which is a part of the Arches release, is designed with an extensive set of functionalities so that it can be used in different areas and a wide range of contexts without any additional amendments. The use of this basic setup does not require any advanced computer knowledge. That makes Arches accessible also to organisations that do not have their own computer departments or have limited funds for information support.

For more advanced users, that is, institutions that wish to adapt Arches to their interests and requirements, the adaptation is very straightforward since open standards and open code enable this. Additional functionality built into the EWD (support for the process of data publishing, ownership of data, viewing of 3D models, etc.) testifies that Arches can be easily expanded beyond the initial framework. That is one of the most valuable benefits of using open source code. The ease of use and the low cost of the platform due to the open source code will hopefully motivate other decision makers to adopt this software solution for the next generation of data management tools in the area of immovable cultural heritage.

A combination of open source code solutions can be used to build information systems that can be easily compared to custom-developed solutions using commercial software platforms. For organisations and institutions that have difficulty allocating sufficient funds for information systems support, this represents a viable and attractive alternative. Like other open source communities that spring up around particular application areas or network environments, the international Arches community is well organised and contributes additional tools and services for the community as well as help and support in solving problems and sharing of information.

Conclusions

The initial goal, to develop a flexible platform for inclusion of early watercraft into a database that can be transnationally connected was fulfilled. In the first instance of this database, all known early watercraft from Ljubljana Marshes were included, and information about them was made available both to specialists and to the general public, using up to date technologies and standards.

We have demonstrated that Arches can be applied on a local and global level. The members of the Early Watercraft Initiative will, thus, be able to use the same platform as described here at their local level almost without any modification, and ultimately all local databases could be connected into a global one.

In this way a much better-connected mosaic of world cultural heritage can be built, simplifying the exchange of data, allowing broader searches for information and supporting the development of conclusions from a geographically much larger dataset. Conclusions about and understanding of early watercraft can be, in this way, much more substantial and relevant.

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Late 19th and Early 20th-Century Institutional Wares of the Pacific Steam Navigation Company: Preliminary Assessment of the Valparaiso Fiscal Mole Ceramic Assemblage, Chile

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Abstract

Site S3-4 PV, located within the harbour of Valparaiso, on the central coast of Chile (33°01'S –71°37'W), is an underwater archaeological site related to the Fiscal Mole, an important port facility employed preferentially by steamships during late 19th and early 20th centuries. During the last few years, harbour redevelopment has prompted a rescue archaeology project, including monitoring, survey and excavation activities. By conducting a preliminary assessment of the ceramic assemblage recovered, we aim to perform an initial characterisation of the tableware used on board the vessels of the Pacific Steam Navigation Company (PSNC), the main steam shipping company operating along the west coast of South America during the period. The results obtained suggest that British Staffordshire refined white-bodied tableware featuring transfer-print decoration is dominant in the archaeological record. The dominant institutional wares of the PSNC emphasise the strong presence of this company at the port of Valparaiso, while dating coincides strongly with the operation period of the Fiscal Mole, confirming the coherence of the assemblage. While further ceramic analysis is required, the patterns identified have the potential to address new research issues and facilitate the investigation of PSNC wreck sites and similar wharf and jetty sites located in the region.

Keywords

Institutional wares, Valparaiso Fiscal Mole, 19th and 20th-century British ceramics, steam shipping companies

Introduction

During the second half of the 19th century, the port of Valparaiso (33°01'S – 71°37'W), on the central coast of Chile, was consolidated as an important centre of commerce, shipping freight and passenger companies, and a required layover for those on board long and exhausting trips from Europe *en route* to other port cities along the pacific coast of South America. Increasing shipping activity, as a consequence of the integration of Chile to global capitalism mainly through maritime commerce, led to the construction of the Valparaiso Fiscal Mole (1873–1883)—the first major port infrastructure developed in the country. This port facility was preferentially reserved for steamer lines, most notably the Pacific Steam Navigation Company (PSNC), a Liverpool-based company, which started service in 1840 along the west coast of South America but rapidly evolved to become one of the leading steamship lines of the British Empire.

During this period, commercial shipping companies working worldwide commissioned pottery as part of the basic equipment required on board, in order to satisfy the daily needs of the different classes of passengers, such as feeding, hygiene and comfort. In particular, institutional wares of the steamship lines are commonly found in wharf and jetty sites, but with very few exceptions, most notably research conducted in Australia (McCarthy 2002; Staniforth and Nash 2006: 92–95), the investigation of this category of underwater archaeological site has been largely neglected by maritime archaeology. Despite the fact that steam railways and shipping companies were major buyers and users of corporate logos in crockery as attested to by the archaeological record, research into 19th

Figure 1. Valparaiso Fiscal Mole *c.* 1888. In the background, a moored PSNC steamship with its characteristic black funnel and company house flag can be seen (Leblanc).

century marketing and corporate identity remains an incomplete area of study (Anderson and Lancellotti 2010: 76).

In 2016, the authors conducted an analysis of a late 19th and early 20th century ceramics assemblage recovered from an underwater archaeological site located within Valparaiso's inner harbour. The first part of this study focused on manufacturer, date of manufacture, and decorative pattern identification—and was based on a fragment count, not a vessel count. Minimum vessel count of the assemblage as to facilitate comparability with other assemblages will require further analysis, and will be the subject of a separate publication.

Historical and archaeological background

The Valparaiso Fiscal Mole

Constructed by the Chilean Government between 1873 and 1883, the Fiscal Mole of the Port of Valparaiso was the first major port infrastructure developed in Chile (Figure 1). The L-shaped concrete and iron pile-supported facility was 305m long and featured a bridge 68m in length and 14.5m in width. The mole itself was 237m long and 15.5m wide; and, had the capacity for accommodating two deep draft vessels to be docked on the exterior or seaward side, two standard size vessels on the interior or coastward side, and eight lighters along the bridge. Merchandise was unloaded using steam powered donkeys and transported by railed carloads to the nearby Customs Warehouses (Carabias 2015).

The Fiscal Mole was preferentially employed by the line steamers arriving regularly at Valparaiso to discharge Customs Warehouses cargoes, while sailing ships preferred to transfer their cargo via lighterage (Carabias 2015). The dominant steam shipping company at the period was the Pacific Steam Navigation Company (PSNC), which since the early 1870s was one of the British Empire's leading steamship lines based in Liverpool, England.

The Fiscal Mole infrastructure only partially coped with the increasing demand of the shipping industry for discharging facilities in Valparaiso at the turn of the century. Major improvement works conducted at the port (1912–1930) included an extensive breakwater that substantially transformed the waterfront creating the modern inner harbour configuration. The Fiscal Mole was partly demolished and its remains, including the massive concrete piles, became embedded in the new pier (Carabias 2015).

The Pacific Steam Navigation Company (PSNC)

Founded in 1838 under the patronage of William Wheelwright, the Pacific Steam Navigation Company (PSNC) was granted exclusive rights to steam navigation by the Chilean Government, who saw an opportunity to profit from the growing trade along the west coast

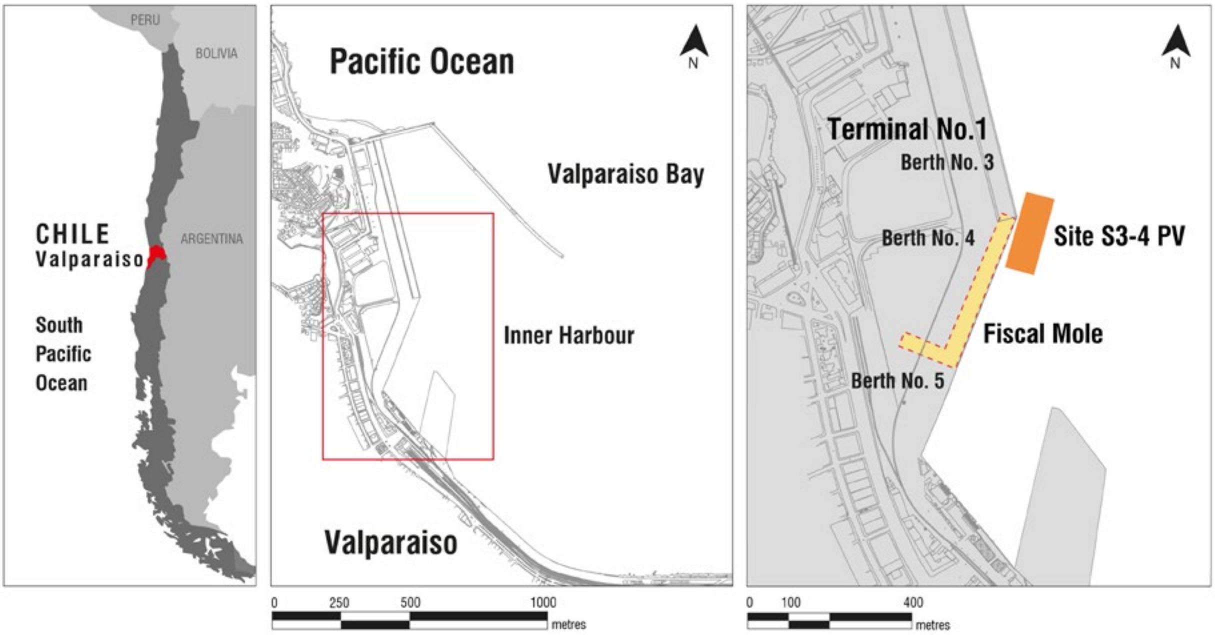

Figure 2. Site S3-4 PV in the inner harbour of Valparaiso; site is adjacent to the remains of the Fiscal Mole, which became embedded in the waterfront built during the modernisation of the port area (1912–1930), now Terminal No. 1.

of South America and its connection with England (Collard 2014), at a time when steam navigation was reaching a global scale (Duncan 1975).

The wooden steamers *Perú* and *Chile* were the first vessels owned by the PSNC to arrive in Chile, laying anchors in Valparaiso in October 1840 and marking the beginning of commercial steam navigation service along the west coast of South America (Collard 2014; Duncan 1975; Haws 1990). Technical innovations (like the introduction of iron hulls in their fleet, the usage of compound engines or the introduction of electric lighting and refrigerated spaces), new routes and services, and a great deal of vision, led this company on an impressive path to becoming one of the companies with the largest merchant steamer fleets in the world, comprising 57 vessels as early as 1873 (Albion 1951; Collard 2014; Haws 1990; NML 2016).

In spite of local wars, economic disruption and new competition, the company was able to maintain its commercial development, so much so that by 1893 the first cargo vessels were commissioned in order to operate alongside the passenger fleet, whilst also starting a process of modernisation and expansion on the latter vessels, including luxury passenger liners such as the SS *Orcoma* in 1908 (Collard 2014; NML 2006).

The introduction of new railways connecting major cities, the First World War, the opening of the Panama Canal, the reserving of the coastal trade by the Chilean government, and the onset of the Second World War, contributed to the slow decline of the PSNC, although it still operated through the second half of the 20th century (McGarry 2006; NML 2016).

S3-4 PV: an underwater archaeological site

In 2011, a dredging project under archaeological monitoring at Terminal No. 1 of Valparaiso, designed for handling container vessels and multi-purpose vessels, revealed evidence of an extensive underwater archaeological site located between Berths No. 3 and No. 4. Designated S3-4 PV, the site proved to be an extensive activity area or refuse site located contiguous to the seaward or exterior line of piles of the Fiscal Mole (Figure 2).

A rescue archaeology project was undertaken during 2011, which included monitoring of backhoe dredging operations and underwater archaeological survey and recovery of disturbed finds after dredging activities. In 2012 underwater test excavations conducted revealed dense archaeological deposits containing ceramic, glass, metal and organic material. Under controlled conditions, a large and diverse assemblage comprising 1716 finds dating to the late 19th century and early 20th century related to shipping activity was recovered (ÀRKA 2012). The remains included ceramic tableware and other wares, liquid and food glassware and ceramic containers, pharmacopoeia containers, and personal items. Building materials including bricks and cement barrels were recorded, as well as coal and patent fuel blocks. The overwhelming majority of the material culture exhibited an apparent British origin, most prominently institutional ceramic wares, glassware and cutlery pertaining to the PSNC.

During 2015–2016, new rescue archaeology operations conducted during the construction of an extension of the terminal included the selective recovery of diagnostic artefacts and new stratigraphic data. Although site formation processes affecting wharf and jetty sites have not been thoroughly investigated, the factors affecting the archaeological record of S3-4 PV are probably similar to those described in the literature, with refuse disposal practices including wastes being intentionally dumped into the Valparaiso harbour, while other elements were lost either from the waterfront or from moored vessels. The materials deposited on the seafloor were later disturbed by natural and cultural post-depositional processes, generating primarily secondary contexts.

Ultimately, the archaeological evidence of site S3-4 PV as an activity area connected to the Fiscal Mole of the port of Valparaiso has been highlighted as a primary source of information on food consumption and discard patterns, hygiene standards aboard steamships moving from Europe to South America, among other research issues. In addition, the S3-4 PV has provided a more precise understanding of the organisation and use of space within the harbour and the historical evolution of Valparaiso's waterfront (Carabias 2015).

Material and methods

Site S3-4 PV Ceramic Assemblage

The analysis methodology used for this research was based on the methodological model proposed by Brooks (2005), which divides the ceramic analysis in two levels of identification and analysis: a first level, which deals with the study of paste, shape, decoration and date; and a second level, which addresses deeper socio-cultural aspects such as economy, status, function and meaning.

The analysis of the ceramic assemblage from the site S3-4 PV associated with the PSNC centred on the first level, registering the decoration and all the information present on the body of each sherd by classifying the patterns, maker's and registration marks. Paste and form were not considered in this preliminary identification mainly because the paste is irrelevant to the analysis of English pottery produced after 1830, due to the gradual change between different pastes and standardisation of the ceramic types (Brooks 2005; Brooks 2016; Sussman 1977). It should be remembered that the wares analysed here are assigned to the period of use and operation of the Valparaiso Fiscal Mole (i.e. late 19th—early 20th century).

On the other hand, the form was not a relevant aspect to consider at this stage of the analysis, beyond being able to define to which group of ware each sherd belonged: dinnerware, tea ware, or toilet ware. Considering this, the methodology was adjusted to developing the identification level defined by Brooks (2005), and postponing as a later research aim, the socio-cultural aspects considered in the second level of analysis.

Therefore, the first stage consisted of the identification and systematic recording of each of the recovered sherds by looking for the marker's marks (Majewski 2002), type of decoration, pattern names and other marks present (n= 585). Thus, it was possible to identify two manufacturers associated with the PSNC's institutional ware (n = 436): Mintons (1793–present) and F.E. Bodley & sons Longport (1881–1898). Furthermore, it was also possible to identify those stamps associated with the designs and names of the patterns.

This was followed by the review of primary and secondary sources, which provided information associated with each of the manufacturers, allowing us to establish with precision, what corresponded to each of the marks found and the origin of the pottery. Such is the case of the makers and registration marks associated with the Minton tableware, which relate to the manufacture date of each piece, each cypher represents a production year ranging between 1842 and 1942. These were usually accompanied by an uppercase letter, which in turn corresponds to the month of manufacture. Also, it was possible to identify an alphanumerical code painted in red, as the series/category code of the pattern used on each artefact (Atterbury 1990; Godden 1966, 1991 and 199; Kowalsky 1999; Minton archive 2016).

On the other hand, the first research stage in which the names of the patterns were identified, allowed us to associate each of the sherds that presented transfer to a particular pattern name, thus, allowing us to assign production ranges for the sherds without marks based on the earliest and latest manufacture date allocated to each of the analysed patterns (Brooks 2005). Finally, the pieces with the highest percentage of completeness recovered during the monitoring activities served as a reference collection for the identification of forms. This procedure was supplemented by a review of historical catalogues of tableware (Adams and Strickland 1891; Mintons Limited 1884), food and serving table manuals (Allen 1915; Beeton 1899).

This way, it was possible to accurately date 69 items associated with the PSNC's institutional ware through the analysis of the year cypher. 43 items were dated using the production ranges associated with the manufacturers' printed globe mark, which was also

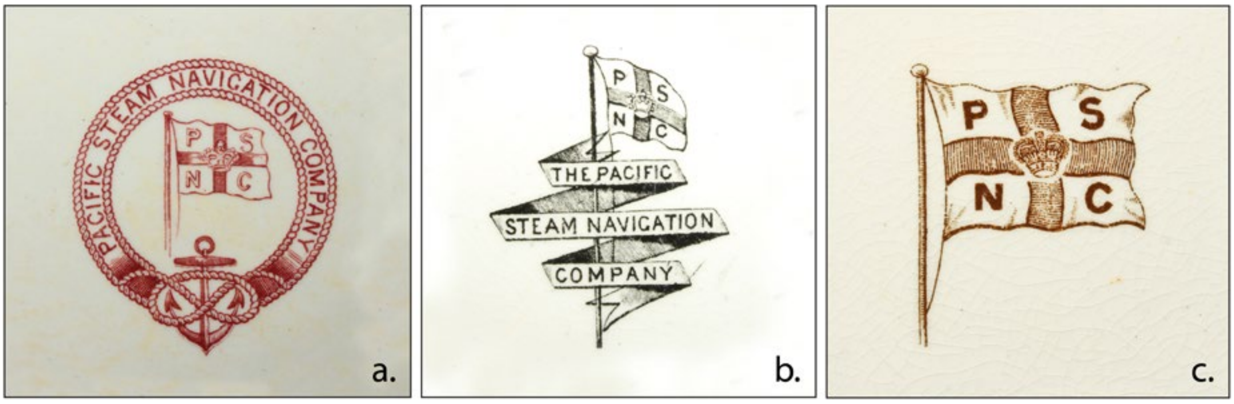

Figure 3. Different transfer-printed PSNC logos found within tableware of the S3-4 PV ceramic assemblage: a) PSNC burgundy house flag with stocked anchor and Stafford knot motif by E. F. Bodley & Son. b) PSNC black flag and ribbon present on Alton wares by Minton. c) PSNC brown flag, recorded on Putney wares by Minton (Photos V. Sepulveda).

compared to the established dates for the pressure marks 'MINTON' and 'MINTONS' (Atterbury 1990; Godden 1966, 1991 and 1999; Minton archive 2016). For the rest of the sherds that did not present year cypher and mark (n = 324), production ranges were assigned based on the earliest and the latest date provided by the analysis of the assemblage.

Results

A total of 17% (n=10) of the overall assemblage, all of them transfer-printed vessels made by British potters, feature the PSNC company logo (Figure 3). Once these distinct logos could be positively matched to a particular decorative pattern and manufacturer, it was then possible to infer the total presence of institutional wares of the PSNC by sherd count at the assemblage: 74,5% (n = 436).

Within the assemblage, commissioned pottery pertaining to other British and also German and Chilean shipping companies and institutions was recorded, including the Kosmos Line, HAPAG, Peninsular and Oriental Steam Navigation Company, Greenock Steamship Company, Braun & Blanchard, among others. However, this material only accounts for 2.2% by sherd count (n = 13) of the total assemblage, stressing the overwhelming majority of the PSNC institutional wares.

Another important aspect of the analysis relates to the pottery manufacturers, the large majority of which were British Staffordshire district potters. In fact, 67.7% (n = 396) of the overall assemblage was produced by the Minton Company. Created in Stoke-on-Trent in 1793, this firm is a long-lived company still producing pottery today. Skilful work, detailed decoration and designs, high quality refined earthenware and porcelain, and innovative techniques, soon made Minton a renowned name in the industry, producing and selling their wide range of products throughout Europe and the Americas (Atterbury and Batkin 1990; Godden 1966; Jones 1993).

At least six different PSNC tableware patterns were identified within the S3-4 PV ceramic assemblage (Figure 4 and Table 1).

Although moderately small by sherd count (n = 14) and accounting 2.4%, an unidentified pattern produced by E. F. Bodley & Son was recorded (Figure 4a). These tableware ceramics have a burgundy transfer pattern with the shipping company's logo. Decorative motifs on the interior and exterior of the rims comprise a continuous rope design and an inner continuous chain design. The PSNC flag is surrounded by a rope band displaying the company's name. At the base of the band, a stocked anchor is placed at the centre of a Stafford knot. The Stafford knot motif was originally used in 1845 but became most popular during the 1870s and 1880s (Godden 1964: 552). It is considered one of the most recurrent English device marks (Majewski 2002: 363; Majewski and O'Brien 1987: 166).

Maker's marks underneath the base include impressed marks and the transfer printed 'E.F. BODLEY & SON LONGPORT' and the words 'GENUINE IRONSTONE CHINA' above. The first refers to Edward Fisher Bodley & Son, pottery manufacturers based in Burslem, Staffordshire, who were in production between 1875 and 1898 (Godden 1991). The latter was a trade name introduced by Stoke-on-Trent manufacturers for a durable and affordable alternative to Chinese porcelain; 'ironstone china' was widely used throughout the 19th century (Barker 2002: 336). According to Godden (1999: 199), 'GENUINE IRONSTONE CHINA' was manufactured by E.F. Bodley & Son between 1881 and 1898.

Dating evidence based on marks and stamps help to place the date of manufacture of this pattern between

Table 1. Patterns recorded on the PSNC institutional wares.

Pattern Name	Pattern Number	Manufacturer	Description	Manufacture Date Range
Unidentified	-	E.F. Bodley & Son	Underglaze burgundy transfer print. Rope, chain, Stafford knot and stocked anchor motif. Refined white-bodied earthenware.	1885–1893
Iolanthe	-	E.F. Bodley & Sons	Underglaze blue transfer print. Geometrical bands with floral/foliage motif. Refined white-bodied earthenware.	1882–?
Alton	-	Minton	Underglaze black transfer print. Zig-zag and geometric bands with foliage motif. Refined white-bodied earthenware.	1872–1915
Ulster	C4386	Minton	Underglaze brown transfer print and red/burgundy painted decoration. Floral/foliage motif. Refined white-bodied earthenware. 'Feather edge ware'.	1873 –1907
Inverness	-	Minton	Green and red/burgundy transfer print. Lineal and floral/foliage motif. Refined white-bodied earthenware.	1850–1925
Putney	C4675	Minton	Underglaze brown transfer print and blue, yellow, green and gold painted decoration (enamelled). Lineal and floral/foliage motif. Gilding. Refined white-bodied earthenware.	1888–1920

Figure 4. Transfer-printed wares, manufacturer's names and stock designs present on the PSNC tableware: a) Unidentified pattern. b) Iolanthe pattern. c) Alton pattern. d) Ulster pattern. e) Inverness pattern. f) Putney pattern (Photos V. Sepulveda).

1885 and 1889, approximately contemporaneous to the first years of activity of the Valparaiso Fiscal Mole. Similar material has been presumably recovered by divers from the remains of the SS *Illimani*, a PSNC steamship lost in 1879 near Mocha Island (38°23'S), off the central-south coast of Chile. In addition, a ceramic assemblage 'decorated with a rope pattern and the inner with a chain pattern', stamped 'GENUINE IRONSTONE CHINA' and printed 'BODLEY & CO., BURSLEM' with a Stafford knot design has been recently reported for SS *Phønix*, a Danish steamer foundered on the Snæfellsnes Peninsula, Iceland (Edvardsson and Egilsson 2015: 199).

The Iolanthe pattern (Figure 4b) is formed by an excessively small group by sherd count (n = 4) accounting 0.7%, and only represented by two plates, an eggcup and one teacup. These items exhibit a blue transfer pattern and the PNSC logo. Decorative motifs on the interior and exterior of the rims comprise geometrical bands and foliage/floral motifs. The PSNC waving flag comprises a cross with a king's crown in the centre and the letters 'P S N C' in the quarters. The flag pole is encircled by a zig-zag flat ribbon displaying the company's name. One base sherd has printed marks featuring the name and place of the firm and the same 'GENUINE IRONSTONE CHINA' designation. The pattern was made by E.F. Bodley & Sons. No impressed backmarks are present.

The Alton pattern manufactured by Minton (Figure 4c) is the most frequent decoration pattern by sherd count (n = 332), accounting for 56.8% of the overall assemblage. The ceramic tableware features a black transfer pattern with the shipping company's logo. The latter is the same design present on the Iolanthe pattern wares. Decorative motifs on the interior and exterior of the rims comprise geometrical bands featuring foliage (acanthus) and zig-zag designs. The bases are marked with the Minton globe and crown transfer mark bearing the word 'ENGLAND' below and impressed/printed marks. The inclusion of 'ENGLAND' in a mark owes to commercial legislation and commonly indicates a manufacture date after 1891, but some potters adopted the convention as early as the 1880s (Majewski 2002: 365; Majewski and O'Brien 1987: 167). One example featured a transfer printed motif with the word 'ALTON' displayed on a ribbon as a back mark. According to the Minton Archive (2016), prints without any colour decorations never seem to have been given a pattern name or number.

The Alton pattern group covers a range of functions. The primary function is food serving and consumption, represented by different forms: dinner plates, meat plates, bread plates, soup bowls, vegetable dishes and round comports and eggcups, among others. Teaware and coffeeware include cups and saucers. Hygiene-related forms are rare in the assemblage, represented by three spittoons and one chamber pot. The dating evidence based on back stamps and year cyphers suggests the Alton pattern group manufacture date range coincides roughly with the period of activity of the Valparaiso Fiscal Mole.

The Ulster pattern group (Figure 4d) accounts 2.9% by sherd count (n = 17), being represented by feather edge ware with a brown transfer print pattern and red/burgundy hand painted decoration with the shipping company's logo. Decoration motifs on the interior and exterior of the rims comprise floral/foliage designs. These ceramics exhibit the PNSC logo design present both on the Alton and Iolanthe pattern wares, in brown transfer. Backmarks include the Minton globe transfer mark without a crown, with the word 'ULSTER' displayed on a ribbon underneath and the word 'ENGLAND' below. Forms included in the Ulster pattern comprise bowls, dinner plates, bread plates and soup bowls.

Accounting 7.2%, the Inverness pattern (Figure 4e) is the second most frequent decoration pattern by sherd count (n = 42). The ceramic tableware items in this group feature interior green transfer printed and red/burgundy painted decoration with lineal and floral/foliage motifs. Back marks include the Minton globe transfer mark with the word 'INVERNESS' displayed on a ribbon underneath and the company's logo to the left. The latter is comprised of a green transfer printed PSNC waving flag design. However, no company logo is included on the exterior or interior of the wares. Some items feature the word 'ENGLAND' underneath the Minton globe and crown mark instead of the pattern's name, suggesting a post-1880 manufacture date. Inverness wares are restricted to the forms related to the consumption of food and beverages, and particularly tea and coffee services.

The Putney pattern group (Figure 4f) only accounts for 0.7% of the assemblage by sherd count (n = 4). Decoration motifs around the rims comprise brown transfer pattern and a blue, yellow, green and gold painted decoration with the company logo. Decoration motifs show lineal and floral designs. Back marks include a Minton globe and crown transfer mark surrounded by a wreath and 'EST. 1793' with the word 'PUTNEY' displayed on a ribbon underneath. In addition, the central PSNC logo on the interior is represented by a waving flag in brown transfer, without the company's name included. The PSNC logo design is the one included at the base of the Inverness pattern wares.

It is worth noting that sherds (n = 3) corresponding to plain plates except for a central black transfer-printed PSNC logo with a ribbon underneath featuring 'ORIENT LINE' were recorded within the assemblage. In 1877, PSNC steamers were used on a new London-Australia service in partnership with Anderson, Anderson & Co., which would eventually become the Orient Steam Navigation Company (Collard 2014; Haws 1990). Minton manufactured this tableware and the backmarks include the Minton globe and crown transfer mark present on the Alton pattern wares. In addition, the PNSC logo design is the one included on the Alton, Iolanthe and Ulster pattern wares.

Finally, it must be noted that refined red earthenware sherds (n = 20) with black-glazed, gilding and enamel decoration with floral/foliage motifs corresponding to teapots, sometimes referred to as 'Jackfield' wares, were recorded within the assemblage. These vessels feature the PSNC logo common to the Alton, Iolanthe and Ulster pattern wares. No maker's marks were identified.

Discussion

The results obtained throughout this research support the dominance of late 19th and early 20th-century British ceramics within the S3-4 sample, with nearly three fourths of the total assemblage corresponding to PSNC institutional wares, emphasising the dominant presence of this powerful company in the port of Valparaiso. These are typically refined white-bodied tablewares featuring transfer-print decoration. The production is concentrated in two Staffordshire potters, E.F. Bodley & Son and Minton, the latter responsible for the overwhelming majority of the wares. The dating of the manufacture is in general in good agreement with the operation period of the Fiscal Mole, roughly *c.* 1885–1925.

Regarding the reliability of dating, discrepancies between the printed company insignia and the impressed date of manufacture became apparent in the course of research. According to Atterbury and Batkin (1990: 324), 'the printed globe mark was used

Figure 5. Blue and white transfer ware recovered at site S3 PV (1855): a) Paddle steamer and mountainous landscape, surrounded by the words 'PACIFIC STEAM NAVIGATION COMPANY 1840', printed at the base. b) Italian pattern decoration on the interior (V. Sepulveda).

on all categories in various colours and forms from the mid 1860s. It started as a plain globe, a crown was added in the early 1880s and the word England in 1891, becoming 'Made in England' with wreaths in, *c.* 1912'. While the post-1891 globe mark with a crown and the word 'ENGLAND' is included on the Alton, Ulster and Inverness patterns, some vessels in these groups exhibit year cyphers that correspond to earlier range dates of manufacture, going back to the 1870s and even 1850s.

These inconsistencies could partly be explained by the nature of the manufacture process itself. Given the sheer size of production carried out in the Minton factory, having a workforce of nearly 1800 in the early 1880s (Atterbury and Batkin 1990: 18), all the different processes involved in the manufacture of the wares were carried out in a series of plants, workshops, and warehouses (i.e. clay making and pressing plant, mould-making shop, jolleying shop, biscuit placing warehouse, dipping house, decorating shop, printing shop, engraving shop). This meant that, before the final decoration pattern was applied, any given stores could be kept in a warehouse for a considerable length of time, therefore creating a discrepancy between the impressed date of manufacture and the printed company insignia. In other cases, the timespan is so significant that an error in the application of the impressed marks can be inferred, or at least, incomplete or imprecise year cypher information can be inferred.

One important aspect of the results is the dominance of Minton's pottery in the S3-4 PV assemblage. While Minton's history as pottery manufacturer has been researched (Atterbury and Batkin 1990; Jones 1993), the study of this company's production has concentrated on fine porcelains (Godden 1999: 291). However, primary documentary data confirms that the Stoke-upon-Trent firm developed a department especially for ship's crockery and the supply of clubs, hotels and restaurants (Pottery Gazette 01/12/1894). In fact, by 1893 Minton was not only the sole supplier of china and earthenware to the PSNC, but also to other leading British steamship lines including the Cunard Steamship Company, White Star Company, the African lines, the Red Cross Line, Canadian Steamship Company, Ducal Line, Naval Construction and Armament Company, among others (Pottery Gazette 01/06/1893). Furthermore, Minton developed innovative forms specially designed for steamship use. The latter included a new-shaped dinner plate with a deep concave rim and cup and saucer. The cup was made to fit in the well of the saucer, which was made for extra depth for the purpose of keeping the cup firm even in the worst sea. These improvements were applied in breakfast cups and saucers, teas, after-dinner coffees and soup bowls (Pottery Gazette 01/06/1893).

The use of commissioned pottery by British shipping companies, particularly passenger lines, has been dated to the first half of the 19th century (Jarret and Thompson 2012: 106). Interestingly, in the case of the PSNC, two fitting sherds of a blue transfer-printed dinner plate recovered from site S3 PV, the wreck site of the *Infatigable*, a Chilean Navy transport sailing ship lost in the harbour of Valparaiso in 1855 feature a central PSNC logo at the base. The device depicts a paddle steamer sailing with a mountainous landscape surrounded by a circle displaying 'PACIFIC STEAM NAVIGATION COMPANY 1840', while the interior of the vessel features an Italian pattern scene (Figure 5).

However, this evidence does not suggest a PSNC institutional ware. In fact, the design probably commemorates the arrival of the first steamers of the company, SS *Chile* and SS *Perú*, which inaugurated steamship navigation along the Andean Pacific coast in 1840. In effect, in a similar way to Wheelwright with the first two steamers of the PSNC, in 1840 Samuel Cunard of Halifax succeeded in carrying mail and passengers on schedule from Britain with a fleet of wooden paddle-wheeler steamers through the Atlantic to Canada. The accomplishment of this new progress was celebrated by Staffordshire potters who produced earthenware patterns depicting the interior arrangements of the ships, passenger life on board and steamship devices and patterns named after the Cunard vessels. These wares were made for general sale, not for use aboard the steamers themselves (Collard 1983: 33–38).

The identification of the institutional wares of the S3-4 PV ceramic assemblage has allowed a first characterisation of the tableware used on board the vessels of the PSNC, the main steam shipping company operating along the West Coast of South America during the late 19th and early 20th century. Although the sample is still limited and further ceramic analysis is required, the archaeological data is in general good agreement with the operation period of the Fiscal Mole, confirming the coherence of the assemblage. Considering the diagnostic condition of steamship crockery, the patterns identified might prove useful for maritime archaeologists studying PSNC wreck sites along the intercontinental and continental maritime routes, but also other wharf and jetty sites located in areas along the west coast of South America where the company maintained important facilities, like the port of Callao in Perú, or Taboga island, in Panamá.

Conclusions

Site S3-4 PV ceramics assemblage offers primary archaeological data on the institutional wares used on board the vessels of the Pacific Steam Navigation Company and other steamship companies employing the Valparaiso Fiscal Mole during late 19th and early 20th century. Preliminary evidence suggests that British Staffordshire refined white-bodied tablewares featuring transfer-print decoration are dominant in the archaeological record. Although further analysis is ongoing, the assemblage has considerable potential for exploring relevant research issues, including steamship crockery supply, use and discard, food and beverage serving and consumption aboard and the cultural interaction between South American and British dining traditions and worldviews. Determining the date of manufacture and identifying decorative patterns is considered to be an important first step for further ceramic analysis.

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Sensory Navigation in the Roman Mediterranean: the Levantine and Ionian Seascapes

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Abstract

Sensory navigation is well documented within ancient geographical narratives, but there is a lack of research driven from an archaeological perspective. This research illustrates ancient mariners' dynamic relationship with the sea in the eastern and central Mediterranean in Roman antiquity. It adopts interdisciplinary methods drawing on ancient textual evidence in conjunction with supporting archaeological, environmental and geospatial data. Applying the theoretical concept of 'common-sense geography', it emphasises the practical experience and mental-mapping of ancient mariners as the primary source for ancient geographers' conceptualisations of maritime travel. This allows the identification of the diverse ways the senses were used as cognitive navigational tools while sailing and interacting with the sea. This research is depicted through hypothetical journeys within the case studies of the Levantine and Ionian Seas using ancient authors' sea-journey descriptions, applying an archaeological framework. These regions present a high degree of variation, physically and conceptually, while the nature and scale of navigation are examined in relation to regional maritime conditions, harbours, activities and seafaring routes. A geospatial analysis is conducted using ArcGIS/QGIS, illustrating a bird's-eye-view along with three-dimensional maps of each seascape. This emphasises contrasting elevations along the coastlines, revealing how the landscape may have been divided into distinguishable navigational markers aiding ancient mariners' orientation in antiquity. This research demonstrates a more intimate insight into 'experiencing' the Roman maritime cultural landscape.

Keywords

Archaeology, Roman, navigation, sensory, GIS

Common-sense geography and navigation

The phenomenological experience of ancient mariners is the primary source of evidence used by ancient authors in their narrative descriptions of maritime travel. The significance of mariners' sailing experience can, thus, be traced within the corpus of information assembled by ancient geographers (Arnaud 2014: 39, 2011; Kowalski 2012), reflecting how geographers' notions were likely shaped by mariners' common-sense geography based on practical knowledge (Geus and Thiering 2014: 39–40, 2012). This approach draws on implicit knowledge cues and mental-maps inherent within ancient sources.

This investigation is framed by an interdisciplinary approach integrating theoretical concepts of sensory navigation and common-sense geography, in conjunction with data from ancient texts, archaeological evidence, modern pilots and digital geospatial analysis. In demonstrating how mariners navigated the Mediterranean using their senses it is vital to consider past notions concerning spatial movement, along with the assumed cognitive implicit knowledge (Thiering 2012: 12). This will offer a more vivid insight into ancient perceptions of the maritime cultural landscape (Westerdahl 1992) and demonstrate various modes of orientation and decision-making using the senses as navigational tools in the Levantine and Ionian seascapes. This work draws on findings from a wider research project and aims to highlight the need to re-evaluate the available data through a fresh approach that builds on the sensory experience of ancient mariners.

Context: ancient sensory navigation

Navigational indicators and mental maps based on sensory perceptions and experience were probably used by ancient mariners along familiar journeys. The main orientation techniques in the past were pilotage (coastal/inshore) and celestial navigation (Lewis 1994: 45, 79–83; Davis 2002: 219–309). Building on Ingold (2000: 237, 242), a way-finder or mariner's sensory interaction with the maritime cultural landscape is varied and continually advances, adapting over time through accumulated experiences and memories. Geographers could in turn draw a more practical account from such

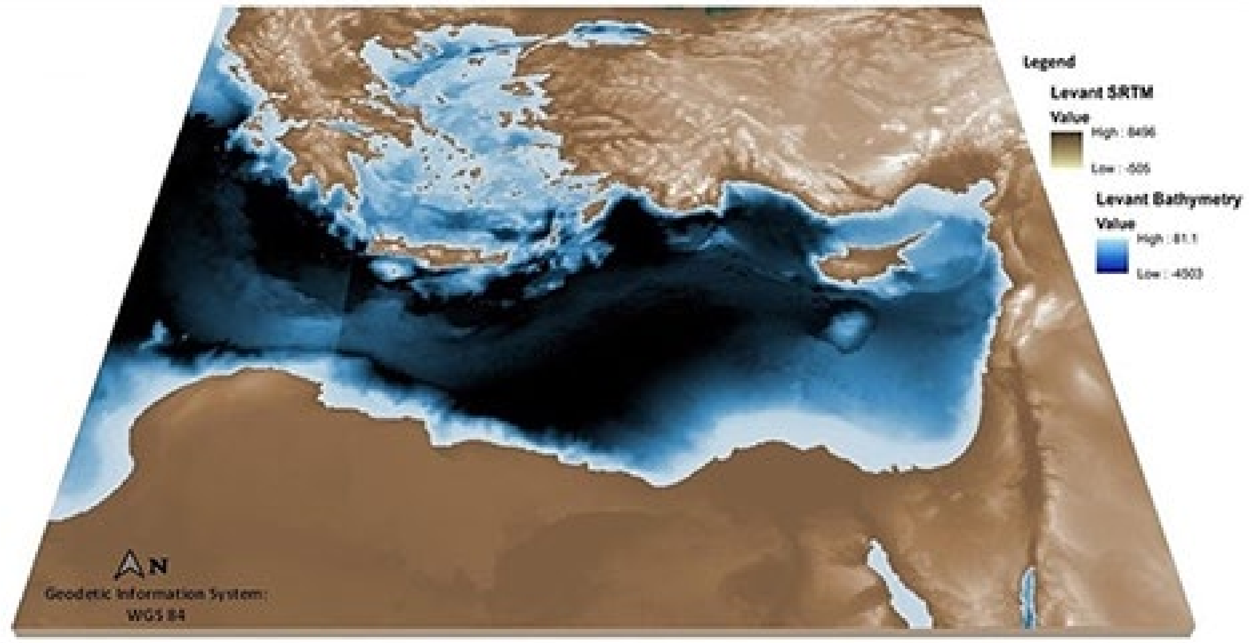

Figure 1. Case study regions: the Levantine and Ionian Seas (3D map by authors using QGIS 2.8.2. DEM: SRTM_1km).

first-hand insights. Natural and artificial landmarks were key navigational aids for ancient seafarers (Morton 2001: 185–214). Landmarks played a structural role in ancient mariners' understanding of the seascape, and subsequently geographers' arrangement of this space, often featured in *periploi* and geographic treatises describing harbours or journeys on a coast (e.g. *Periplus Maris Erythrai*). Natural markers of sensory navigation alluded to in ancient sources included: physical features (elevated and chromatic points, river mouths, islands), sky observations (birds, clouds, stars, constellations), and sea behaviour, sounds and smells (surf break, changes in shape/direction of swells/waves, land smells). Artificial structures included shrines, towers and lighthouses. Seamarks (stakes, pillars) were at times used to warn of shallows or submerged reefs (Herodotus 7.183).

Evidence for navigational and sensory markers can, thus, be drawn from ancient texts on sea travel, combined with archaeological data, physical landmarks, meteorological conditions and toponyms. Further links can be traced in ethnographic studies of Micronesian and Polynesian navigators who orient themselves via a highly developed navigational system without navigational instruments, as attested by experimental Pacific Ocean voyages in replicas of ancient local boats such as the *Hokule'a* (Gladwin 1970; Hutchins 1983; Oatley 1977). Their system encompasses relatively extensive knowledge of meteorological conditions and astronomy (celestial navigation), allowing them to sail longer distances using *star compasses*, based on a *mental triangulation* of memorised star-risings or settings known as 'star paths', while incorporating a *phantom* or *emergency island* (Davis 2001: 177–85; Gladwin 1970; Lewis 1994: 94–7; Thiering 2012: 14, 33). Micronesians used the *etak* system based on distances measured by time segments/durations, comparable to the ancient Greeks' early measurement units (Arnaud 2014: 41–46). On a different but related note, in terms of meteorology, during spring and summer (Beresford 2013: 64; Tammuz 2005: 145) the Mediterranean is subject to recurrent wind storms, which haptically[1] blow a visually impairing amount of dust and sand over its atmosphere (Davis 2001: 48; Russo *et al.* 2009: 117). This reduction in navigational visibility causes a loss of most natural references and celestial orientation. Consequently, ancient mariners began to recognise and sense weather patterns associated with an approaching storm. Aristotle even notes the distinct smell of the southerly *Notos* wind (26.17). References to favourable winds occur regularly in ancient accounts, and mariners in the Graeco-Roman world were familiar with navigational aids of local land/sea breezes (Arnaud 2014: 51–8; Leidweinger 2013: 3303–5; Morton 2001: 51).

Case studies: the Levantine and Ionian Seas

This research is depicted through hypothetical journeys in the case study regions of the Levantine and Ionian Seas during the Roman period (*c.* 1st century BC to 3rd/4th century AD, Figure 1). The journeys were devised using travel descriptions of ancient authors,

[1] Haptic extends beyond straightforward skin contact to include internally felt bodily sensations (Paterson 2009).

applying an archaeological framework (detailed methodologies in Obied 2016 and Lopez 2015). The case studies present a high degree of variation, physically and conceptually, while aspects linked to the nature and scale of navigation are examined in relation to regional maritime conditions, harbours, activities and seafaring routes. Building on notions of seascapes and *maritime cultural landscapes* (Horden and Purcell 2000: 11, 123–72; Westerdahl 1992: 6), these regions are perceived here as part of a 'political seascape' (Lopez 2015: 12, 92), encompassing the dynamic socio-political/economic setting of topographical features along the coast. A geospatial analysis is conducted using ArcGIS/QGIS, illustrating a bird's-eye view of the regions along with three-dimensional maps of each seascape. This emphasises contrasting elevations along the coastlines, revealing how the landscape may have been divided into distinguishable navigational markers to aid ancient mariners' orientation. It is, thus, crucial to consider the main local meteorological conditions and patterns affecting seafaring by accounting for the coastal topography, shelter, potential hazards and entering/leaving harbours *en route*. In light of the various parameters on a journey, chosen landmarks and tentative routes proposed should be perceived in the context of 'optimum sailing journeys' under 'favourable conditions', as a means of comparing and depicting ancient authors' representations of a journey (see Arnaud 2005: 61–96, 98–197; Casson 1951: 143; McGrail 1987: 275; Palmer 2009; Whitewright 2011: 3–15).

Theoretical: Levantine Sea

The Levant offers the broader theoretical scope, which is then applied to Albania for a more focused and practical comparable case study. The Levantine coast's distinct physical geography played a key role in the development of its maritime cultural landscape, serving as a major crossroad of communication and trade throughout antiquity linking the continents of Europe, Africa and Asia (Blackman 1982; Cline 2003: 364; Frost 1972; Carayon *et al.* 2011; Galili *et al.* 2002). Its varied character and strategic role offer a suitable theoretical framework for examining different aspects of spatial orientation, modes and scale of travel/navigation, and shifting views of the seascape.

Practical: Ionian Sea

The theoretical framework advocated for the Levant was applied during the 2016 Albanian Marine Science Expedition, conducted along Albania's southern coast with an international team of marine archaeologists and ecologists.[2] The Corfu Strait served as a pivotal point in trans-Mediterranean seafaring in the Roman period, with Albania lying in a strategic geo-political position between the Ionian and Adriatic Seas (Arnaud 2005: 194–205; Jurisic 2000: 49; Royal 2012: 448). In this context, it would seem ideal for ancient mariners to navigate via the Corfu Strait based on the influence of the natural environment within this 'political seascape' (Lopez 2015: 12, 92).

Navigating the Levantine seascape

The Levant comprises a series of micro-regions characterised by its diverse geography and geology, ranging from the mountainous coast in the NW to the arid coastal plain in the SE. The northern Levantine coast, with its mostly westward-facing aspect, is exposed to prevailing westerly winds (Blue 1995; MPV 2005: 25). The most advantageous location for harbours and anchorages would, thus, be in the lee of an off-lying island, promontory or reef sheltered from the west. An awareness of the diurnal cycles is crucial for navigating the Levantine coast, particularly in assisting the entering/leaving of a harbour and offering flexibility in mariners' capability to sail in unfavourable conditions or against prevailing winds. Ancient seafarers perceiving the coast from the sea relied on familiar landmarks such as elevated or chromatic points, river mouths and islands (e.g. Ptolemy 4.5.7, 4.5.15; Pseudo-Skylax 67.31; *Stadiasmus Maris Magni* 139) (Figure 2).

Elevated and chromatic features

Mariners sailing the Levant often perceived the coast as a series of connected anchorage nodes with linked features forming a continuous reference line. Along the northern Levant's mountainous coast, ancient authors distinguish elevated landmarks such as Mount Casius and Anti-Casius (Figure 3), where they allude to the voice of a local/traveller observing the landscape from a mountain-top (Pliny, *NH* 5.18; Mela 1:61; *Stadiasmus* 144–5). A boundary-marker between Seleucia and Laodicea (*Stadiasmus* 143), Mount Casius functioned as both a navigational and sacred landmark for mariners, associated with Zeus Casius (Cohen 2006: 127–8).[3] Coastal shrines and towers were often located on promontories clearly visible from the sea, serving as valuable artificial landmarks between Levantine harbours. They were often associated with religious or defensive symbols, connecting mariners with their holy patrons that guided them on journeys (Brody 1998; Morton 2001: 200; Semple 1927).[4] Additional

[2] Directed by Dr P. Campbell (University of Southampton/Albanian Center for Marine Research) with N. Ceka (Albanian Institute of Archaeology), National Coastal Agency, Albanian Navy & Deep Blue Explorers. See 'Submerged Heritage 2017'.

[3] Temples found near Seleucia of Zeus, Apollo and Seleukid kings. Evidence of Zeus Casius worship on Mt Casius includes Roman imperial coins with a sacred stone symbol and Graeco-Roman tiles stamped with Zeus' name (Cohen 2006: 127–8).

[4] Excavated examples at Nahariyah, Ashkelon, Mevorakh, Makmish, Tell Sukas, Kommos, Capo San Marco, Kition and Ras ed-Drek show

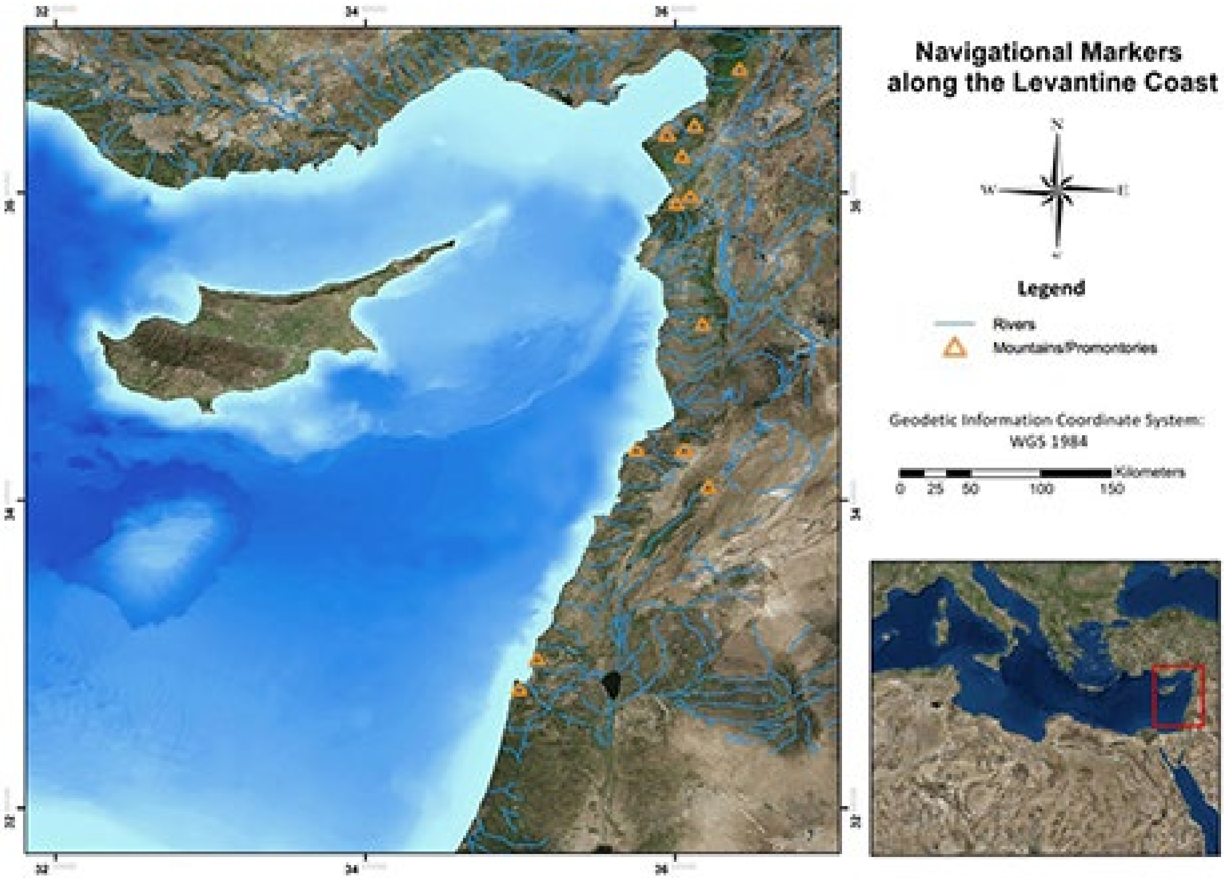

Figure 2. Navigational markers along the Levantine coast included mountains/promontories, rivers and islands (Map by authors using ArcGIS 10.2.2).

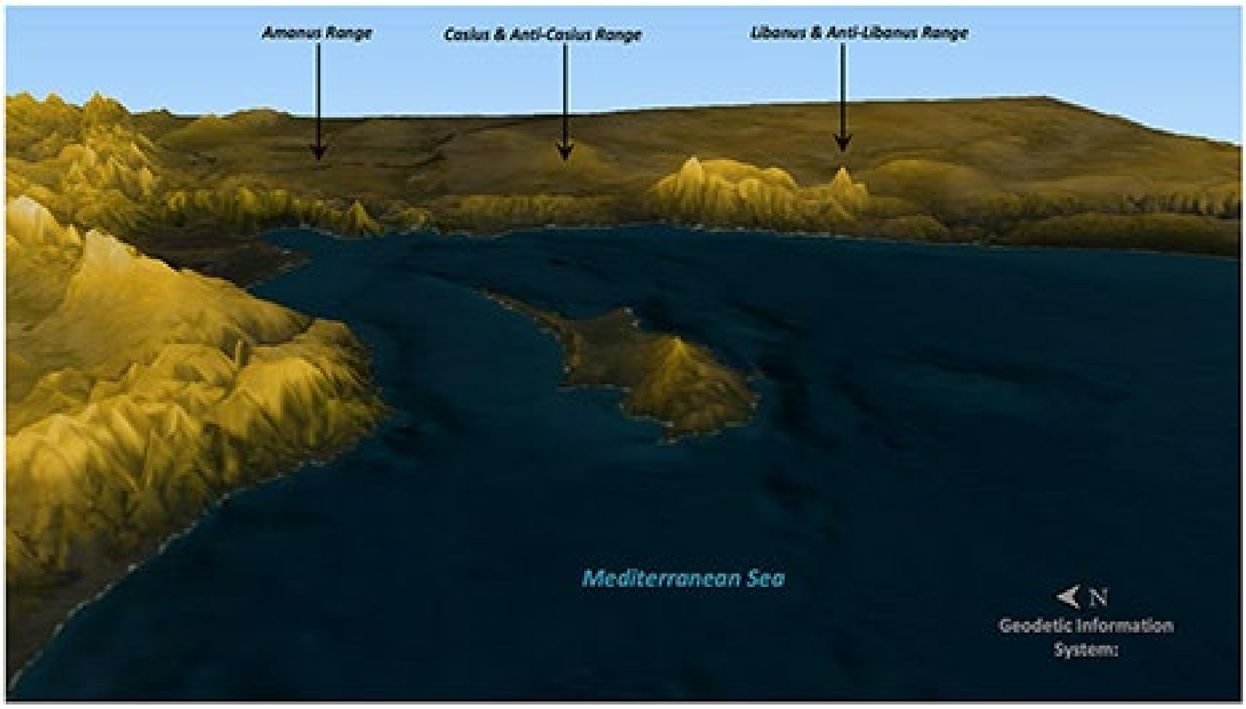

Figure 3. Navigational Markers: 3D Map of the northern Levant region, highlighting key elevations observed along this stretch of the coast from the sea (Map by authors using QGIS2.8.2. Basemap (©Bing Aerial Layer); DEM: SRTM_1km).

landmarks included Mount Amanus and the parallel Libanus and Antilibanus ranges. Furthermore, as 'white' capes, coasts and harbours were easily visible at a distance from the shore, such markers feature abundantly along key sea routes and ancient written accounts. Topographical markers are also reflected in the naming of familiar features based on such chromatic distinctions. *Stadiasmus* (139–40) mentions *Leukos Limen*, 'White Harbour' (Minet el-Beida, Syria) due to its white-chalk calcareous topographic nature, which 'when viewed from a distance to the S, this peninsula appears as a chain of rocky islets' (MPV 2005: 39; SDEEM 2011: 48; Pliny *NH* 5.17; Strabo *Geog.* 12.2.7).[5] The well-sheltered harbour complexes of Ras Ibn Hani, Minet el-Beida and Ras al-Bassit took advantage of the series of natural anchorages (estuaries, lagoons, bays and pocket beaches). Crossing to the southern Levant, the coast possesses far fewer elevated landmarks or distinct peaks to reference. Notable elevations include the 'Klimax Tyrian' Mountains (between the Adonis and Lycus Rivers) and the prominent Carmel promontory (Strabo, *Geog.* 16.2.19, 27; Pliny, *NH* 5.7.19; Ptol. *GH* 15.5).

Rivers and river mouths

In Greek and Latin periplographic traditions, as with the sea, rivers act as a reference to guide a reader along the landscape or journey (see Campbell 2012a). Strabo claims the 'best known [towns] are those situated on the rivers, on the estuaries, and on the sea...due to their commercial intercourse' (*Geog.* 3.2.1). Levantine coastal sites tended to be linked to a nearby river or stream (e.g. Orontes, Eleutheros, Adonis, Lycus and Crocodilon). Known/named rivers that could be distinguished on a journey led to river mouths often serving as anchorages, landmarks, boundary/distance-markers, fresh water sources and inland communication (e.g. *Stadiasmus* 145–48). Though the *Stadiasmus* frequently mentions fresh water sources for North Africa, such inclusions are absent for the Levant. Along northern Syria, the Orontes mouth served as a natural anchorage, represented in ancient sources as a major navigable river linking coastal-hinterland communication and trade. Additionally, vessels often used the *chôma,* a breakwater on the outside of a port, as a place for commercial exchange or unloading onto smaller vessels or barges moving upstream. This complex network was facilitated by secondary harbours along the coastal journey, as well as seaports functioning in tandem with fluvial harbours upstream, particularly with advanced maritime trade in the Roman era (Arnaud 2016; Blue 1997; Obied 2016: 152–4; Raban 1985). As rivers are shifting landscape features, changes in the coast and associated rivers often led to settlement adaptation, as at Akko/Ptolemais which caused a shift from the tel to the peninsula's bay where an artificial harbour was built (Artzy 2012: 6). The conditions of such fluvio-maritime secondary ports or moorings, thus, influenced the route choices, journey efficiency and settlement/harbour distribution of maritime communities.

Islands and palaeo-islands

At times less conspicuous features such as inshore islands could serve as useful intermediary navigational markers or stopovers *en route*, adding to knowledge of localised navigation (Thiering 2014: 296–98). Few islands are noted in the Levant in ancient sources, coinciding with the modern coast. The exception is the rocky island of Arados (with its παραλία/*peraia*) and several islets (Strabo, *Geog.* 16.2.12–3; *Stadiasmus* 128).[6] The island-state acted as a key navigational marker, offering shelter from prevailing winds and links with its mainland dependencies for water, re-supplies and trade. Recent geoarchaeological studies of *tombolos*/breakwaters and palaeo-landscapes (Carayon *et al.* 2011; Marriner *et al.* 2012, 2008) show that in the pre-imperial period certain harbour sites that used to be islands became attached to the mainland due to morphological coastal changes and artificial actions (e.g. Ras Ibn Hani, Sidon, Tyre). Though a mainland settlement in the Roman era, ancient authors reference Tyre's 'palaeo-island' and breakwater formations, stating that the island attached to the mainland due to a semi-artificial breakwater built by Alexander the Great in 332 BC (Strabo 16.2.22; Mela 1: 65; Pliny 5.17), corroborated by geoarchaeological data (Marriner *et al.* 2008: 378). Ancient references to islands and breakwaters thus reflect a level of understanding of dynamic coastal changes and human adaptation. Different types of Levantine anchorages and their capacity/affordance (Safadi 2015) would have influenced the impact of localised knowledge on a chosen sailing route, plus any stop-off points for re-supplies, *cabotage* or inland trade (Arnaud 2007; Robinson and Wilson 2011; Scheidel 2013).

These topographic and chromatic navigational markers thus create a reference framework to orient the reader as though sailing a journey (similar to the way a mariner would have in antiquity), in turn revealing the nature and conditions of navigating within this maritime cultural landscape. Whether undergoing short or long voyages, mariners would have applied sensory navigation as a means of creating mental maps while moving through the Levantine seascape.

physical remains of the shrines that marked routes throughout the Mediterranean (Brody 1998).

[5] For geoarchaeological evidence of this harbour complex, comparable to the neighbouring Heraclea/Ras Ibn Hani and Posidium/Ras al-Bassit sites, see Mariner *et al.* (2012: 35–6).

[6] Peraia were settlements or neighbouring island clusters politically controlled by island-states (Constantokoupou 2007; Obied 2016) at strategic points in relation to one another to create a platform for communication/exchange.

Archaeological record

Though extant navigational instruments are rare (e.g. Antikythera Mechanism), sounding-weights are extensively documented archaeologically (Galili *et al.* 2009: 344; Oleson 2008; Price 1974). Sounding weights were mariners' primary navigational tool from *c.* 6th century BC until the 12th century AD (McGrail 1983: 304; Oleson 2008:117–18). Sediment samples recovered from the seabed also revealed information of a more sensory nature, such as smell, taste, colour, contours and texture of the local topography and seabed from various positions at sea. In the Mediterranean, the archaeological record illustrates the instruments' various classes and types (see catalogue in Oleson 2008: 143–69). To expand on their sensory aspect, sounding weights offer vivid insights into past perceptions, revealing their influence in the decision-making process at sea. In early accounts, Herodotus (*c.* 440 BC) describes weights used for sounding and sampling (2.5.28). Paul's shipwreck narrative (*Acts* 27: 13–20, 27–32) provides one on the most descriptive surviving shipwreck accounts, and more significantly, it documents the use of a sounding weight to determine if the ship was approaching shallow water. This was likely a common practice in antiquity but is rarely noted in extant ancient texts. Perhaps the most intriguing and relevant aspect to sensory navigation is that 'the sailors suspected that they were nearing land' before their decision of 'casting the sounding weight [βολίσαντες]'. It is probable sailors sensed an upcoming change in the seascape before taking action (Oleson 2008 presents plausible 'sensings' that caused their action. See also Lucian's *Navig.* 7–9 in Davis 2009: 220). Their senses of sight, smell and sound likely influenced the sailors to cast a sounding weight to determine the severity of the situation, demonstrating the value of the senses and their use in an ancient maritime context.

Evidence of Roman sounding weights in the Levant has predominantly been found along the southern Levant's low-lying less-sheltered coastline. Significant cases include Dor, Appolonia and Caesarea (Oleson 2008). Further notable indicators of coaster wrecks and local sailing patterns on this exposed coastal stretch can be drawn from evidence of Roman anchors (e.g. Atlit, Appolonia, Yavneh-Yam, Ashkelon) and shipwrecks, such as the Tantura B Shipwreck (Dor/Tantura Lagoon), a Byzantine shipwreck hull lying on a large Roman shipwreck (Wachsmann *et al.* 1997: 6–7, 112). Additionally, papyrological evidence, though rare, yields valuable insights on the nature of trade and trading vessels. Small coaster merchant galleys, *akatoi/actuariae* (Rougé 1966: 60–1), were a predominant vessel type in the eastern Mediterranean, as attested by Papyrus Bingen 77 (early 2nd century AD – Heilporn 2000: 342–6). Thisrecords sailing routes from the Levantine ports of Paltos and Laodikeia, and the use of coaster ships, *akatoi,* as depicted on the 4th-century Althiburis mosaic (Davis 2009: 269). Sailing patterns were influenced by increased knowledge of maritime conditions and technological skills, efficient networks of communication, periods of political-economic stability and organised specialised trade (Arnaud 2005: 35, 57; McCormick *et al*. 2012).

Albanian Marine Science Expedition

As part of the 2016 Albanian Marine Science Expedition (Figure 4), the theoretical framework put forward for this research was tested through a hypothetical journey from the island of Corfu (Corcyra) across to Sarandë (Onchesmus), then sailing northward via and beyond the Corfu Strait to Sazan Island and Vlorë Bay (Aulon) (see Adriatic Pilot 1861; Campbell 2012b; Hammond 1967; Lopez 2015; MPIII 2011; Royal 2012). Along the Corfu Strait, the island of Corfu, in connection with the land, formed a channel that aided safe enclosed passage, advocating the link of various landscapes through the practice of seafaring. Certain geographical features often displayed familiar, distinguishable chromatic markers visible to sailors from many

Figure 4. Map illustrating the Albanian coastline and its major ancient ports as well the journey sailed by the authors during the 2016 Marine Science Expedition (Map by authors using Google Earth Pro).

Figure 5. The 'White Roads' on the Albanian coastline characterised by Cretaceous limestone-ringed layers (Photo by authors while sailing during the 2016 Marine Science Expedition).

kilometres offshore (Adriatic Pilot 1861: 220; Dini *et al.* 2007: 236–7). For instance, at the entrance of the channel, the Sybota Islands were a notable navigational marker and military strategic point, characterised by a dense concentration of trees (SDEEM 2011: 118; Thuc. 1.45–54), which may have also produced a distinct smell which could have been sensed from a relatively long distance (Lopez 2015: 81). They are also conspicuous due to their dark nature. Ancient mariners would probably have sighted their dark chromatic display, along with Cape Bianco's white limestone cliffs, to sail into the channel (modern pilots depict Cape Bianco shaped as a white sail – Nori 1831: 180–9, Purdy 1826: 258). At night, the Sybota Islands may have been hazardous with their dark nature concealing them under the night sky. In this way, such features served as dynamic navigational reference points along sea routes, further illustrating the use of the visual sense at sea.

Sailing northward from Corcyra, the next stop of interest to the ancient mariner would likely be Butrint (Strabo, *Geog.* 7.7.5; Pliny, *NH* 4.1), the next highly populated and protected site *en route*. In reference to Butrint, Thucydides refers to certain factions fleeing to the 'Corcyrean territory' across the channel (3.85.2), indicating that Butrint may have acted as a *peraia* of Corcyra, further attesting to its role in the political seascape (cf. Lopez 2015). In the Bay of Butrint, there is record of an anchor dating between the 2nd century BC and 4th century AD, with associated amphora sherds (Campbell 2012b: 412). In a navigational sense, the bay is noted as the safest anchorage between Saranda Bay and Lake Butrint on Albania's coast. However, while its interior is protected, the area outside the bay marks the convergent weather flowing into the strait from the north-west, with steady southerly winds. The ancient mariner would have likely been aware of these weather patterns and anchored in one of the nearby bays/anchorages to resupply or wait-out unfavourable meteorological conditions encountered.

Continuing the journey to Vlorë Bay, the next navigational reference point to an ancient mariner would have been Panormus (*Porto Palermos*), the only protected harbour between Oricum and the Ceraunian Mountains (Ptol. *Geog.* 3.14.2). Sailing from Onchesmus to Panormus, the team avoided the inconspicuous outcropping reef that rises from the seabed (*c.* 1-1.2m below the surface), known as the 'Devil's Tongue' or 'Razor' (Adriatic Pilot 1961: 222). It has been hazardous to sailors throughout antiquity, as attested by the Joni Wreck, a large 4th-century AD Roman shipwreck (Royal 2012; Stratton 2015). Upon leaving Panormos for Oricum, the ancient mariner would have had to sail along the coast of the Ceraunian range and around the largely harbourless Karaburun Peninsula (Strabo, *Geog.* 7.5.8). This stretch has high potential for being extremely hazardous for vessels in bad weather conditions, characterised by large protruding rocks that precede the 2000m mountain range. While sailing along the peninsula, the team caught sight of the distinct Cretaceous limestone-ringed rocky coastal layer known as the 'White Roads' in antiquity (Figure 5; Hysi 2010: 5–6). This stretch, with the combination of the white layer and high mountains, would have been easily visible from a relatively far distance offshore and functioned as a navigational aid for mariners sailing in or out of the Adriatic Sea, guided along the eastern coast. In the event of mariners sailing past the 'White Roads' with lower visibility (in fog or at night) it is likely they would still be aware of their relative spatial range to the coast due to the audible surf impact of waves crashing against the rocks (see ancient references in Davis 2009: 220). Their sense of sound would guide them out of danger. Future research will aim to reconstruct coastal soundscapes of the region, measuring the spatial range of the sound/noise of crashing waves from a boat in to interpret mariners' ability to judge sound distance for navigation, particularly during low visibility. The team anchored *en route* and explored the seabed of Gramma Bay, the only suitable bay for anchoring in this area, where Roman forces famously landed. Its small natural bay contains ancient Greek and Latin inscriptions of sailors engraved on cliff walls, a sailors' 'rock diary' depicting maritime cultural practices and identities in this region (Lopez 2015: 88).

The team then set sail around the tip of the peninsula where it curves into Vlorë Bay, past the natural colour-changing border where the Adriatic and Ionian Seas merge. On this stretch lies the Cave of the Illyrians, a pirate hideout in the past. Rounding into Vlorë Bay, a mariner would have passed ancient Aulon (Vlorë) on the portside (Ptol. *Geog.* 3.12.3) and continued south into Oricum, at the edge of the bay on a limestone hill. It is extremely well guarded from the *Scirocco* and *Gregale* prevailing winds due to the Ceraunian Mountains, thus, navigating this stretch would have been favourable to the mariner before continuing onward to resupply at Aulon or Oricum. Near Aulon, the project explored threatened areas, finding evidence for ancient sea-level change and maritime trade from every time period, but primarily 4th-century BC to 7th-century AD. Finds included anchors (stone, lead, iron – Figure 6), amphoras (mainly central and western Mediterranean, plus Aegean types) and everyday items (*imbrices*, *tegulae*, plates, water jugs). At the nearby site of Triport, the project uncovered submerged wall remains covering *c.* 20 acres, reflecting the port-city's great importance, as well as the impacts of sea-level change and urban development. Ancient archaeological sites such as cities, harbour structures and quarries around southern Albania showed submergence up to 150cm. These are due to processes such as plate tectonics, isostatic sea-level change, and compression of fluvial sediments. Future research is planned to reconstruct the morphology of Albania's past coastline.

Figure 6. A stone anchor found near the ancient harbour at Triport, Albania (Photograph by authors for the 2016 Marine Science Expedition, published in Submerged Heritage 2017: 59).

Discussion and conclusion

The experimental journey therefore resulted in confirming the practicality and reality of common-sense geography as a means of conceptualising spatial associations and navigating the seascape. Mental maps probably dominated through the Roman Era, with sensory navigation being the primary tool used by ancient mariners for navigation. Aspects of visibility (e.g. chromatics and elevations) played a key role in maritime navigation, with regional variations in topographic and meteorological conditions influencing way finding and distinction of visible orientation markers. Shifts in coastal and riverine landscapes would have impacted transportation and exchange between places and people, in turn influencing cultural practices and perceptions of the landscape. Furthermore, certain harbour toponyms carried meanings indicative of local resources or landmarks, which would have been useful to mariners. An illustrative example of this includes Strabo's reference to the *Glykys Limen* (Sweet Harbour). Implicit clues in the place names would have informed the mariners as to the availability of resources *en route* (e.g. fresh water). Possessing this local knowledge would have guided the mariner to look for distinctive coastal features such as watercolour change (from river mouths discharging into the ocean). The various types of markers demonstrate the value of their senses and their use in an ancient maritime context. In sum, the sense of sight, sound, touch, taste and smell all play a significant role in the various aspects of navigation, while fostering a general ability to navigate the sea astronomically. In compliment to the use of senses in antiquity, the ancient geographer Strabo explicitly emphasises their significance:

> for **our senses report the shape, colour, and size** of an apple, **and also its smell, feel, and flavour**; ... So, too, even in the case of large figures,...**while the senses perceive only the parts, the mind forms a concept of the whole from what the senses have perceived** (Geog. 2.5.11).

The application of sensory navigation is present throughout the depictions of the ancient authors, archaeological record, and within the physical characteristics of the landscape. Our research methodology and findings illustrated how the wide range of navigational sensory markers along the Levantine and Ionian coastlines created a 'memory database' of places and features along a journey in the Roman period. Moreover, these case studies further exemplify that the nature and role of the landmarks described in ancient treatises are interconnected with mental maps, familiarity of the seascape and an ability to adapt to dynamic settings through common-sense geography. Such spatial references are not static; they form part of the maritime cultural landscape in which they change and are remembered depending on context. This research, thus, demonstrates a more intimate insight into 'experiencing' the Roman maritime cultural landscape in these regions, drawing further links between mariners' practical journeys based on multisensory navigation and geographers' spatial representations of the political seascape.

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Shipwrecks and Communities: Responses to Shipping Mishaps in Victoria, Australia

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Abstract

Shipwrecks have been conventionally examined archaeologically from various aspects (including ship design, cargoes and trade route identification, and have traditionally been regarded as tragic catastrophic events. Victorian shipwrecks occurred within a near-shore arena, often close to the coasts of small isolated maritime communities. These incidents potentially stimulate a range of reactive behavioural traits and perceptions from nearby residents, which have not been extensively explored, and may offer new understandings of the effects of shipping mishaps on frontier societies. A range of responses to altruistic/opportunistic reactions to maritime disasters is examined in a maritime cultural landscape context, along with new archaeological characterisations and material culture associated with the exploitation of shipping mishaps around Queenscliffe in Victoria, Australia. These observations present interesting new insights into understanding the maritime cultural landscapes of shipping mishaps and their subsequent archaeological signatures from social and cultural perspectives.

Keywords

Shipwrecks, strandings, subsistence salvage, maritime cultural landscapes, social aspects

Introduction

The Australian coastline offers a rich assortment of physical remains of shipwrecks, many of which after over 40 years of archaeological research, have been well documented in terms of technical construction, information on transport and trade links, cargoes carried etc. However, traditional approaches portray shipwrecks as episodic and singular events which signal the transformation point of these vessels from the systemic to the archaeological context, and consequently a terminus of their cultural utility, other than occasional reference to salvage activity as a site formation process (Gavin-Schwartz and Holtorf 1999: 5). Nowhere is this more evident than in the often misused concept of a wreck as 'time capsule', suggesting a static terminus to the process (Dean *et al.* 1996: 32, 214; Gould 2000: 12–3; Muckelroy 1978: 56–7). In truth, many coastal 'shipping mishaps' (wrecks and strandings) occurred near to the shore and close to populations, with ongoing interactions with and effects upon sites and the neighbouring communities.

An aim of the authors' research is to demonstrate that the wreck event was just one stage in the transformation of a vessel to a derelict, and eventually into a place in one or several cultural landscapes. The incidence of a shipping mishap might signal the end of a vessel's operational life, but could also stimulate new behavioural traits from nearby residents through its introduction as a new element into an area (Duncan 2006). In many cases these coastal groups were exposed to multiple low and high intensity shipping mishaps. The remains of these vessels or their cargoes might be utilised continuously long after the wrecking 'event' and play an active and cross-generational role as an ongoing economic resource. Similarly, the mechanisms established to cope with shipping mishaps and their prevention also influenced the formulation of a social and economic relationship both within and beyond the township.

This paper, summarising aspects of a wider and ongoing study (Duncan and Gibbs 2015), considers community perceptions, social and economic and other responses to shipping mishaps, and the possible archaeological signatures of those activities. We explore in our case study the characteristics of several resultant thematic maritime cultural landscapes in and around the township of Queenscliff, in the Borough of Queenscliffe, southern Port Phillip Bay in Victoria, Australia.[1] The study incorporates not only historical and archaeological sources, but also social data derived

[1] Queenscliff refers to the township; Queenscliffe refers to wider borough including Queenscliff and Point Lonsdale.

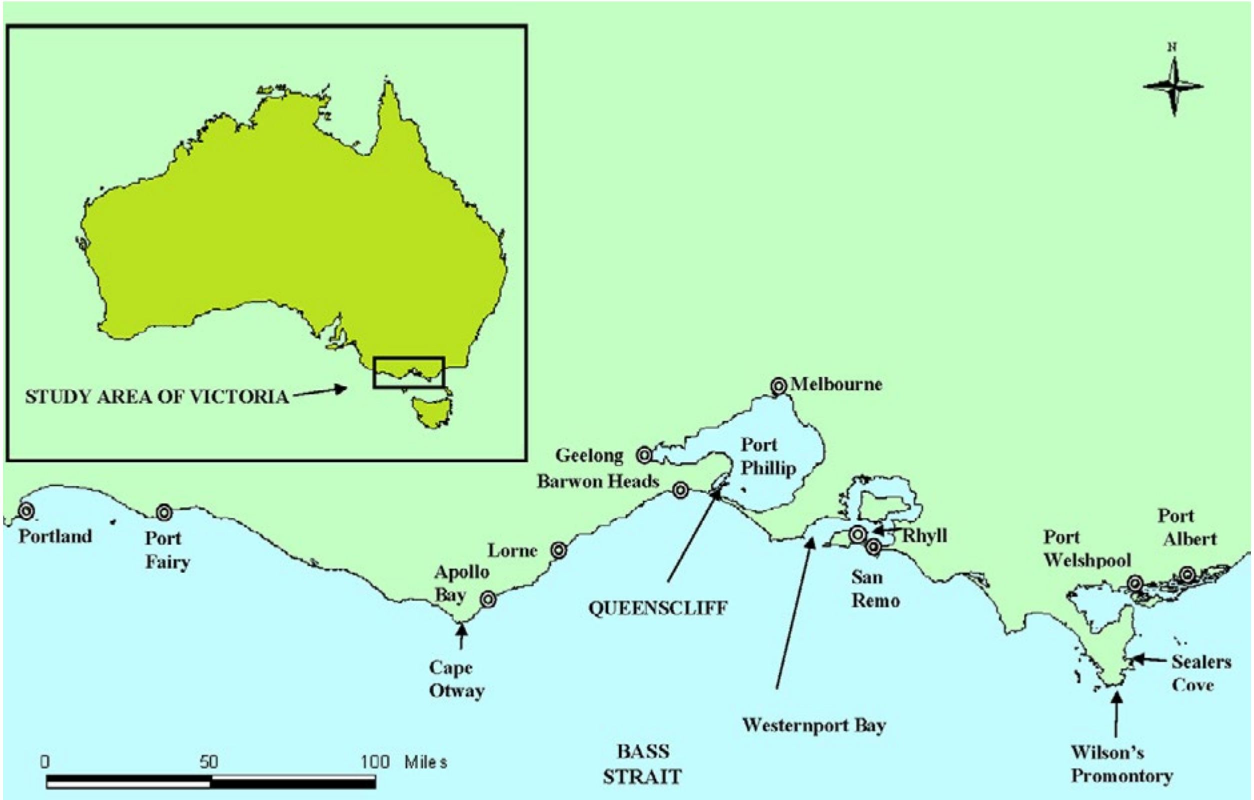

Figure 1. Map of study area.

from regional oral histories and local knowledge of archaeological sites.

Archaeological, Historical and Oral History Evidence

Shipping Mishaps at Port Phillip Heads

The many causes of catastrophic shipwrecking at Port Phillip Heads since 1840, whether from collision, running aground on sandbanks or subsequently destroyed by storms, are already well understood (Anderson 1997; Anderson and Cahir 2003; Arnott n.d.; Foster 1987, 1988, 1989, 1990; Heritage Victoria Shiplist Database; Loney n.d. a, n.d. b, 1971, 1981; Love 2006; Naylor n.d.; Williams and Serle 1963, 1964; Wealthy and Bugg 1995). Thanks to extensive archaeological research, the remains of over 95 known wreck sites have been identified within 10km of the Heads, both inside and outside the Bay (Anderson 1997a, Anderson and Cahir 2003; Bateson 1972: 149; Foster 1987–1990). However, in embracing the wider concept of shipping mishaps we have also turned our attention to the incidence and nature of strandings, where a vessel was inadvertently or deliberately run on to shore or a sandbank (the latter to prevent sinking or further damage) and subsequently refloated or towed away for salvage. It is apparent that deliberate stranding was a well-established historical practice as a means of saving vessels which had been damaged while entering the Heads and was even a strategy mentioned in contemporary marine insurance manuals (Gow 1917; Hardy Ivamy 1874; Hopkins 1867). Such stranding sites were in effect 'phantom shipwrecks' often leaving limited or no structural remains, and have often been overlooked in strictly archaeological studies (Duncan 2000: 56; 2004; 2006: 218; Gibbs 2006: 10; Gibbs and McPhee 2004: 46–7). Research to date has identified well over 160 strandings in the study area from 1839 (e.g. see Bateson 1972: 93; Cole 1860; 1865 [as cited in Taylor in prep.]; Department of Ports and Harbours 1959; Loney 1971: 143; Miller 1860; Williams and Serle 1963; 1964), but this is thought to be only a fraction of incidents that occurred in this area. Historical accounts document numerous instances where large quantities of cargo and ballast were jettisoned or transferred in attempts to lighten and refloat vessels, providing rich opportunities for coastal communities to access these resources (Loney 1971; Love n.d.; 2001; 2006; Ferrier 2001–2004; Williams and Serle 1963; 1964). Only recently have archaeological studies been applied to both the surviving archaeological signatures of these incidents and the recovery processes of materials from them (Duncan 2000; 2004; 2006: 218–221).

A core element of the research on community responses to shipping mishaps has been an exploration of the balance between altruism and opportunism. The

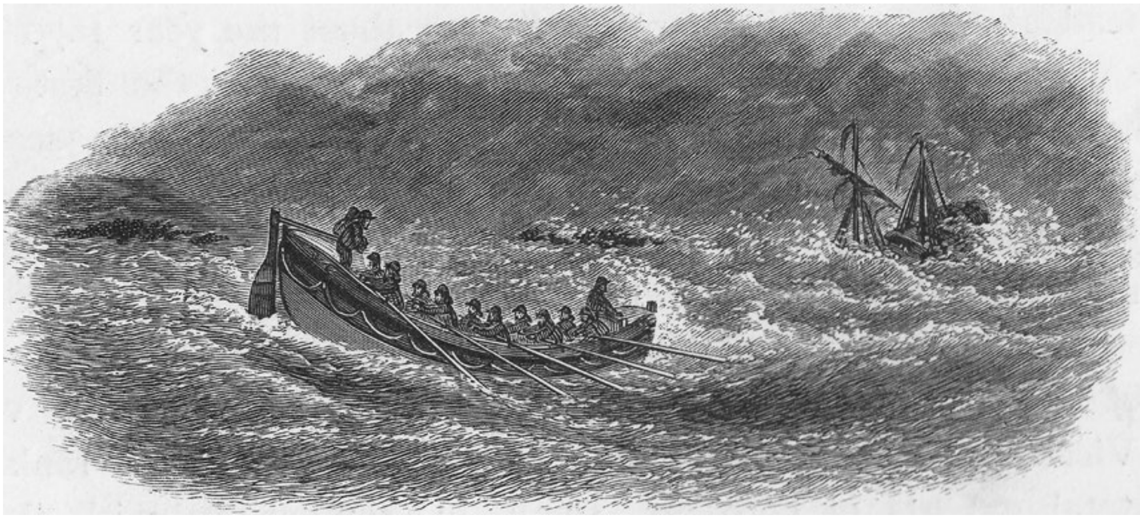

Figure 2. Queenscliff lifeboat attending the wreck of the *Asa Packer* in 1861 (Sutherland 1888: 443).

following sections summarise some features of both aspects, as revealed in the historical and archaeological records.

Altruism: Responses to Shipping Mishap Crises

In most instances, an incident would generate immediate altruistic responses to aid survivors, assist in saving lives and property, and prevent vessels becoming wrecks. Whenever shipping mishaps occurred around the Heads, a series of pre-planned and organised actions were instituted. The Queenscliff Pilots Service, which commenced in 1839, initially undertook the rescues, but by the 1850s a lifeboat service was established to coordinate shipwreck response, utilising a series of purpose-built lifeboats (Duncan 2006; Noble 1979: 8, 9, 42). When a ship was at risk the wreck bell was rung in town, alerting mariners to come to the lifeboat shed (Beazley 2001–2004; Mouchmore 2001–2004; Ferrier 2001–2004). The crew was then handpicked from experienced volunteer local seamen, predominantly fishermen (Boyd and Roddick 1996; Duncan 2006: 224–225; Fanning 1892b; McGrath n.d.). Despite the dangers, competition was often fierce to gain a seat in the lifeboat since the role offered various financial and other rewards, and it was reported that often the doors to the lifeboat shed would be locked to prevent more men getting into the boat once the places were filled (Kerr 1985: 73).

The lifeboat crew often risked their lives in gales to attend to distressed vessels (see Figure 2), often rowing up to 15km in wild gales to the wreck site, where they would anchor, and then drift back to the vessel to conduct rescues (Baillieu 1887; Dickson 1887). Rescues could include using a rocket launching device to pass an attached rope to the wreck, which, when tied to the wreck mast could be used to transfer survivors ashore via a breaches buoy (Noble 1979; Syme 2001: 27). Military forces and other community members stationed at Queenscliff and Pt Nepean also often assisted with these rescues wherever they could (Duncan 2006: 221–31; Welch 1969: 43). The lifeboat crews were frequently lauded within and beyond the local community for their heroism and were regularly given awards from the government and those related to the rescued (Fanning 1892a; *Queenscliff Sentinel* 4/7/1891; 13/8/1897).

The wider Queenscliffe community also became known for its great philanthropy towards survivors. Local people often provided food, shelter and accommodation at their own expense, for victims had lost everything in the wrecking event (Cuzens 1912: 1; *Geelong Advertiser* 2/5/1853: 2; 3/5/1853: 2; 1/2/1872; Higgenbotham 2004; Kruithof 2002: 89; *Queenscliff Sentinel* 22/10/1892; 26/11/1892). Survivors were regularly assisted by charitable trusts and benefit concerts, and local widows were often supported by the community who even bought houses for them after the husbands had perished (Duncan 2006: 232–33; Mathers 2001; *Queenscliff Sentinel* 10/12/1892; 23/9/1893).

Opportunism—Exploitation Responses to Shipping Crises

The converse to altruist responses was the potential economic benefits of shipping mishaps and especially shipwreck for the community. In truth, and despite their heroism, the lifeboat crew did receive significant financial incentives, being paid the equivalent of a week's wages each time the lifeboat was launched (Duncan 2006: 235; *Queenscliff Sentinel* 4/7/1891; Werry 2003–2004). A place in the lifeboat crew therefore represented a valuable income. The fishermen who later formed the majority of the volunteer lifeboat crew were amongst the poorest members of the community, and they relied heavily on this extra income, which probably explains the reported rushes to be on the lifeboat prior to launching. Further rewards were also available to the lifeboat crew who were paid monthly to undertake lifeboat practice duties (Boyd and Roddick 1996: 11). Local fishermen commented that there was a real economic dependence on the lifeboat duties as it supplemented their meagre incomes during the lean winter months when fish stocks were limited and the weather deteriorated (Ferrier 2001–2004).

An additional incentive for participation in rescue was the potential to claim salvage. Although later outlawed, the lifeboat crew and some government mariners and officials also regularly claimed personal salvage rights whilst attending to stranded vessels, leading one newspaper to label one government official's vessel as a 'wrecker' for its constant salvage claims (*Geelong Advertiser* 23/5/1851: 2; Duncan 2006: 234). Local mariners also regularly pursued salvage claims after towing stricken vessels, or otherwise pursued payment for lighterage services transferring goods from stricken vessels (see Figure 3), or for ferrying stranded passengers from immigrant ships. The economic importance of salvage to local mariners often resulted in cut-throat practices, such as when a towrope prematurely parted and the ship wrecked (*Craigburn*) while negotiations were under way over salvage rights with the original towing vessel (Noble 1979: 57). Early pilots also regularly claimed salvage rights over stricken vessels they had been assisting, or where gold specie had been transferred to their boats for safe keeping, and in one case the pilot made enough profit to retire from the profession after only six weeks on the job (Draper 1900: 10; *Queenscliff Sentinel* 30/7/1910).

Many other ancillary opportunities were stimulated within the borough of Queenscliffe as a direct result of shipping mishaps, including boatbuilding and repair services; accommodation, victualling and transport of shipwreck survivors, tourism, the establishment of a local Customs Service, and even local carpenters who derived extra income as undertakers and coffin makers (Duncan 2006: 236; Springall 2001).

Figure 3. Tug *Blackboy* salving the *George Roper* (Ebsworth 1883a).

Figure 4. Looters at work after the *Craigieburn* shipwreck (Queenscliffe Historical Society Collection).

Smuggling, looting, and the establishment of customs services

When large shipwrecks occurred close to the coast, walls of debris up to 8ft high and one mile long were reported to have washed ashore (e.g. Duncan and Gibbs 2015: 166). By the mid-19th century, looting from shipwrecks had become a major source of income and goods for many Queenscliff households. Townspeople would often visit the scene of a wreck, with different intentions of either helping out or helping themselves (Ferrier 2001–2004). Numerous historical and oral accounts describe pillaging after survivors had been removed from a wreck, and how stricken vessels were quickly surrounded by bands of looters (*Ballarat Star* 5/1/1872; Shapter 2001), who hauled anything they could carry off into the bush (Figure 4). The day after the *Sussex* wrecked at Barwon Heads, 1500 people were encamped on the shore nearby waiting for the wreck to break up (Duncan 2006: 240–43; *Geelong Advertiser* 6/1/1872).

During the Gold Rush period of the 1850s, vessels often carried imported luxury goods destined for the richer members of the flourishing colony. When these large vessels became wrecked so close to shore, they often proved a huge temptation to the local community. Looting was often so bad that the road to Geelong (the nearest large town) had to be closed to prevent the salvaged material from leaving the district for regional markets (Loney 1989: 42). Customs Officials and Police were regularly stationed on and nearby to wrecks to protect the vessels from the hordes of looters (Day 1992: 283, 292; *Geelong Advertiser* 18/1/1868: 3; 4/1/1872; see Figure 5). There also emerged new types of behaviour associated with looting activities.

Overindulgence: Many accounts also detail scenes of drunkenness at wreck sites, where if looters could not bring the booty home, they attempted to consume as much of it as possible at the location. When the ship *Sussex* went ashore on 31 December 1871 with a cargo of liquor, extensive local looting was reported, leading one maritime archaeologist to comment that it must have been the best New Years Eve they ever had (Staniforth 2004).

This overindulgent behaviour also took place at flotsam traps, where the mariners would binge on liquor that had been washed ashore out of sight of the authorities, and it was common knowledge locally that men would disappear for weeks at a time, drinking until the barrels were finished (Ferrier 2003). This led to traditions in the township that still exist today, where teenagers engage in 'Barrel Days' (drunken weekends consuming kegs of beer) on remote islands in Port Phillip Bay (Rogers 2003; Wilson 2003).

Burying loot: In attempts to circumvent discovery, looters would often hide contraband material close by the wreck by collapsing eroding sand dunes over the booty for recovery at a later date (*Argus* 10/12/1853; 29/11/1853; 10/12/1853; Dod 1931: 69, 97; Dunn 1949: 40; Irving-Dusting 2002–2006; Loney 1989: 37, 40; P Ferrier 2001–2004; Shapter 2001; Werry 2003–2004;). Current eroding sand dunes around the foreshores of Pt Lonsdale attest to the ease with which this practice could be undertaken. Many caching areas around the district were reported where goods were either buried close to the wreck, or where debris was hidden where it washed ashore at flotsam traps. Barrels buried in dunes or elaborate trenches lined with corrugated iron were also used to hide tobacco and other loot (Brownhill 1990: 311; Duncan 2016: 244). Drunkenness leading to forgotten loot burial locations also raises the possibility of secreted hoard sites that may still exist in the area (Ferrier 2001–2004; Werry 2003–2004).

Contraband houses/public places: When the opportunity presented, looted goods were also buried closer to home in backyards, under nearby beaches or were stored in attics, cellars and behind skirting boards in houses to avoid detection by Customs officials (Irving-Dusting 2002–2006; Loney 1989: 43; Ferrier 2001–2004; Werry 2003–2004). This caching behaviour led to secondary professions within the community, whereby it was locally known that given individuals could supply certain types of materials, and these led to black-market trade networks within and around the town (Beames 2003). Public places were also allegedly favoured as sites to conceal contraband, possibly because direct blame could not be associated with any one person, or because the officials were also involved (Duncan 2006: 246; Kerr 1985: 73). There have been historical reports of buried relics discovered around the periphery of the Queenscliff township (Duncan 2006: 268; Hayden 1966: 15; Lawson 2004a; *Queenscliff Sentinel* 25/9/1909; Thompson n.d.: 8).

Figure 5. Police and Customs Officer guarding salvage operations at the wreck of *Glaneuse* 1886 (Sleap 1886).

Arson: Local residents remained contemptuous of authorities trying to control looting, and there is at least one case where a Police and Customs tent was deliberately set on fire to distract officers from pilfering being undertaken further along the beach (Loney 1989: 18). In another instance it was alleged that arson was used to conceal evidence of looting and to prevent the removal of at least two twentieth century shipwrecks (Duncan 2006: 245). This observation may provide alternative interpretations of fire damage found on shipwrecks.

Despite formal salvage law, it appears that these behaviours reflected a common attitude that shipwrecks and associated debris represented a godsend from the sea, which every citizen had the right to exploit. Nor was looting restricted only to the poorer members of the town, with local merchants and the military also known to be involved (Dod 1931: 97). These attitudes persisted well into the twentieth century. When a steamer (SS *Corsair*) grounded on an uncharted rock at the Heads in 1949, it was alleged that droves of mariners descended on the abandoned vessel to loot it.

Floating items from the superstructure and cargoes of shipping mishaps were also often spread by the seas, not just immediately after the initial wreck event but sometimes for decades afterwards (*Geelong Advertiser* 20/1/1868: 3, 30/5/1853: 2; *Ballarat Star* 5/1/1872). Mariners and residents developed traditional knowledge of the locations and conditions where this material would be available at flotsam traps, which were often located far away along the coast or inside the Bay. These flotsam traps frequently provided as much material as the wreck site itself; looters would anticipate availability of flotsam based on the prevailing weather conditions (Beasely 2001–2004; L Ferrier 2003; P. Ferrier 2001–2004; Simpkin n.d.; Thompson n.d.). Caching behaviour would also occur at these locations and beachcombing for flotsam and jetsam materials was a popular pastime in the community (Patrick 2004–2012). Seasonal coal availability at jetsam traps long after mishap events was a particularly valued commodity (due the degradation of local firewood sources which led to expensive local supplies). This led to the development of specific material culture in the form of coal rakes, designed for collecting this bounty from the seashore (Duncan 2006: 253; Grant 2001–2012; Patrick 2002–2012; Werry 2003–2004; see Figure 6). All classes of Queenscliffe society used this resource, and many of the poorer members of the community relied heavily of coal jetsam (Naylor 2004; Shapter 2001; Springall 2001). The Queenscliff community also evolved informal rules and etiquettes surrounding the collection of coal, where locals would mark their collected coal in a pile or in some other way to indicate that it had been claimed, and no-one else would then take it (Patrick 2004–2012).

Figure 6. Harvesting jettisoned coal using coal rakes in Lonsdale Bight
(Queenscliffe Historical Museum Collection).

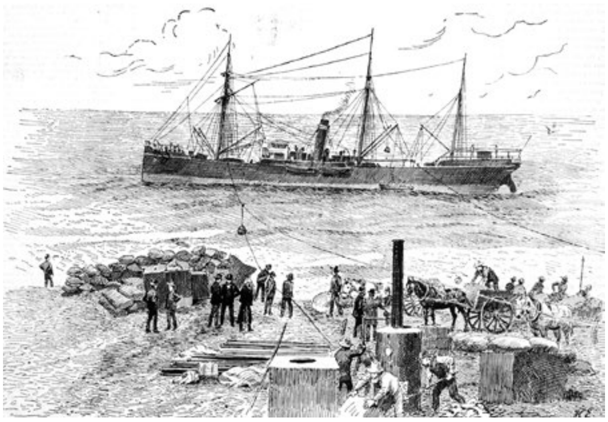

Figure 7. Salving the stranded vessel *Bancoora*
(Syme 1891).

Organised and Official Salvage

Official commercial salvage ventures proved to be a lucrative business for many entrepreneurs at Queenscliff (Fanning 1892c; *Geelong Advertiser* 20/1/1872; *Melbourne Morning Herald* 6/3/1849: 4; *Queenscliff Sentinel* 13/8/1887; 26/11/1892), who often paid substantial sums to purchase salvage rights (*Queenscliff Sentinel* 29/3/1890). Some wrecks realised hefty profits, particularly if they could be salvaged or removed before they broke up (*Geelong Advertiser* 1/2/1872). Organised salvage presented many other economic opportunities for the community as well as the salvors, as local mariners and fishermen were often hired to assist with salvage operations (Dod 1931: 97; Simpkin n.d.: 9). The salvaged shipwreck material was often sold cheaply within the local community (*Queenscliff Sentinel* 4/7/1891).

Salving led to the development of its own types of material culture and mechanisms used to transport merchandise from the wreck. Salvors often established camps in the sand dunes close to the vessels, and used flying foxes made from ships masts, tramways powered by donkey boilers/ship's winch to heave cargo and the ship's equipment ashore and to the nearest road. Other salvage devices included watertight ship's iron tanks and corduroy roads for transporting cargo ashore, along with wooden sleds (Brownhill 1990: 311; Loney 1989: 45; see Figure 7). A number of known wreck sites in the area are associated with large blowouts in the sand dunes immediately adjacent, possibly resulting from the salvage activities. This hypothesis raises the possibility that currently undiscovered historically known shipwreck sites, which occurred onshore and were salvaged, may be pinpointed by searching for eroded areas in local sand dunes (Duncan 2006: 267).

Shipwrecks as other types of places

Shipping mishaps also created a range of other opportunities and situations, which influenced the

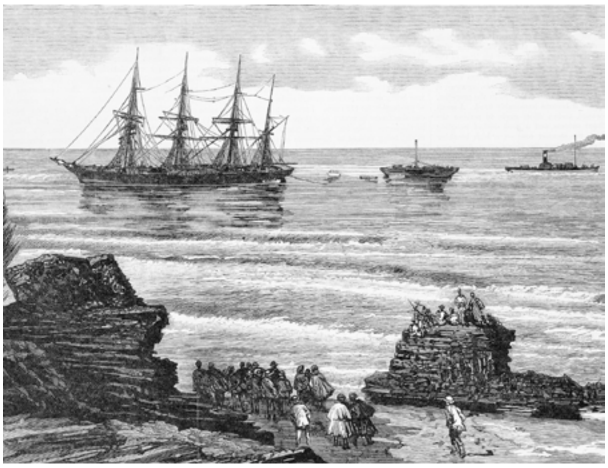

Figure 8. Tourists watch salvage operations at the wreck of the *George Roper* in 1883 (Ebsworth 1883b).

social and economic nature of Queenscliffe. The following are examples:

Shipwrecks as marine navigational markers and fishing resources: Many wreck sites became integral components of the fishing community's landscapes, and have been used by fishermen as seamarks, especially where structural components are visible above water (Mouchmore 2003–2004). The boilers of several wrecks in the area were even enshrined in official sailing directions (Ports and Harbours Branch 1959: 189, 191). Wreck sites also often provided new environments that encouraged the aggregation of fish life, particularly snapper, as their newly created topography resembled the rough ground favoured by this species. This observation is well known amongst commercial and recreational fishermen, who have also observed that the presence of seals in an area is often the indicator of large fish schools living on a submerged wreck (Ferrier 2001–2004).

Shipwrecks as tourist attractions: Shipwrecks also drew large crowds, which substantially increased the incomes of many tourism operators in the area (Cecil Anderson, pers. comm. 23/73/2004. Interview at Queenscliff Victoria; *Geelong Advertiser* 4/1/1872; Naylor 2004; *Queenscliff Sentinel* 15/2/1890; 22/2/1908). Indeed, shipwreck sites were often subsequently treated with a carnival atmosphere, which was a stark contrast to the solemnity of the initial emergency (*Geelong Advertiser* 4/1/1872). These forms of dark tourism actively contributed to the local tourist economy and are the subject of further research elsewhere (see Gibbs and Duncan 2014; see Figure 8).

Shipwrecks as picnic, recreational playgrounds and places: After the initial disaster event, shipwrecks usually became integrated into the community as new places. Some wrecks on the foreshore became the focus for sightseeing on Sunday picnics, and stranded vessels and old hulks often provided new playgrounds for local children (Dod 1931: 66; Dunn 1949: 40; Mills 2002; Mouchmore 2003; R. Beames 2003). Some shipping mishaps also worked their way into local toponymy, being recalled through the naming of places (especially for submerged hazards), and some townships derived their names from the initial meeting places associated with beached wrecks (Rogers 1960: 50).

Discussion

Traditional practice/transported landscapes associated with shipping mishaps

The numerous incidences of shipping mishaps in the study area have produced many observations of the salvation/salvage behaviour. They have similarities in many other nineteenth-century maritime communities worldwide where salvage/plunder from shipwrecks was often seen as an inalienable right, especially where local natural resources were scarce (e.g. Bathurst 2000; 2006; Evans 1957: 232; Goldsmith Carter 1945: 14–5; Larn and Carter 1973; Malster 1974; Rönnby 1998; Souza 1998: 25–7; Stevenson 1912: 17; Thoreau 1865: 4, 5, 29, 34; Treanor, 1904: 57, 102; US Dept of Commerce *et al.* 1999). It is therefore suggested that the exploitation of shipping mishap sites is not a new phenomenon that developed locally, but may actually represent the transportation of a suite of traditional routine seasonal practices that were previously widely undertaken in various ancestral homelands. These activities may be a continuation of a traditional communal lifestyle that may be centuries old that have simply been applied to a new setting.

Furthermore, where local divers demonstrate lengthy ancestral ties to this area, their continued collection of shipwreck material may (in light of this study) be alternatively viewed as a traditional practice (rather than souvenir hunting). It is clear that wrecks have been continually exploited as a resource in Queenscliff for almost 150 years, and only the environmental medium of access has changed from above to below water over time. This perspective offers interesting new interpretations of community values for current heritage management of shipwreck sites and artefacts.

Shipping mishaps as a social phenomenon

Many of the individual maritime trades within the community maintained their distance from one another, and this was influenced by social status and economic differences. However, the occurrence of a shipping disaster often led sections of the community to interact and come together sometimes for a common cause. A whole range of community groups were involved with the shipwrecks through rescue efforts, organised or illegal salvage, beachcombing and recreational activities, and these overlapped normally accepted class divisions to create new temporary social groups that disbanded after the wrecking event (see Duncan 2006; Duncan and Gibbs 2015).

Perhaps the most pronounced transmutation was the elevation of the fishermen from the lowest social strata (Duncan 2011) to local heroes as lifeboat men, who shared a common cause with the lighthouse service and military. Furthermore, this same social group was commonly vilified as the perpetrators of pillaging wrecked vessels. Shipwrecks, therefore, presented an interesting dichotomy, which transmogrified fishers to temporarily become a class of respected lifeboat men whilst later reinforcing the class-conscious status quo through their popular identification as looters. It is clear that the occurrence of shipwrecks led to multiple overlapping landscapes within the Queenscliff society that cross-cut the normal social and hierarchical boundaries, and therefore further influenced the structuring of the community both cognitively and physically (see Duncan 2006).

Perhaps less well recognised is the suite of sites associated with shipping mishaps that represent critical elements for constructing landscapes that are based around economic resources for a broad section of the Queenscliff community. Shipping mishaps created new places in the landscape as they became identified as new resource areas. The event of a shipping mishap not only altered existing local cultural landscapes through the introduction of a new physical wreck site, but also through the perceived generation of economic zones associated with new foraging places.

These new opportunities for scavenging were clearly recognised as part of the renewable resource, which became available and/or was replenished from subsequent shipwrecks and strandings. It has been shown that the community has developed new technology, both to harvest these new resources and to hide them, which in turn is reflected in the recognition of these new landscape places and their associated innovative material culture. Therefore, in areas where wrecks are a common and semi-predictable event, the use of these secondary sites and the associated harvesting tools may further be considered to be the archaeological signatures of those events.

Subsistence Salvage

This brief glimpse has shown that shipping mishaps brought new economic zones into the community landscape. If we widen the scope of shipwreck research to include these new perspectives of secondary sites, then this allows a detailed understanding of stranding and/or flotsam/jetsam sites associated with shipping mishaps to also be considered. This enables further analysis of a whole new set of other behaviour that is currently less well recognised, but also defines community, and in some cases distinguishes groups within the community (e.g. fishers and Customs men). Suddenly these wreck sites become resource areas of hunter/gatherer behaviour, with a whole set of actions/archaeological signatures that help define Queenscliff itself. In terms of what happens after the shipwreck event, these behaviours go on continuously, but they require replenishment as new shipping mishaps consistently occur in the same areas.

Although the incidence of these bounties did not offer the reliability on which to base a living, they did supply many people with a financial windfall to tide them through lean times (especially in the winter). This salvage was therefore not only an opportunistic behavioural trait of many Queenscliff inhabitants, but also a consistently routine event which many townsfolk depended upon and planned for. These events have strong analogies to the seasonal availability of fish species, and tourists in the area, where the seasonality of the resource is known, but the volume and reliability of the occurrence varies with the weather and the other external factors.

This dependence on shipping mishaps to supplement the incomes of the lower socio-economic classes might be termed 'subsistence salvage', where, even though the events are sporadic and random, they are also predictable in that it was likely that they would eventually occur again over time.

This highlights the duality of shipping tragedies, where both certainty and uncertainty co-exist, and thus generate a plethora of diverse and often conflicting behaviours. The certainty of the event has generated a suite of responsive organised routines and procedures designed to mitigate and minimise the damage caused by a shipwreck, which are centred on altruistic ideals. Conversely, the uncertainty of *when* the event will occur generates an opportunistic response to it, where frantic, often over-indulgent behaviour is undertaken in a race against time to secure the resource before it is reclaimed by the elements and/or the authorities. Furthermore, the unpredictable event then generates a relatively reliable seasonal resource (through the replenishment of flotsam and jetsam traps).

Conclusion: shipping mishaps and cultural landscape construction

Shipwrecks have modified and re-stratified the landscapes of the Queenscliff region affecting the social structure of the local community not only through the implementation of altruistic ideals (and subsequent practices), but also through the introduction of profitable economic opportunities that have at once united and yet polarised often disparate sections of the community.

Shipping mishaps have drawn out both the best and worst ideals of the community, which have produced distinct archaeological signatures and material culture beyond the locality of the wrecking incident itself. Shipwrecks and strandings create (and are systemic components of) cultural landscapes through their generation of idealistic virtues of heroism and altruism, profit and opportunism, and memorialisation of events, and through the subsequent creation of permanent, though often (physically) unseen places in the physical world.

It has been further suggested that these practices may have been transported to the Queenscliff area as a result of cultural diffusion initially associated with increased immigration destined for the Victorian Gold Rush, which curiously also provided favourable conditions for their evolution in the new colony through an increase in shipping and hence subsequent shipwreck numbers. As such, the transferal of traditional practices from ancestral homelands overseas to Victoria represents a form of transported landscapes.

The investigation of local oral histories and folklore, documentary and archaeological data sources has revealed that far from being isolated, unrelated and opportunistic events, there was a seasonal reliance on shipwrecks and strandings as integral components of the local/regional/state economic communities. Both historical and potential archaeological remnants of practices associated with looting have been highlighted, and shipping mishaps have been shown to be pervasive elements of all facets of Queenscliff culture and essential components which continue to shape (and reshape) the cognitive and physical cultural landscapes of Port Phillip Bay. Finally, shipwrecks have been illustrated as both an event and a place of resource procurement, which cross-cut the social boundaries normally extant in nineteenth-century Australian culture.

These observations have potential utility for examining shipping mishap events and sites worldwide. In conclusion, this ongoing study has shown that shipwrecks, therefore, do not only represent doomed ships associated with an isolated event, but also in a fundamental way create dynamic new landscapes and places in the regions where they occur. This is a fresh way to look at the coastal zone, where shipping mishaps generate hope and profit for the local population. Therefore, in the mindset of the Queenscliff community, shipping mishaps not necessarily only indicate a dangerous coast, but also contributed to a coast of opportunity.

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An Interdisciplinary and Layered Approach Towards Reconstruction of the Late Medieval Maritime Cultural Landscapes of the Noordoostpolder Region, the Netherlands

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Abstract

This study presents an overview of the interdisciplinary and layered approach that was used for reconstructing the late medieval maritime cultural landscapes of the Noordoostpolder region in the Netherlands. This region is a reclaimed part of the former Zuiderzee—a large inlet of the North Sea in the central part of the Netherlands. There has been much doubt about the medieval appearance of the area, as some believe that the entire region was covered by water, while others suggest that a part of the area existed as inhabited peatlands. Scattered geological, archaeological and historical datasets, aerial photographs and LiDAR-data concerning the research area were layered and examined in a spatial environment. Relevant information from each of these layers was then transported and integrated into the reconstruction. The interpretation of this interdisciplinary dataset has led to important new insights on the appearance of the late medieval Noordoostpolder region—a substantial part of the region was still covered by peatlands and relatively densely inhabited during the late Middle Ages. The late medieval remains of drowned settlements, dikes, mounds and parcelling patterns are very well represented in the different datasets and made visible by the new approach.

Keywords

Maritime cultural landscape, interdisciplinary approach, Zuiderzee, the Netherlands, Middle Ages

Introduction

The research presented in this paper focuses on the methodology that is used by the author for examining the late medieval maritime cultural landscape of the former Zuiderzee. The Zuiderzee functioned as a large inlet of the North Sea in the Netherlands but was closed off by a dike (Afsluitdijk) during the 20th century. A large part of the water (*c*. 1400km^2) was then reclaimed (polders) and is now known as the province of Flevoland. The newly reclaimed land contained the remains of hundreds of ships that had wrecked in the hazardous waters of Zuiderzee. Although most of these wrecks have been examined and excavated, the clayish soil still contains undiscovered wrecks (Van Popta 2012: 100). It is, however, more promising to wonder what other archaeological remains the seabed might contain. There is strong evidence that part of the region was inhabited during the Middle Ages until storm floods washed away the remaining land and small and vulnerable settlements (see for example: Van der Heide 1965; Van Popta 2016; Wiggers 1955).

The best way to find out whether there are remains of these cultivated medieval lands is by focusing on the north-eastern part of the research area, nowadays called the 'Noordoostpolder' (Figure 1). Much research has been done in this polder, with focus on the geology, palaeogeography, archaeology and history of the area, but the results have never been thoroughly examined and combined for a reconstruction of the late medieval landscape. Hence, an interdisciplinary and spatial approach, combined with the concept of the maritime cultural landscape (Van Popta, Westerdahl and Duncan in press; Westerdahl 1992) might provide new results and form the core of the author's PhD research. The main aim of this paper is to (a) explain the methodology used, and (b) demonstrate the effects by presenting some of the new results.

Setting

It is important to mention that this paper is part of the author's PhD research that aims to reconstruct the late medieval maritime cultural landscape of the north-eastern Zuiderzee region. The content of the current contribution focuses strongly on the methodology used and provides the reader insights in the multiple datasets that were used and combined. However, it does not cover other aspects of the PhD research, like the theoretical framework of the maritime cultural landscape. These aspects are the subject of a series of related articles. For a critical engagement with the theoretical aspects of the Maritime Cultural Landscape concept, projected on the current research area see Van Popta, Westerdahl and Duncan (2019). The physical reconstruction of the eroded medieval landscapes, presented as a palaeogeographical map-series is

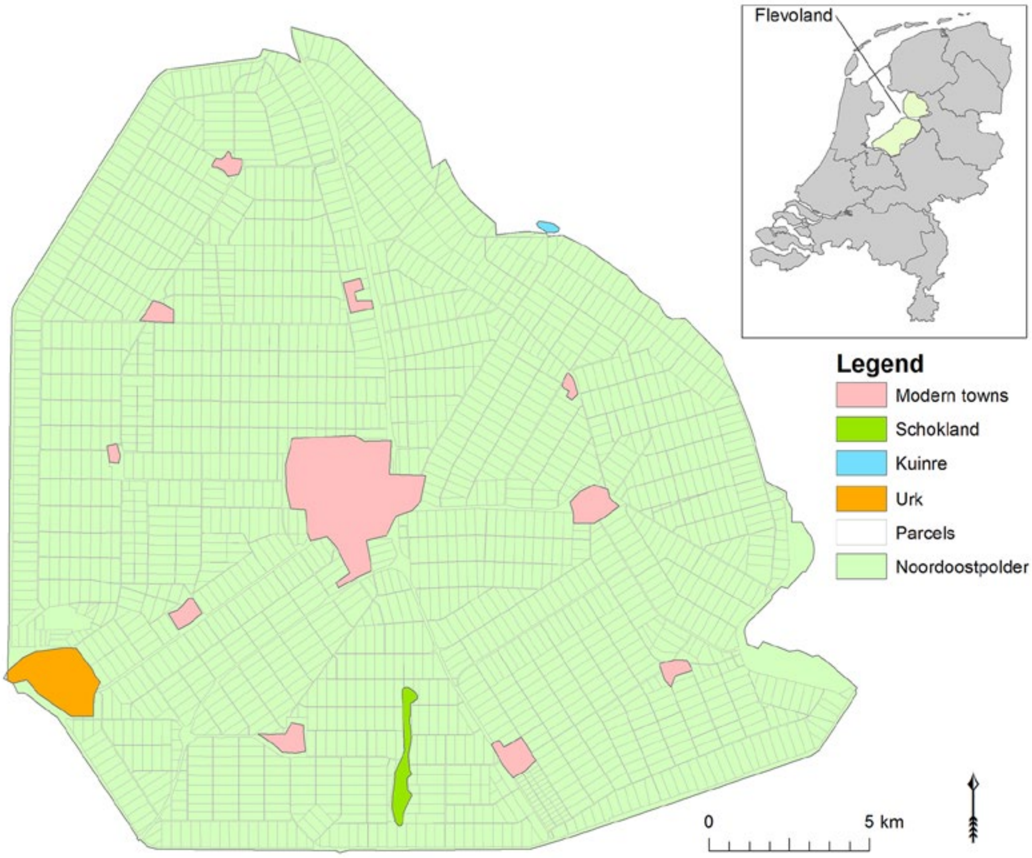

Figure 1. Topographic map of the research area. The islands of Urk (orange) and Schokland (green) and the settlement of Kuinre (blue) are marked on the map.

published by Van Popta *et al.* (in press). A third article focuses on the shipwrecks from the research area (Van Popta and Van Holk 2018). In addition, a fourth article focuses on linking the material and immaterial datasets for a modern-day perception of the medieval battle against the Zuiderzee (Van Popta 2019). The individual papers examine different aspects of the maritime cultural landscape; only when combined do they target the full range of the concept.

Historical background and state of research

The Zuiderzee region is mentioned for the first time in historical sources at the beginning of the Roman era.[1] Roman historiographers like Pomponius Mela and Pliny the Elder mentioned the region as '*Lacus Flevo*', meaning Flevo lake (referring to multiple bodies of water) (Gerrets 2010: 31). The lakes started to grow as water, transported by multiple rivers, accumulated in the region. There was not yet an active connection with the North Sea, so the water discharged slowly from the lakes. Further increase of the bodies of water was caused by high winds and large waves, tormenting the surrounding peatlands. During the early Middle Ages, multiple lakes merged into one large mass of water. In historical sources, the name of the region changed into 'Almaere' (Mostert 1999: 9). Even though water was gaining more influence on the region, human presence and influence on the remaining peatlands started to increase: land was cultivated and inhabited. Heavy storm floods in the 9th and 10th centuries AD created an active connection with the North Sea, causing the region to transform into a lagoon (de Mulder *et al.* 2003: 236). By the end of the late Middle Ages, the final peat barrier between the North Sea and the Almaere was breached, causing the lagoon to become an inland sea (Jongmans *et al.* 2015: 682). In the 14th century the inland sea was named the 'Zuiderzee' (Southern Sea). The volume of water would reach a more or less stable size at approximately AD 1600, but storm floods kept terrorising the inhabitants of the coastal region and the multiple islands. After a heavy flood in 1916, it was decided to dam the Zuiderzee and the plan was executed in 1932. As part of the plan, large parts of the

[1] The historical background of the research area in this paper is limited to the most relevant period: from the Roman era until the late Middle Ages. For a complete overview see e.g. Wiggers (1955), Jongmans *et al.* (2015).

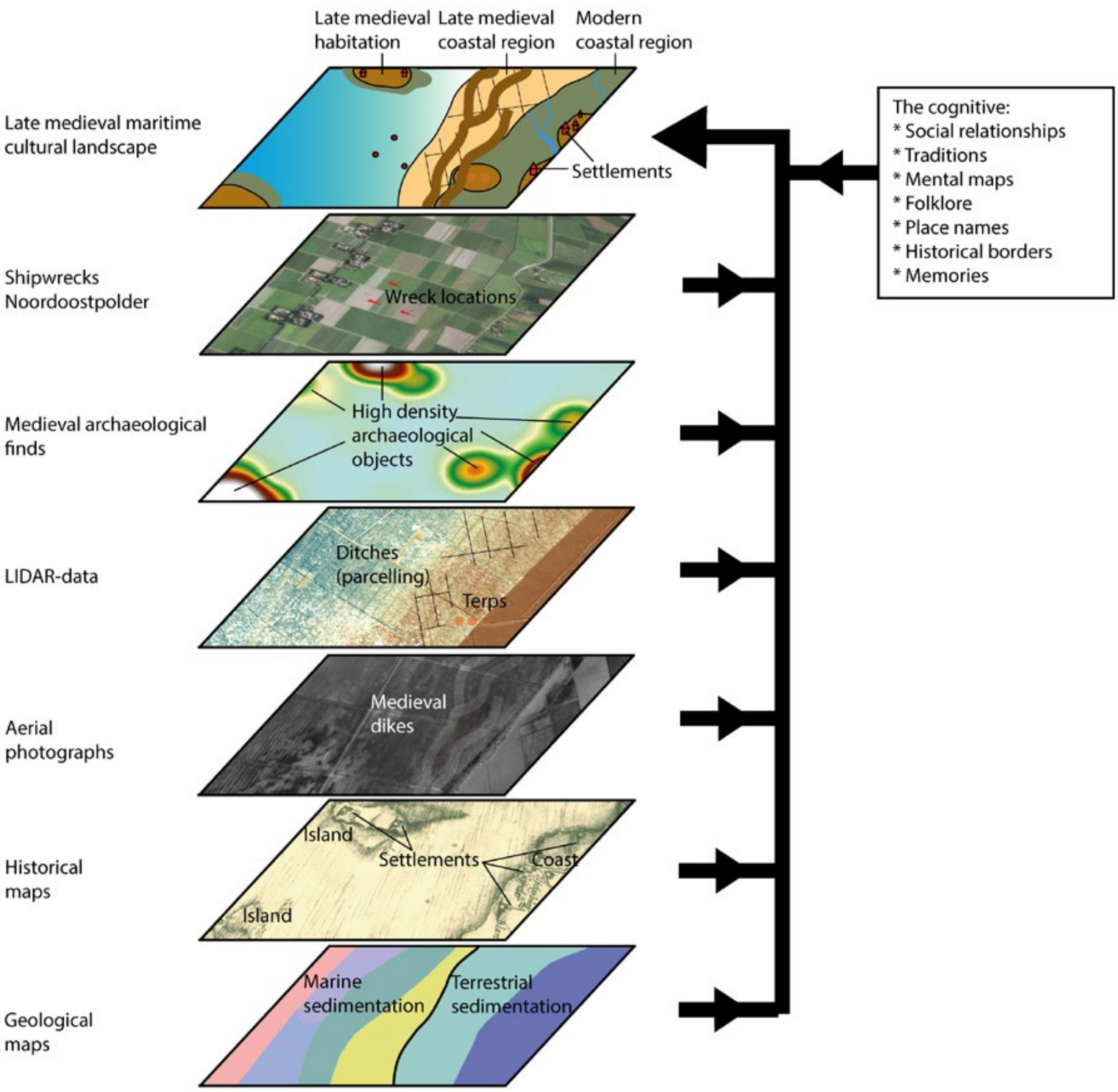

Figure 2. Overview of the interdisciplinary and layered approach that was used for reconstructing the late medieval maritime cultural landscape of the Noordoostpolder region. Information from the different layers is transported to the top layer (reconstruction).

former sea were reclaimed, resulting in three major polders (Noordoostpolder, Eastern Flevoland, Southern Flevoland), united as the Province of Flevoland.

Research on the Noordoostpolder started directly after its reclamation in the 1940s and resulted in the discovery of many shipwrecks. Nowadays, over 200 wrecks have been found and examined and together with the 230 wrecks from the other polders, the province of Flevoland claims to be the largest ship graveyard on land in the world. Archaeologists also focused on the former islands of Schokland, Urk and their surroundings, discovering the remains of dikes, terps (inhabited artificial mounds) and scattered archaeological finds. Geologists started to examine the thousands of corings and the soil profiles of newly dug ditches, resulting in detailed geological maps of the whole area (see Wiggers 1955). Based on these maps, several palaeogeographic reconstructions were made, though with a strong focus on the Neolithic, Bronze Age and Iron Age (see e.g. Gotjé 1993; Ten Anscher 2008). A reliable reconstruction of the medieval landscape has not previously been attempted, despite the large amount of available data.

Approach

Data from multiple disciplines in a variety of formats were collated for this research into a single GIS project. The assembled data does not only focus on the past landscape (palaeogeography) but also on the (remains of) human indicators or cultural heritage. In order to work with natural and cultural factors, it was decided to examine the research area within the scope of the maritime cultural landscape. This holistic concept was introduced by Westerdahl in the 1990s and proved to bridge the boundaries between data from multiple disciplines in relation with the land as well as the water (Westerdahl 1992). The principal material remnants of maritime human life used in this concept are shipwrecks and land remains (Westerdahl 1992: 8).

For creating a reconstruction of the maritime cultural landscape of the Noordoostpolder, an overview of shipwrecks and land remains is insufficient. It is commonly accepted that large parts of the Noordoostpolder were covered by peat in the Middle Ages, but the exact dimensions of the peatlands remain unclear (Wiggers 1962: 42). Most of the medieval land is eroded or covered by marine sediment. The only exceptions are the former islands of Urk and Schokland: they outlived the Zuiderzee. Besides these islands, the sites of medieval shipwrecks can add detail to the division between land and water: wreck sites simply represent areas of water. However, the number of relevant wreck sites is too limited to cover the whole research area in a sufficient way. Therefore, it was decided to use an interdisciplinary and spatial approach by creating a reconstruction of the late medieval maritime landscape that is based on multiple underlying layers (Figure 2). Each of these layers represents a dataset of which the information is transformed to a spatial environment. Relevant information is then distributed to the top layer (the actual reconstruction), where the combination and interaction of information leads to a first reconstruction. The reconstruction is then fine-tuned by adding extra (non-spatial) information and by using expert judgement. In some cases information of different layers corresponds, like dike remains that are visible on aerial photographs, LIDAR-data and geological maps. This overlap strengthens the method as well as the reconstruction itself.

A layered model

The different layers were added to the GIS in a specific order, beginning with information from geological and historical maps. The first provides information on the pre-medieval and medieval landscape, while the latter depicts the research area beyond the Middle Ages. They both limit the appearance of the Noordoostpolder: before and after the erosion of the peatlands in the Middle Ages. Then, information from the never thoroughly exploited aerial photographs and the remote sensing method LiDAR is added to the reconstruction. The different archaeological datasets (medieval archaeological finds, shipwrecks) are added for pinpointing settlement locations (they also represent land) and wreck sites (representing water). Each of the layers is further introduced below.

Geological maps

The soil of the Noordoostpolder region has been carefully studied in the past, even before the reclamation. The first accurate soil maps appeared in the period of 1947–1956 (Bodemkundige Code- en Profielenkaarten). The doctoral thesis of Wiggers (1955), partially based on these maps, provided relevant geological maps of the research area. Although these datasets are over 60 years old, they are still considered as reliable, accurate and of importance for current research. Ever since Wiggers published his maps, they have been adopted (more or less overtly) in many other maps and studies. The palaeogeographical maps of for example Zagwijn (1986), Gotjé (1993), Ten Anscher (2012) and Vos and de Vries (2013) all relate (partially) back to the interpretations of Wiggers.

In theory, the geology of the late medieval Noordoostpolder landscape can be split into two categories: marine sediments representing bodies of water, and clay-on-peat layers representing land. Unfortunately, the layers of medieval clay-on-peat have almost completely eroded, making it impossible to map them. The marine sediments, consisting of layers of detritus-gyttja, clay and sand, are well preserved and were accurately documented in the past. The first marine phase, referring to the Roman Flevo Lake-phase is represented by a layer of detritus-gyttja, formed from the partial decay of peat, and deposited on the bottom of bodies of water. The distribution of this layer is captured by Wiggers (1955: 67) and is crucial to the interpretation of the physical late medieval landscape of the region. Since the Roman era, the bodies of water (lakes) in the research area kept on increasing until the late 16th century. Hence, the distribution of the detritus-gyttja represents areas unsuited for habitation from the Roman era onwards. In other words, remains of late medieval habitation is only expected in areas where no detritus has been found (Wiggers 1955: 68). The map containing the distribution of the detritus-gyttja is therefore transported to the top layer of the reconstruction model. The few areas that contained actual remains of the medieval clay-on-peat deck, together with traces of late medieval habitation (mounds and dike remains) are also depicted on several geological maps: they have also been added to the reconstruction model.

Historical maps

Further important data for the reconstruction comes from historical maps: Walsmit *et al.* (2009) created a

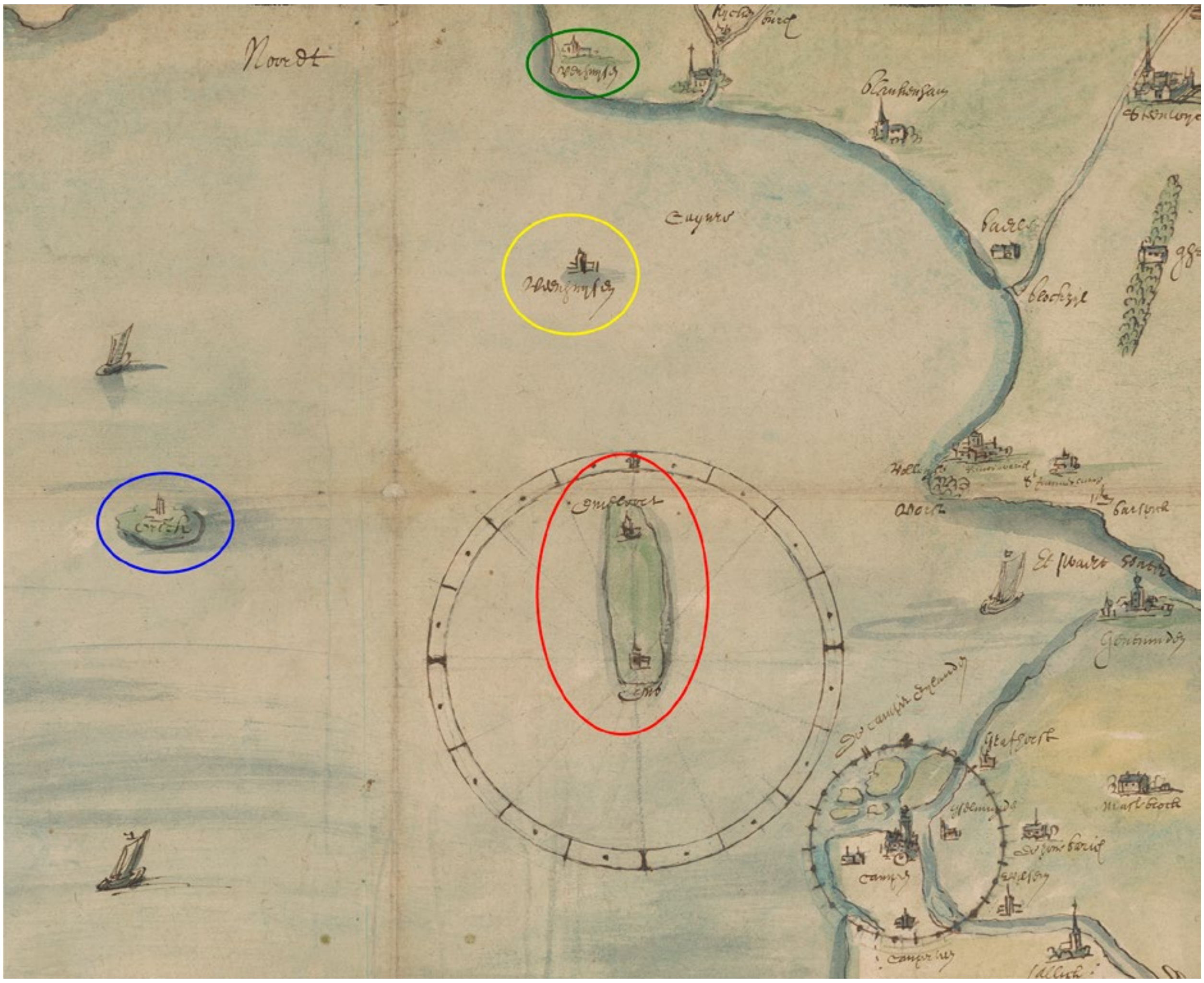

Figure 3. Cropped part of a historical map of the Zuiderzee (*c.* AD 1540), depicting the islands of Urk (blue circle), Schokland (red circle), the drowned settlement of Veenhuizen (yellow circle) and the second location of Veenhuizen (green circle). Map after Historisch Centrum Overijssel.

clear overview of the available and known historical maps of the Zuiderzee region. Most of the maps from the 19th and 20th centuries depict the Zuiderzee in its final shape (the end product of marine erosion). The oldest maps in the overview date back to the 16th century and, although they are not very spatially accurate, they contain valuable information on settlement locations (especially those that eventually drowned) and the layout of the landscape (division between land and water, rivers, roads). It is important to keep in mind that they provide an overview of the Noordoostpolder region after the late Middle Ages.

There are a few 16th-century maps that contain great details on the Noordoostpolder region. The oldest one dates to approximately AD 1540 and covers the whole Zuiderzee region. Within the research area, the known settlements of Vollenhove, Blokzijl, Baarlo, Blankenham, Kuinre, Slijkenburg, Emmeloord, Ens and Urk, are marked. However, another settlement called 'Veenhuizen' is depicted close to the north-west of Kuinre. The existence of this settlement is already proven by 13th-century charters from the St Odulphus monastery near Stavoren (see Mol and Van Vliet 1998). The name Veenhuizen (meaning 'peat houses') can be found a second time on the map, a couple of kilometers to the south of the first name and in the middle of the Zuiderzee. This position even contains a small drawing that could represent something like a drowned building (Figure 3). It is, so far known, the only historical map that actually depicts a drowned settlement in the research area. The first location of Veenhuizen (the southern one) was probably abandoned in the Middle Ages when large parts of the peat deck crumbled away. The second location was at first an inland location, but due to coastal erosion this location also became threatened by the Zuiderzee.

A more accurate historical map of the Zuiderzee region was made by Christian Sgroten (*c.* AD 1570) and also depicts the same settlements as the map from 1540, including the settlement of Veenhuizen, again several kilometers to the north-west of Kuinre. The first (oldest) location of Veenhuizen is not shown on this map. There is however another interesting aspect to this map—to the north of the island of Urk a flat or shallow water is depicted on which the toponym 'De Hofste' ('the homestead') is written. It implies that a settlement, or at least a building, was once positioned somewhere in close vicinity of this toponym on (perhaps) an island. More evidence for the presence of a third island (besides Urk and Schokland) comes from a 17th-century map (Provinces Unies des Pays Bas, 1648) on which an unknown island is depicted to the north of Urk, not far from the location where the 16th-century toponym 'De Hofste' can be found. The depicted island might be a mistake of the cartographer, as it is not shown on any other historical map from the same period. However, it equally might be a reference to an island that once existed in the same region, perhaps the flat that is called 'De Hofste' (Van Popta 2016: 83). All other information on the above-mentioned historical maps (settlements, rivers, flats, roads) is also transported to the top layer of the reconstruction.

Aerial photographs

Aerial photographs were already analysed for archaeological purposes in the late 19th century, although they were not primarily made for this purpose (Ceraudo 2013: 11; Cowley and Ferguson 2010: 97; Reeves 1936: 102). The techniques used and the quality of the photographs were however very basic in the early days. The quality of the images improved from the moment they were taken from planes. Especially during the Second World War, when Allied forces took hundreds of thousands photographs of Europe, the quality and quantity of the dataset drastically improved.

The first photographs of the Noordoostpolder region were taken during the Second World War by the Royal Air Force (RAF), shortly after the reclamation process was finished. They focused on the former islands of Urk and Schokland and on the former east shore of the Zuiderzee. More photographs were taken after the war (1947, 1949) and these ones cover the whole Noordoostpolder region. They offer a unique view of the former seabed with as yet very limited urban development. New aerial photographs were taken in 1960, 1971, 1981 and 1989, but their content is more limited due to increased extent of urban areas, extensive and mechanised agriculture and altered vegetation cover (development of forests).

The RAF photographs of the Noordoostpolder depict the partially cultivated soil of the research area (the western part of the polder was not yet dry enough). Remains of dikes and terps are visible as a network of linear dark lines and circles in the direct surroundings of Schokland and Urk, although not very clear (Figure 4). The post-war photographs from especially 1949 and 1971 very clearly show (1) the networks of dike remains and terps, (2) medieval parcelling in the eastern coastal zone and near Urk and (3) the remains of the second castle of Kuinre (see De Boer and Geurts 2002). It is clear that specific soil conditions (e.g. dry and ploughed) can strongly influence the visible archaeological traces, as they are much clearer on some aerial photographs. The visible archaeological traces like dikes, ditches (parcelling), terps and moats are digitised in a GIS and transported to the top layer of the reconstruction.

LiDAR data

LiDAR was used in the Netherlands for the first time in 1997 for the construction of a nationwide Digital Elevation Model (DEM), with a start resolution of one height point per 16m^2 (Lemmens 2011: 153). This DEM, called AHN1 (Actual Height Model) was finalised in 2003 and had a maximum resolution (depending on the region) of 1 surface elevation point per 1m^2 (Van der Zon 2013: 6). This would prove to be insufficient for finding archaeological traces and sites in the Noordoostpolder region. As needs were created, the building of the AHN2 started in 2006 and the new nationwide coverage by LiDAR-data was finished in 2012. The new DEM turned out to have a resolution of 6–10 height points per m^2, with the possibility to create a grid with cell sizes of 0.5m x 0.5m (compared to the 100m, 25m and 5m grid of the AHN1). Detailed analyses of AHN2 data in a GIS have proven to be of high value in finding archaeological sites in the research area, especially in those places where aerial photography is of no use—the forests. Laser pulses that are shot from an aircraft towards the earth's surface result in multiple returns; the first return will be received from the first obstacle that is hit (this would be the top of a tree in a forest), while the last return in theory would come from the surface of the forest (Lim *et al.* 2003: 93). By separating the results from different returns, it is possible to make a DEM of the ground surface of a forest.

With the relative high resolution of the AHN2 and the possibility to make a DEM of the ground surface of forests, some interesting results can be gained from the Noordoostpolder region. The best example of the added value of LiDAR-data comes from the Kuinder forest. This forest was planted in between 1947 and 1953, which means that only the aerial photographs taken before 1949 can be consulted. These photographs depict some vague traces of historical parcelling to the north-west of Kuinre. When a detailed DEM of the same region is examined in a GIS, it becomes clear that a whole system of historical parcelling is preserved in the forest soil

Figure 4. Aerial photograph (1971) of the middle section of the former island of Schokland. The blue arrows point out decolourations that represent medieval dike remains; the red arrows point out terp remains.

(Figure 5). In one part of the region, the visible traces of ditches deviate from the more general orientation (east-west): there are clear rectangular terrains and a more dense system of linear structures visible. These traces have, so far, never been examined and were discovered by the author after analysing detailed LiDAR-data. More traces of parcelling, dikes and terps can be found in the immediate surroundings of the former islands of Urk (Urker forest) and Schokland. Most of the agricultural grounds in the Noordoostpolder have been ploughed so often that the ground surface is relatively flat and archaeological traces have become invisible. Some large natural traces, like prehistoric creek systems and river dunes are still visible: this is caused by the limited soil compaction of these sandy traces, compared to the stronger compaction of the clayish or peaty surrounding soils. The newly discovered archaeological traces to the north-west of Kuinre and the already known dikes, parcelling ditches and terp remains near the former islands of Urk and Schokland are transported to the top layer of the model.

Medieval archaeological finds

Ever since the reclamation of the Noordoostpolder, thousands of archaeological objects have been found in the former seabed. Some of these finds are of prehistoric age (see e.g. Raemaekers 2010), but a substantial volume of material belongs to the Middle Ages. Many of these finds were found *ex situ*, for example during agricultural processes like ploughing. Until now, no overview existed of these finds and an overall interpretation of the lost contexts is lacking. The presence of medieval archaeological remains is in some cases interpreted as part of the inventory of wrecked ships, while others simply consider the material as noise. Wiggers (1955) and Van der Heide (1965) were the first scholars to interpret the assemblage of material as the remains of medieval settlements. Although their interpretations were put on paper, they were never thoroughly updated or expanded.

In order to find out whether the medieval archaeological material actually represents lost settlements, a reliable dataset had to be created. Therefore, information on relevant archaeological finds was assembled from all kinds of sources—the national archaeological database (Archis), documentation of amateur archaeologists, archaeological reports, daily reports and distribution maps. Besides primary information on type, amount and age of the material, spatial information (coordinates) was provided. The whole set of information was transported to the new Medieval Settlement Database (MSD). Spatial analyses on the archaeological objects in the MSD have shown distinct patterns in the distribution and density of material. Only those locations that contain a significantly larger amount of material than the average spread of objects in the region are expected to represent the remains of a settlement (Van Popta 2016: 86). There are multiple locations in the Noordoostpolder that meet the above-mentioned requirement.

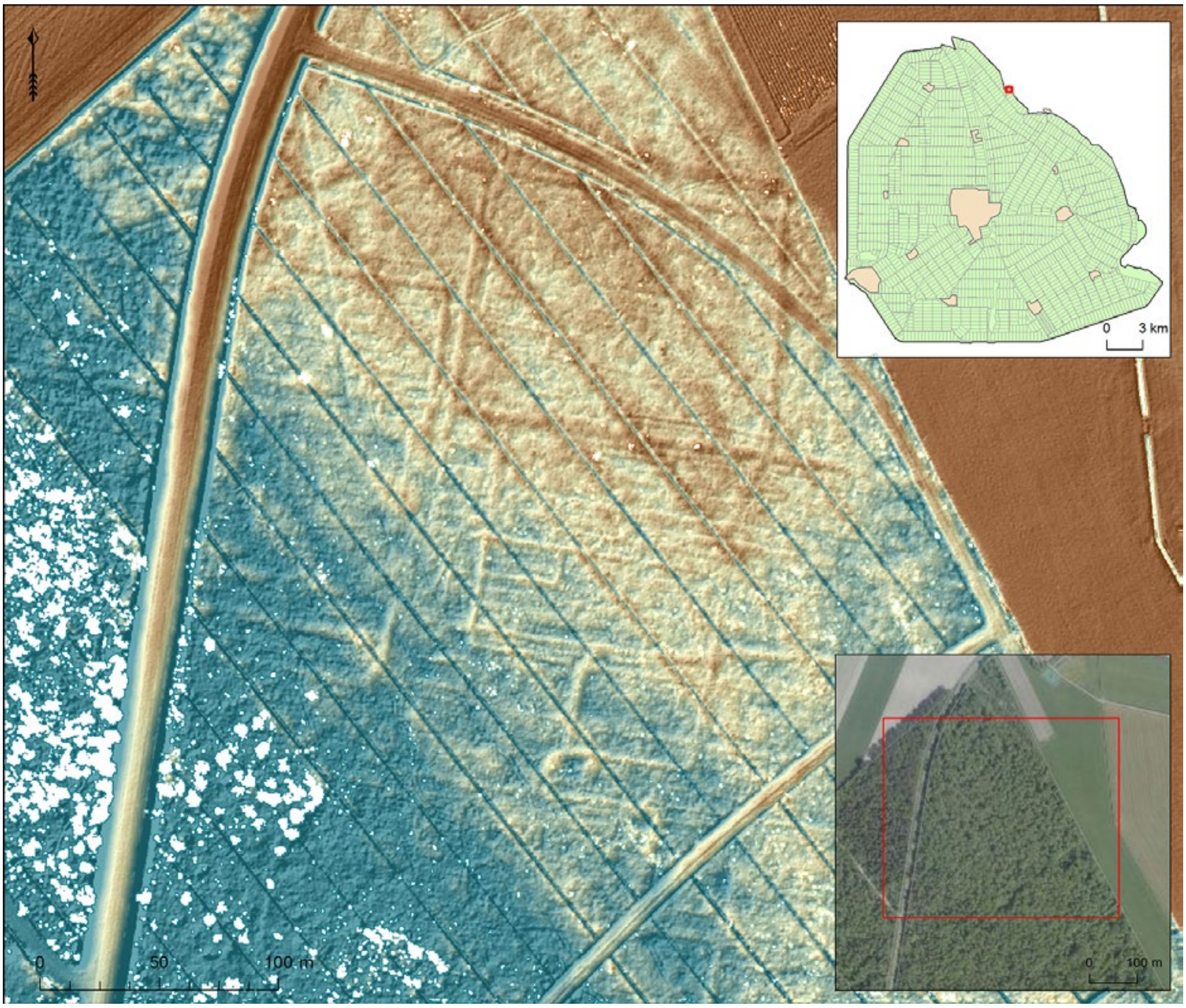

Figure 5. LiDAR-map of the Kuinderbos, approximately 4km to the north-west of the settlement of Kuinre. The map clearly depicts linear structures that represent medieval parcelling and possible settlement remains.

As well as the spread of objects, the composition of the archaeological material is of importance for recognising settlement remains. Medieval pottery sherds are the most commonly found artefacts in the research area, but the assemblage of settlement remains should consist of more than only sherds. This is the case for the locations that were mentioned before (Urk, Schokland, and Kuinre)—within these sites, remains of late medieval pottery, bricks, roof tiles (slate) and large amounts of animal bone have been found.

Shipwrecks

Wrecks are of importance for dating local contexts or even whole regions, and provide important information on specific periods (Westerdahl 1992: 7). In most cases, wrecks will be discovered underwater but the present maritime archaeological situation in the province of Flevoland is quite the opposite—most wrecks have been found in the reclaimed soil of the former Zuiderzee. Therefore, their presence in combination with their date of wrecking also provides information on the division of land-water and the age of specific (marine) soil layers (see Van Popta 2013). The number of relevant ships for this research, namely those that wrecked in the late Middle Ages, is limited to approximately 15. Their small number has multiple causes: first of all, the Zuiderzee was not yet an important sailing ground in the Middle Ages (poorly accessible, hazardous) and the number of ships on the Zuiderzee was therefore smaller than in the 17th and 18th century. Secondly, some of the medieval wrecks are unlikely to be found as they completely eroded over time or were removed.

The 'cognitive' finishing touch

The above-mentioned datasets focus solely on the physical part of the landscape. The study of maritime

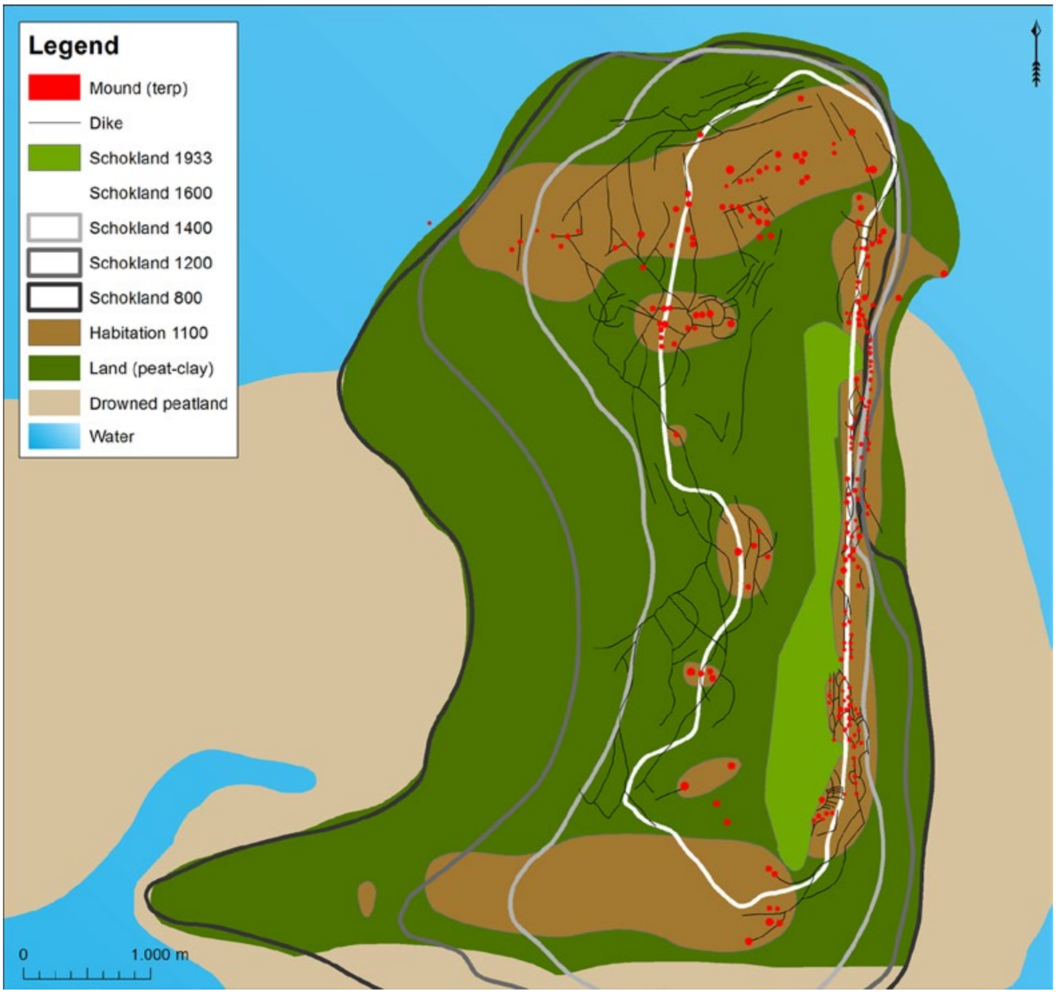

Figure 6. Detailed reconstruction of the former island of Schokland. The map emphasizes on the medieval land erosion and the remains that indicate human presence (dikes, mounds).

cultural landscapes is however not complete without immaterial cultural components: social relationships between the inhabitants and the physical landscape, traditions, folklore, mental maps, place names; or in other words—'the landscape in the back of our minds' (Westerdahl 2011: 339). There are many ways to obtain data belonging to this cognitive landscape, but the best way is probably by visiting the area of research. One should not be fooled by its modern appearance (a reclaimed part of the sea) as there are many historical references, some are clear (e.g. dialects, traditional costumes, fishermen-societies) while others can be somewhat vague (memories, oral traditions, historical borders). Without the information derived from these aspects, the reconstruction would depict the maritime landscape with the leftover evidence of humans (submerged settlements, shipwrecks, traces of land cultivation), but without the people themselves. With the cognitive finishing touch, we can discuss how people lived in the research area and how they engaged with water.

Challenges and gaps

The interdisciplinary character of the research and the use of multiple datasets have created some challenges and gaps that have to be dealt with. First of all, there are some chronological differences between the used datasets. For example, the interpretation of the physical landscape is partially based on geological layers from the Roman era, the distribution of late medieval archaeological objects and historical maps from the 16th century onwards. Each individual dataset is insufficient for making a reliable reconstruction, but the combination works: the geological data is used to frame the original landscape (before the marine erosion), the archaeological data is used to pinpoint the places of habitation and the historical maps depict the final stage of the marine erosion. Furthermore, some of the datasets differ in precision and resolution: some provide general information on the whole research area (e.g. a 16th-century historical map), while others provide very detailed information on one specific part of the research area (e.g. an excavation report of a late medieval mound). Due to the spatial character of the research, the difficulties in precision and resolution can be resolved by storing the data in a GIS.

Creating the reconstruction

The top layer of the model is in fact the reconstruction of the late medieval maritime cultural landscape itself. Information from all other layers is transported to this layer and complemented with extra information (literature, maps) and expert judgement. Two examples will be given of results that were gained by adopting the interdisciplinary methodology and restraining information from different sources/layers.

Schokland

The former island of Schokland is one of the few preserved parts of the late medieval landscape in the Noordoostpolder region. The island itself is small with an area of approximately 115ha, but its medieval predecessor was a lot bigger (approximately 2200–3000ha; Van Popta and Aalbersberg 2016: 129). Based on multiple datasets, an overview was made of the size of the island, its decline and human presence (Figure 6). The division of land and water is based on geological maps and interpretations (Van der Heide 1958; Wiggers 1955) as well as corings and soil profiles (Bodemkundige Code- en Profielenkaarten). Traces of habitation, like dikes and terps, were retrieved from multiple sources. The medieval dikes that were created to protect medieval Schokland against the water were partially documented during geological and archaeological research. However, other dike sections remained hidden for a long time until analyses of aerial photographs and LiDAR-data revealed their presence (Van Popta 2017). The late medieval inhabitants of Schokland lived on small terps (artificial mounds), of which approximately 130 were discovered since the reclamation (decolorations in the soil, aerial photographs). However, new and detailed analyses of (old) aerial photographs and LiDAR-data revealed over 80 new possible terp locations (Van Popta 2017: in press). The distribution and density of archaeological objects further defines the inhabited parts of the former island, while the distribution and age of shipwrecks demonstrates the loss of land as the younger wrecks are found closer to the island than the older wrecks.

Kuinderbos

The Kuinderbos is the largest and oldest forest of the Noordoostpolder, laying near the coast of the former Zuiderzee. Traces of medieval parcelling (ditches) and dike remains can be found throughout the whole forest, but they are only visible on the oldest aerial photographs (before the forest was planted), LiDAR-data and some geological maps. In the north-eastern part of the forest, some peculiar rectangular traces are visible on aerial photographs as well as LiDAR-data (see paragraph 'LiDAR-data'). When this information is combined with data from the historical maps, it becomes clear that these traces might very well represent the drowned settlement of Veenhuizen (second location; Figures 3 and 5). Multiple archaeological objects have been found in the surroundings of this location that also imply the presence of a drowned settlement. Further evidence comes from geological and palaeogeographic maps that prove that the region was still land in the Middle Ages.

Concluding remarks

The methodology presented in this paper emphasises the importance of interdisciplinary research in maritime archaeology and the way it is brought to life in the author's PhD thesis. Instead of solely focusing on archaeological data, information was assembled from multiple datasets, layered and combined in order to reconstruct the late medieval maritime cultural landscape of the Noordoostpolder region (former Zuiderzee) in the Netherlands.

The interpretation of combined data leads to new insights on the appearance of the late medieval Noordoostpolder region. A substantial part of the region was still covered by peatlands (geological data) and relative densely inhabited (archaeological data) in the late Middle Ages. People protected themselves against the water of the Zuiderzee by constructing dikes and by living on mounds (aerial- and LiDAR-data), but most of the peatlands were eventually washed away by the expanding Zuiderzee. As a consequence, many settlements drowned. Some of their names are mentioned in historical documents or depicted on historical maps, making it possible to relocate them to a certain extent.

Not just the combination of datasets, but also the use of relatively new data is of great importance for the overall interpretation of the research area. The analysis of detailed LiDAR-data has revealed multiple new areas that contain medieval traces of human presence, as well as the digital analysis of old aerial photographs. The interdisciplinary approach and use of new data slowly reveals the true identity of what the late medieval Noordoostpolder region once looked like. However, more steps need to be taken for completing the reconstruction of the maritime cultural landscape. Firstly, a reliable palaeogeographical reconstruction will be made of the physical landscape. Next, the physical remaining evidence of human presence/influence in the region will be studied and mapped. Finally, the cultural component will be added to the reconstruction by studying the cognitive maritime aspects of the region.

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Cultural Landscapes at the Urban Waterside: Investigating the Impacts and Effects of the Chelsea Embankment Construction on Working-Class Riverside Residents

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Abstract

Nineteenth-century Victorian London was the largest city and port in the world. It was home to the world's wealthiest and people experiencing excruciating poverty. The River Thames shaped the city, with hundreds of wharves, factories, quays and docks lining the riverside and providing employment for thousands. The Thames was also polluted with sewage, which caused thousands of deaths annually from cholera, typhoid fever and dysentery. In an attempt to clear the Thames of sewage and prevent diseases, a complex new sewage system was constructed between 1850 and 1890, which included the clearance of around 8.6km of river frontage and the construction of the Chelsea, Victoria and Albert Embankments.

Using the London riverside as a case study, this paper explores the difficulties that the traditional maritime/terrestrial division poses for studies of urban ports and harbours and argues that the maritime cultural landscape approach perpetuates the division between land and sea, and is inappropriate for the study of the 19th-century urban waterside. This paper uses historical and archaeological material to examine the relationships between the River Thames and working-class riverside residents, and the social and economic impacts and effects of the Thames Embankment constructions. It proposes that personal experiences and social relationships are what create meaningful places, and that experience-based approaches provide a more appropriate alternative method for studying the social archaeology of watery places.

Keywords

Maritime cultural landscape, Victorian London, River Thames, social archaeology, 'meshworks'

Introduction

This paper presents the conceptual foundation for doctoral research on post-medieval London, which focuses on the Thames-side residents. The paper discusses ways in which historical and archaeological approaches might be combined to investigate the impacts and effects of the construction of the Thames Embankment at Chelsea, west London, United Kingdom, in the late 19th century. The research is specifically focused on how the working classes who lived and worked on and around the river were affected by the physical impacts, as well as economic and social changes (effects) that the construction of the Embankment brought about.

Embankments have been constructed on the River Thames since the Roman period (Milne 1985; Milne 2003). However, all the pre-Victorian structures shared a common purpose—that of facilitating access to the river. In contrast, the Victorian Embankments created a barrier between dry land and the river. Their construction required the closure and demolition of numerous waterfront businesses and houses in order to construct the iconic solid granite walls that exist today. Once the embankments were complete, access to the Thames was significantly reduced, and primarily limited to the new steamboat piers. At Chelsea, three sets of stairs were inserted into the embankment wall three years after its completion, where previously up to six sets are recorded in historic mapping and documentary sources along the same stretch between 1837–1864 (Cary 1837; Cross 1850; Stanford 1864).

In order for the change from embankments as access facilitators to barriers to occur, there must have been a change in people's perception and relationship with the river in the Victorian period to allow the creation of such a substantial barrier between land and water. This research questions how this might have happened and examines what effect the embankment construction had on the people who had previously relied on access to the river for employment. In addressing these questions, this current article suggests that the complexities of social relationship networks linking people-places-community and watery places cannot be fully explored within traditional maritime cultural landscape type approaches. In outlining a theoretical framework and methodology, this paper proposes an alternate conceptual and methodological approach for the study of the social archaeology of ports and harbours.

Connections to place

There is of course a substantial body of work in the social sciences that explores the importance of connections to place in relation to community building and identity (for example see summary in Hubbard and Kitchin 2011). Within archaeology the topic has been widely researched (Bender 1993; Bender *et al.* 2001; Low *et al.* 2003; Macdonald 2006; Thomas 1996), with scholarship also investigating the ways in which communities actively engage in the transformation of landscapes (Casella *et al.* 2010; Lawrence 2000). My research approaches the relationship somewhat differently, with a specific interest in what happens to networks of social relations between (working-class) people, places and the river as a result of major landscape transformation. This approach has been designed to take specific account of the historic situation at Chelsea whereby such changes were imposed by an external group—the Metropolitan Board of Works—leading to the forcible relocation of people who previously lived and worked at the riverside. Whilst not denying the agency of local residents in re-negotiating responses and relationships within the situation, it is from the perspective of an unequal relationship and externally imposed set of transformations that this study proceeds.

Archaeologists, anthropologists and human geographers have long highlighted the importance of bodies of water to people who live or lived in watery places, not just for economic purposes, but also from social and cultural perspectives. Numerous terms have been developed including ‘fluidscapes’ (Strang 2006; Strang 2010), seascapes (McNiven 2003; 2010) and maritime cultural landscapes (Westerdahl 1992) to describe and understand places with cultural meaning around, on and within water. However, as Cobb and Ransley (2016) have noted, these approaches still imply some kind of boundary between land and water ‘scapes’ or places. For example, within these traditional frameworks, if one moves significantly far enough away from the coast, one can no longer be considered to be within a ‘seascape’ and must be beyond what could be reasonably considered a ‘maritime cultural landscape’. In this way, these approaches also imply that the beholder, or conceptual ‘owner/creator’ of the cultural landscape/seascape, is predominately *either* on water *or* on land. These place-focused approaches also have limitations in coping with the varying types of interactions that individuals within a group or a landscape have with water; be they, for example, domestic, transport, subsistence, social, cultural, religious or economic. This variety in the nature of the person-water interactions affects the relationships that people have with both the water itself and water-specific material culture, which therefore also affects the meaning that places in, on and around the water have. A key idea behind the fluidscape, seascape and maritime cultural landscape approaches was to remove our ‘modern’ conceptual boundaries between water and land, in order to view waterside environments as seamless places. In trying to redress the balance, however, they are overly water-focused and therefore cannot manage the complexities and variety of relationships and meanings that might exist between people, place, things and water. Urban environments at the waterside pose specific and significant problems for these concepts due to the highly varied relationships with water and the complexities of social relationships at play.

This article proposes that archaeological studies of the waterside should bring the rich descriptive language of watery places to the fore, to reflect a material distinctiveness of the littoral zone—the foreshore, waterfront, riverside, strand, etc. This variety of descriptive language provides a sense of the material experience of landscape features such as rocks, sands, shingle and pools, or the distinctive built environment of wharves, docks, quays, piers, jetties and moorings. Using such descriptive and varied language also brings the character of people who populated, inhabited and navigated these places into our study, and ensuring that it is the watermen, lightermen, pilots, dockers and fish-women who are the central focus of this study.

In contrast to place-focused approaches then, we can make experience of and actions within place—what Heidegger termed ‘dwelling’ and ‘being-in-the-world’ (Heidegger 1962)—the main analytical focus of such a study, acknowledging that it is through inhabitation that space *becomes* meaningful place (Relph 1976; Tilley 1994; Thomas 1996 chap.4; see also Hubbard and Kitchin 2011). This approach acknowledges that we do not experience our world only as sea and land—or even a seamless ‘scape’ including both—but in a much more complex manner that also encompasses sky, weather, people, boats, travel, things, experiences and relationships. Cobb and Ransley have suggested that if we accept this complexity, then a more ‘experience-based’ approach could provide a better understanding of past habitation of watery places (Cobb *et al.* 2016). This paper uses the above conceptual and methodological approaches to explore how we might do this within the context of a 19th-century urban riverside.

The concept that each individual creates their own cultural landscape, through their personal experiences and actions, is a central theme for this research because a person’s relationship with watery places, and its centrality to their life experience, is not lost to them simply by moving inland. In urban environments, such as pre-embankment London, this type of movement becomes highlighted. In many areas of London, particularly west of the enclosed docks, waterside residents and workers could walk just a few streets away from the river and be in a place that had

Figure 1. 'Meet the neighbours: where place becomes community' on the construction site hoardings around the Battersea Power Station site, Battersea, London (Author 2016).

absolutely no relation with the water. Here, you may not have been able to hear, smell or see the river, and there might not have been topography, streetscape features or businesses to indicate that you were still physically close to the river. Yet, despite this, a riverside resident or river worker would still carry with them their experiences, perceptions and understanding of London, and the world, in relation to the central role that the river played in his or her life.

Ingold (2011) described the complex and boundless networks of interactions and relationships that people form by doing and being-in-the-world as 'meshworks'. The topography, water transport, weather, smells and sounds that are unique to watery places all form part of a person's meshwork, as do colleagues, family, acquaintances, places, and material culture encountered and utilised in one's life. Because everyone experiences place differently and has different meshworks of relationships, we should expect that the working-class riverside residents would have different experiences and relationships with the river to the middle-class managers of the Metropolitan Board of Works who designed and constructed the Embankments. If we can understand these varying meshworks, they may provide insight as to why the Victorian Embankments broke with traditional waterfront construction and were designed as barriers to the water instead of facilitating access.

Communities

The concept of 'community' is a contested and complex idea, with multiple definitions across different disciplines. Broadly speaking, there is some agreement that it is relationships with other people within some context—such as a place, shared experience or faith, for example—that creates a community, summarised in the billboard in Figure 1.

As outlined above, the idea that relationships with meaningful places and people are formed by our experience of, and with, the world around us, is central to this research. This approach views our constant movement and action through, and within, places as creating constantly changing networks of social relations. Therefore, we should see the idea of 'community' itself as a 'fluid' concept, made up of many active and changing social relationships with different purposes. This approach allows a person to be part of many communities, and for many communities to co-exist in the same place. This situation is known to be true of urban areas like Victorian, and contemporary, London where the variety of social classes living in close proximity suggests complex systems of social interaction.

Our social interactions include places and things that provide context and meaning to the relationship (Harris 2014; Hubbard *et al.* 2011: 7; Tilley 1994), and watery places can be particularly important in the formation and evolution of such relationships. For people who work and live on near the water, many social interactions take place solely on, or connected with, boats. For example, friendships might form between work colleagues as a result of a shared experience that took place on a boat during particularly bad weather. Such relationships may be close and enduring, but are always linked to, and given context by, both the weather and the boat. If meshworks of relationships between people, places and things are seen as central to understanding the implications of the landscape transformation that the embankment construction brought, then understanding how people engaged with the riverside environment becomes a central aim of the research.

Investigating the impacts and effects of the Chelsea Embankment construction

The Thames Embankments are located in central London and are generally thought of in three sections:

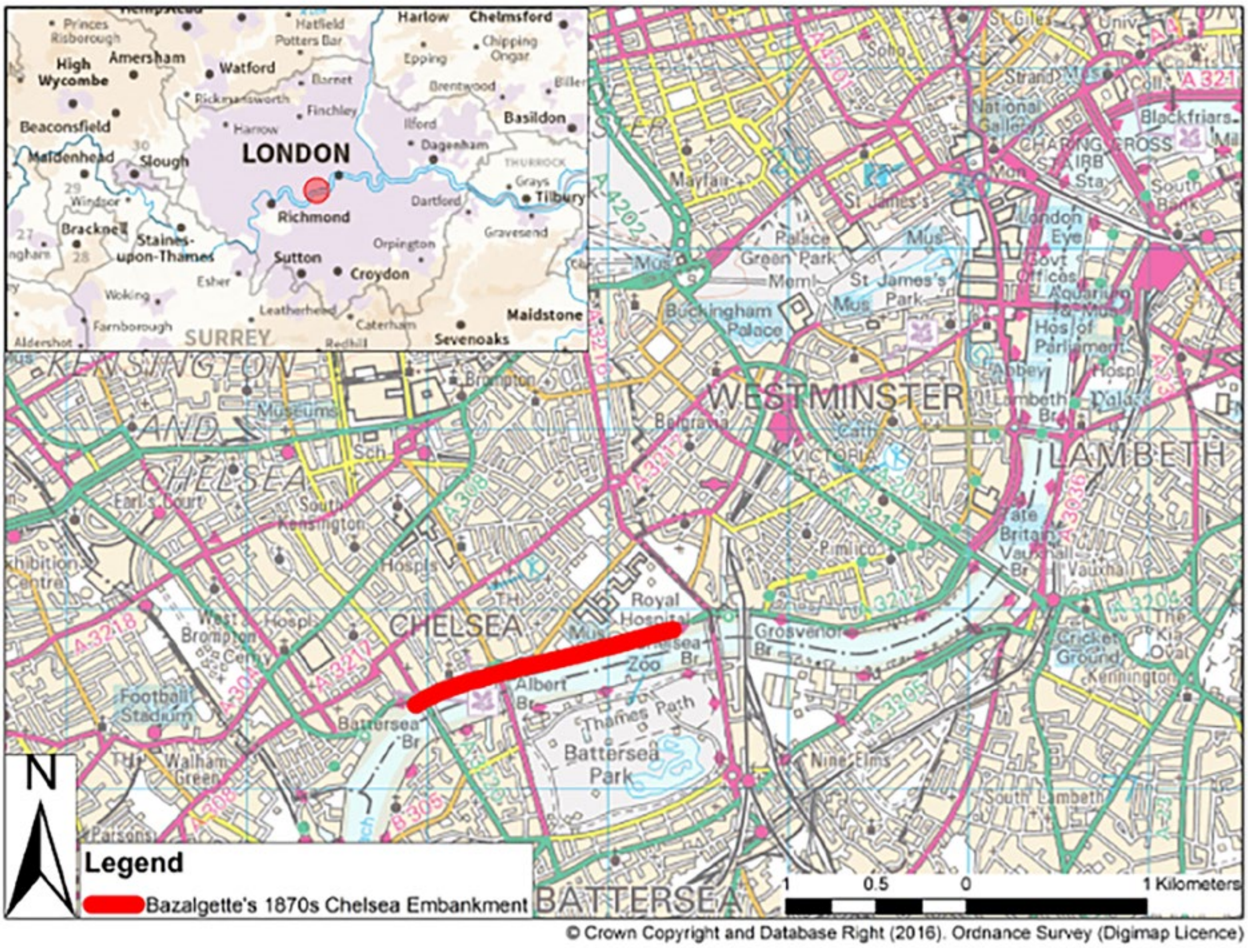

Figure 2. The location of the Chelsea Embankment in central London (© Crown Copyright and Database Right) (November 2016). Ordnance Survey (Digimap Licence).

the Victoria, Albert and Chelsea Embankments. The embankments were built by the first city-wide government organisation, the Metropolitan Board of Works, under the supervision of their chief engineer Joseph Bazalgette. The embankments contained huge brick-lined sewers and were one part of the Main Drainage System, the first comprehensive sewer system for London, which prevented raw sewage being dumped into the Thames and effectively ended decades of cholera, typhoid fever and dysentery epidemics caused by the consumption of polluted drinking water (Halliday 2001; Luckin 1986).

The Victoria Embankment runs between Westminster and Blackfriars Bridges on the north bank of the Thames and is the largest and most complex of the three embankments, as it included the underground railway line in addition to the sewer. It was built between 1865 and 1870. The Albert Embankment was built primarily for flood defence, and does not contain a sewer but does conform in its external appearance with the Victoria and Chelsea Embankments. The Albert Embankment was constructed between 1866 and 1869 and runs between Vauxhall and Westminster Bridges on the south bank.

The construction history of the Chelsea Embankment is less understood, but it was built in at least three sections between 1850 and the 1890s. In total it is 4.5km long with the earliest section built in 1854, running between Chelsea Royal Hospital to Millbank and the latest area running south from the Houses of Parliament towards Millbank, creating Victoria Tower Gardens. This research is specifically interested in the section of the Chelsea Embankment that was built as part of Bazalgette's Main Drainage System between 1870 and 1874 (Figure 2). This section is 1.6km long and runs from Battersea Bridge in the west, to the Royal Chelsea Hospital in the east where it joins with the earlier brick-faced 1850s embankment (Figure 3). It contains a section of the low level sewer and connects with the sewer in the Victoria Embankment. Historical documents and archaeological remains indicate that construction of this section of the Chelsea Embankment

Figure 3. Royal Hospital Stairs, Chelsea. The 1850s embankment is on the right of the river stairs, and is brick built. The 1870s embankment is on the left of the river stairs and is finished with faced granite blocks (Author and Clare Dowling 2016).

involved the demolition of a number of working-class homes and waterfront businesses, which are the focus of this research.

London underwent a physical transformation during the Victorian period, with monumental infrastructure projects such as the embankments, railways and new roads demolishing huge swathes of largely 'slum' housing and reorganising the road layout. In his 1848 book *Dombey and Son*, Dickens describes a common mid-century London scene and captures the scale of landscape changes resulting from the construction of the railways:

> Houses were knocked down; streets broken through and stopped; deep pits and trenches dug in the ground; enormous heaps of earth and clay thrown up; buildings that were undermined and shaking, propped by great beams of wood ... Everywhere were bridges that led nowhere; thoroughfares that were wholly impassable ... carcases of ragged tenements, and fragments of unfinished walls and arches... In short the yet unfinished and unopened Railroad was in progress ... (Dickens 1848, chap. 6).

Dickens goes on to write that these works rendered whole areas of London unrecognisable. Whilst the railways and construction of new roads have been widely recognised as responsible for such disruption (Anthony 2011: 57; Dwyer 2011; Porter 1994; White 2008), the embankments have not been talked about in similar terms; and, in fact, any negative impacts or effects have largely been ignored. The reasons for this seem to be connected with the central role that concepts of Improvement and Modernity played within Victorian middle and upper-class politics and morality (Oliver 2000), but the omission of negative impacts from the historiography of the embankments is a topic beyond the scope of this article and will be explored further elsewhere.

These enormous, destructive infrastructure projects were all part of the Victorian desire to create a 'modern' city, as Dickens highlights when he describes the railroad trailing away from landscapes of destruction on its 'course of civilisation and improvement' (Dickens 1848: chap. 6). Old buildings and the narrow medieval streets of London were seen as harbouring foul air and disease, and were no longer an appropriate part of the wealthy, international, industrialised seat of the British Empire (Jackson 2014; White 2008). To this end, improvement and modernisation works demolished large areas of the city to create routes for above and underground railways, new streets such as New Oxford Street, and transport links such as the Holborn Viaduct. These were carried out largely at the behest and instruction of the middle and upper classes, through processes of national and local governance, such as the establishment of local Improvement Trusts, or Acts of Parliament (White 2008, chapter 1). Many of the areas demolished for these improvement works were older residential buildings, occupied by the poorer working classes, described at the time as slums or rookeries (Jackson 2014; Picard 2005: 55, 85–92; Porter 1994;

White 2008: 28–35). Urban improvement works became a way to both clear the slums and modernise the city. Although thousands of people were displaced by the works, no affordable replacement housing was provided (Jackson 2014: 190–2). New housing on the outskirts of London was aimed at the growing middle class, and the transport costs into the city for work made living further afield prohibitively expensive for those on low or irregular incomes. Even the housing built by Model Dwelling Companies, such as the Peabody Trust and Four Percent Industrial Dwellings Company, were beyond the financial means of many of the poorer working classes (Picard 2005: 58), who instead found themselves in ever more crowded extant slums (Anthony 2011: 56). There is ongoing discussion about how the working classes engaged with the Improvement Movement (Casella 2005; Casella *et al.* 2010; Tarlow 2007: 200), particularly in relation to self-improvement and education (Griffin 2013; Turk in press), but less attention has been paid to the working-class reaction to urban landscape and infrastructure improvements, which were *imposed* on them, and of which they had no active involvement in designing, but may have been employed to build.

To those who planned, designed and managed the construction of the embankments, the Thames foreshore prior to embankment was a stinking, muddy and inaccessible place. It has been described, in 20th-century academic publications, as a wasteland, a wilderness of piers and jetties, and a place of filth and squalor (Halliday 2001: 160; Picard 2005: 33; Porter 1994: 321, 1998: 4; Werner *et al.* 2011: 255). The histories of the embankments have been written by people who saw them as engineering triumphs and in terms of the sanitation improvements that the main drainage system brought. They celebrate the creation of a clean, tamed, ornamental river and the wide road and walkway that eased the traffic flow (Ackroyd 2007; Black *et al.* 2003; Halliday 2001; Nead 2000; Oliver 2000; Picard 2005; Porter 1994; Porter 1998; Werner *et al.* 2011; White 2008).

However, James Hedderly's photographs of the Chelsea waterfront in the 1860s, such as in Figure 4, show a busy, working and lived-in landscape (Walker 2011a, 2011b, 2012a, 2012b, 2012c). There are clearly businesses, colleagues, houses, families and communities in these photographs. The images do show poverty and buildings in poor repair, but it is not the wasteland recorded and perpetuated by historians. Descriptions of the waterfront and foreshore as an unpleasant place seem to be a largely middle-class view (no doubt helping to justify radical landscape change which was to their social and financial benefit), wherein the working classes—the people who actually worked and lived in this landscape—became largely absent from both historical records and the historiography of the embankments.

So far, no research on the Embankments has discussed any negative impacts or effects of their construction. So how can we reconcile this discrepancy between observed change and its logical consequences for displaced and disenfranchised communities: how can we move away from the dominant middle-class vision of the riverfront? The Victorian concepts of Modernity and Improvement provide a useful context for this research, to help understand two opposing views of the river: that of the working classes for whom it was an economic facilitator with social, economic and 'cultural' meaning, versus that of the upper classes who saw the river as a disgusting, unsightly wasteland to be controlled, tamed, tidied and, in the language of the 21st century, 'gentrified'.

The pre-embankment riverside at Chelsea has not yet been the subject of published historical research, and what is known comes largely from 19th-century primary sources. The historic archives for London provide overwhelming quantities of source material, which is reflected in the vast numbers of books on histories of London and academic theses (Centre for Metropolitan History 2017). Yet, by contrast, there has been very little thematic archaeological research on 19th-century London (Jeffries *et al.* 2009), less on the waterfront, and none on the Chelsea area. This is important as archaeological material cuts across class boundaries to evidence both working conditions as well as the detritus of inhabitation, providing potential opportunities to give voice to those written out of the maps, plans and records of engineering triumphs.

The author's current research, therefore, uses both archaeological and historical sources to investigate the landscape and experience of the working-class riverside residents in Chelsea through the period of embankment construction. The research uses a methodology published by Steyne (2013), which gives a cultural landscape twist to traditional historical landscape characterisation methodologies (Aldred and Fairclough 2003; Clark *et al.* 2004; Clark 2005; Turner 2006), and attempts to characterise riverside use as a basis for understanding experience and meaning of place. Where traditional historic landscape characterisation maps the surviving historic features in the present day, Steyne's proposed methodology creates maps for multiple points in the past to visualise changing land-use patterns. This is not a simple matter of map regression; this research proposes decadal intervals to take advantage of census records and the availability of historic mapping. The approach uses primary sources, such as historic mapping, business directories and census records to identify land use and riverfront economic activity. These sources alone cannot provide the 'experience-based' view of the Victorian riverside advocated above, but they do provide a basic framework within which activity and relationships can

Figure 4. View of Alldin's coal wharf at Arch House Wharf on the waterfront at Chelsea around 1866 prior to the construction of the Chelsea Embankment. Buildings and infrastructure on the foreshore were demolished to make way for the embankment (James Hedderly, (© Royal Borough of Kensington and Chelsea)).

be understood. Onto this broad landscape study, finer grained studies of inhabitation and materiality will be layered, to bring the study towards an understanding of the experience of individual residents.

The archaeological remains on the foreshore at Chelsea provide a more focused understanding of activity specifically on the foreshore. The archaeological survey was carried out in 2016 by the author and a small group of volunteers. The survey used a pole mounted Leica Zeno GPS to record the location and extent of features visible on the foreshore in conjunction with photography, some measured drawing and photogrammetry to record additional details. No excavation was carried out but due to the presence of a number of local mudlarks taking material from the foreshore, some artefacts were recovered from the surface for further study. The survey recorded 79 features likely to be associated with 19th-century businesses on the pre-embankment riverfront, in addition to a number of drain openings and river outlets, which may also coincide with pre-embankment tributaries, riverfront features and activity. All archaeological features seen on the foreshore were recorded, including prehistoric peat exposures, and (with the exception of the peat and an Anglo-Saxon fishtrap) all are thought to date to the 19th century, based on construction techniques and artefacts. Features recorded include timber jetties, chalk barge beds—which provided a soft and stable surface for flat bottomed Thames barges to beach on at low tide—and artefact scatters. Some of these features correspond well with the locations of businesses named on historic mapping, such as the barge beds that seem to correlate with the historic position of Arch House wharf (Figure 4), which was demolished as part of the embankment construction. Many other features do not relate to known businesses, but research in this area is ongoing, and it seems likely that the features are associated with landing points and businesses on the riverfront.

In addition to the structural features, a number of discreet artefact scatters were identified during archaeological survey. Further work is needed to clarify the sediment transport patterns and hydrodynamics in the study area, but initial observation and survey of the scatters established that they have definable edges, and are interspersed by areas of foreshore that are completely clear of archaeological material. The scatters also seem to vary in content across the study area. The location and extent of the scatters indicate that some are clearly associated with structural features, such as the jetties and barge beds mentioned above. The fragile nature of some of the finds, and the lack of rounding and wear of the breaks to ceramic and glass objects suggests that the objects have not moved around much within the foreshore gravels. This suggestion is supported by bathymetry and LiDAR data of the foreshore, collected quarterly by Thames Tideway between 2013–15, which suggests that unlike other stretches of the Thames, the foreshore sediments at Chelsea are stable (Martin Turner, Thames Tideway, pers. comm. 11/02/17). The stability or otherwise of the foreshore sediments and artefact scatters needs to be examined more fully. To this end a methodology to examine the roundness of breaks in ceramic and glass objects, based on the Powers Roundness Scale (Powers 1953) is being explored to support the data collected by Thames Tideway.

The archaeological survey work has only been subject to a preliminary analysis, but is already indicating that the riverfront was more densely occupied and heavily used than is suggested through historic mapping and documentary sources alone. The combination of landscape characterisation and archaeological data from the foreshore will provide an insight into focal places that local residents and workers would have spent their time. By identifying the number, location and scale of businesses on the riverfront, an indication of the number of people employed in river related work can be estimated. When combined with historical documents such as census records, this will help establish the relative importance of access to the river for employment for local families. The archaeological and historical data combine to create the spaces and places in which people were living, working and moving.

In order to explore the way in which people experienced the foreshore, the cultural meaning of the river, and therefore what the impacts and effects of the embankment construction might be, Steyne (2013: 5) proposes the use of micro-case studies. These focus on individual streets, houses, people or sites of employment, and build on the data collected in the landscape study and archaeological survey. These small studies serve to create more personalised perspectives of the landscape change, and provide a way of investigating how the embankment construction might have been experienced by the riverside residents. The construction of these individual narratives uses methods advocated by Mayne and Lawrence (1998) and Yamin (2001) in their respective 'ethnography of place' and 'inside out' approaches. Early work with the census records has identified lightermen living locally and a number of families living within the riverside houses that were demolished as part of the embankment construction works. The autobiography of George Winn, who grew up in a waterfront house in Chelsea immediately prior to their demolition, adds a child's perspective of the waterfront (Winn 2009), and will be extremely useful in building these individual narratives. By focusing on small-scale stories of individuals as they move within and between the home, street and/or workplace, the experiential side of the research can be explored, providing a clearer understanding of the impact and effect that the construction of the Thames embankment that Chelsea had on these working-class residents.

Conclusions

This research has begun to investigate the changing relationship between local working-class residents and the River Thames in London during the latter half of the 19th century by using an archaeological and historical study of the physical impacts and social and economic effects of the construction of the Chelsea Embankment. Following Cobb and Ransley (2016), this paper proposes that although traditional maritime cultural landscape and seascape-type approaches attempt to study waterside places in a seamless manner, they are in fact overly water-focused, because they imply that the conceptual 'owner/creator' of the cultural landscape/seascape must be predominately on water, rather than on land. As such, these place-based approaches do not provide a sufficiently nuanced framework to cope with the complexities of relationships that exist between people, things, places and bodies of water, especially within the post-medieval urban environment.

In addition to being inclusive of the rich language of watery places, and a biographical focus on the dwellers of these spaces, an alternative, more experiential-based approach, is proposed in this paper, which uses Ingold's (2011) concept of meshworks. The meshwork system identifies that it is personal experiences and actions that shape a person's network of meaningful relationships with other people, places and things. It is suggested here that in the context of riverside, or indeed any waterside environment, such meshworks need to incorporate aspects of the experienced world beyond the people-place relationship, and indeed beyond the people-place-thing relationship, to include things such as weather, smells, sounds and transit routes. It is only by incorporating all aspects of the experienced riverside landscape that we can understand the implications of landscape change. Seeking the differences in the meshworks of the working-class riverside residents of Chelsea and the middle-class managers of the Metropolitan Board of Works may also provide a clearer indication as to why the Victorian Embankments were created as barriers between land and river, instead of facilitators of movement.

It has been suggested here that the unprecedented transformation of the riverside at Chelsea was a result of changing relationship networks between people and the river. In order to investigate these meshworks, a primary aim of this research must be to understand how people engaged with the riverside environment. To this end, a methodology has been proposed which combines archaeological survey data from the Chelsea foreshore with historic source material to investigate the working and lived-in spaces of the riverside, and places with meaning for working-class residents. The use of micro-histories will enable the lives and experiences of individual people or households to be explored, thereby providing a more personalised perspective of the impacts and effects of the construction of the Chelsea Embankment, and a tentative experiment in the creation of a more experiential approach to the study of past habitation of watery places.

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Vado Ligure Bay (Liguria, Italy)—Dredging Through the Long Life of an Ancient Harbour

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Abstract

This is an ongoing report on the preventive archaeology carried out over more than a decade in the harbour of Vado Ligure (Savona, Liguria, Italy). Due to the planned construction of a multipurpose platform, geoarchaeological surveys were carried out from 2005 to 2016. Archaeological monitoring of the dredging activities is still underway. This was an opportunity to investigate an important natural harbour in use since Republican times.

Keywords

Preventive archaeology, harbour, dredging, geoarchaeological surveys

Historical-archaeological background

Liguria is a narrow region in the north-west of Italy with high mountains along a predominantly rocky coastline. Its few natural harbours and shelters have often been used as ports of refuge along the major coastal sea routes that connected Italy to the western markets of Gaul and Spain.

In this natural landscape, from as far back as late Republican times, Vada Sabatia (modern Vado Ligure Savona, Italy) has had a particularly important position in the Ligurian port system. The Roman road network, running inland from the western Mediterranean coast, naturally converged on its wide, open bay. The Via Julia Augusta, inaugurated by Augustus in 13 BC, set off from here, retracing the route of the Via Aemilia Scauri of 101 BC heading up through the Cadibona pass into the Po Valley. Passing the towns of Aquae Statiellae (modern Acqui Terme) and Dertona (modern Tortona) it merged with the Via Postumia leading on to Aquileia. Other routes ran up the river Tanaro basin towards Augusta Taurinorum (Torino) through the towns of Augusta Bagiennorum (Benevagienna), Alba Pompeia (Alba) and Hasta (Asti) (Figure 1). It is no surprise that the bay was chosen by the Carthaginian fleet as a naval base during the Second Punic War.

Vada Sabatia (Vado Ligure) is one of the few Ligurian ports which qualified as a '*portus*' in the *Itinerarium Maritimum*, a portolan chart from the 5th or 6th century (Uggeri 2004: 47). It harboured a well-sheltered bay along the major shipping routes. Its deep waters were suitable for anchorage and it was wide enough to accommodate entire fleets. Fresh water was guaranteed by a nearby spring, canalised since Roman times for the requirements of the port and the city (Valgelata fountain), and by the rivers Segno and Quiliano. Their alluvial plain fanned out into a sandy coast, meaning that ships could easily be beached. The small island of Bergeggi, south of the bay of Vado Ligure, provided further protection for ships reaching the port. It was a prominent lookout point and probably had a lighthouse (Bulgarelli 2010: 96–98 with references). Consistent archaeological evidence on the seabed, as shown by a significant concentration of up to 30 Dressel 14B-Beltràn IVB amphoras, points to the existence of one of the few known wrecks with a cargo entirely consisting of these containers.[1]

In spite of ancient Vada Sabatia's rich archaeological record, it has not been possible to construct a comprehensive framework of the development of the Roman city.[2] Its fulcrum was probably in the Costa district, near the course of the River Segno. Only

[1] At least 30 specimens of Dressel 14B, collected during archaeological investigations and confiscations, come from the site; for a report on excavations and recoveries: Pallarés 1986; Spadea 1995–1996: 103. They identify the amphoras with the Haltern 70 type; for a precise comparison on amphoras, opercoli and wreck typology, see Calmes 1973 (Cap Benat 1).

[2] Many archaeological discoveries took place between the 17th and the 19th century AD: they were not carried out following the stratigraphic method and cannot be precisely located. Moreover, archaeological research is currently limited by the high industrialisation and dense urbanisation of the area. For a synthesis on the discoveries, see Bulgarelli 2010.

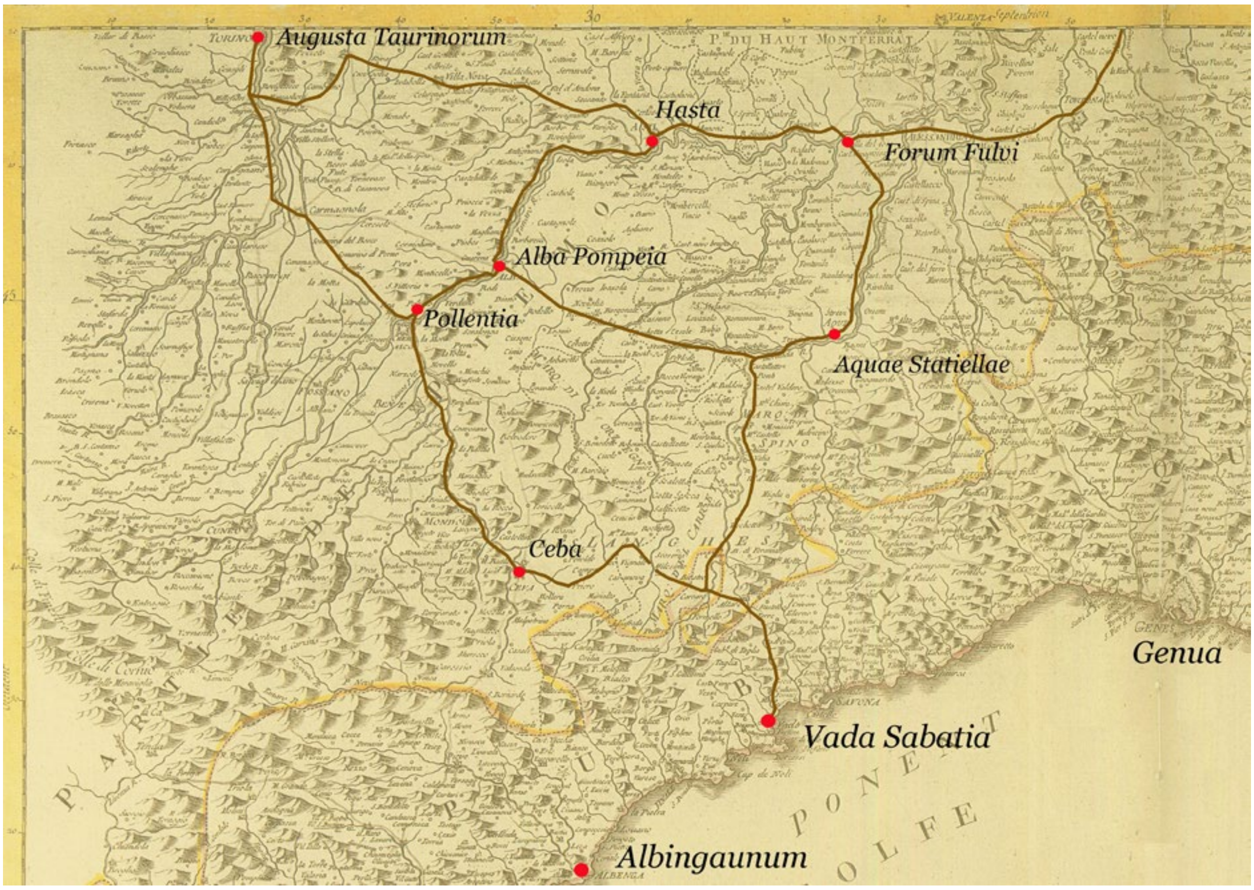

Figure 1. Positioning of Vado Ligure within the Roman period road system, retraced by the routes outlined by charts from the end of the 1700s (from Ferro and Grosso 1992: 169; re-elaborated version S.L. Trigona).

partially verifiable sources mention the presence of impressive public structures here. These may have been service buildings for the port. Iron Age finds have been found in Republican and Imperial layers. These include Tyrrhenian and Massaliote imports, similar to those found in the nearby Castellaro di Bergeggi-Monte S. Elena hill fort. Though still to be scientifically verified, reports indicate, from a site at the mouth of the Segno, the presence of orientalising pottery (Bulgarelli 2007: 183–85). Port facilities have not yet been identified, except for the discovery of a 16th-century quay equipped with mooring rings (Riccardi and Ciciliot 1997: 4). However, geoarchaeological studies have identified the mouth of the River Segno as the most suitable place to have housed them (Carobene *et al.* 2008: 452), although the late-medieval toponymy indicates that the *Portus* and the *Burgus Romanus* were further south, on the Capo di Vado promontory (Bulgarelli 2010: 97; Bulgarelli 2011: 240–44; Riccardi and Ciciliot 1997).

In line with similar Ligurian contexts, there was probably a Sabates emporium linked with a major pass connecting the landing point with the hinterland. The emporium, as in other similar contexts, would have sprung up near the lagoon at the mouth of the rivers Segno and Quiliano's alluvial plain. It was probably the *Σαβάτων Οὐάδα* (*Sabatōn Ouada*) mentioned by Strabo (IV 6.2). Along the Ligurian coast Pliny (*Naturalis Historia* III, 5, 46) mentions only two harbours: *portus Vadorum Sabatium* and *portus Dolphini* (Portofino). Vado Ligure is also cited as a port of call in later navigation manuals and the numerous finds concentrated in the south-western part of Vado Ligure's harbour confirm this (Bulgarelli 2011: 244–46).

Methodology

The construction of the multipurpose platform in Vado Ligure,[3] covering approximately six hectares including the dredging area, is of national strategic importance, aiming to reinforce the whole Italian port system. It includes the relocation of the existing wharfs and oil

[3] The first activities took place in the area of S. Raffaele Pier, where the deep basin created over the years by the coal ships had already revealed the archaeological stratigraphy, which elsewhere is covered by metres of alluvial deposit. For a view on present research, in addition to the cited articles, see Bulgarelli *et al.* 2013; Martino 1995–1996; Martino and Bracco 2010; Riccardi 1977; Riccardi 1987; Riccardi 1988.

installations resulting in environmental, operational and urban improvements.

The dredging, required to build the structure and to allow docking of high-draft vessels, provided an important opportunity to discuss the need for new development, as opposed to the protection of archaeological heritage. From 2006, rescue archaeology in Italy has received institutional recognition targeted at an effective planning of the heritage protection following the preliminary phases. Despite a large wealth of knowledge regarding working procedures in dryland contexts, in the case of major works in submerged environments there have been fewer opportunities to apply systematically the methodology of rescue archaeology. Furthermore, the present case is a complex operation where each working step is strictly connected to the other and where risks are temporally and economically high in case of standstills in fieldwork.

The effective and continuous collaboration between the Superintendency, promoters, archaeologists and companies[4] allowed the various needs to be met and rescue archaeology to be accommodated in the project's agenda.

To begin with, all data on underwater archaeology in Vado Ligure have been systematically collected in order to understand better the archaeological potential of the examined area.

During the following phases we carried out:

- Coring and seismic profiles targeted to define the geological and palaeoenvironmental reconstruction of the area;
- Archaeological surveys and focused excavations organised according to a regular grid, which allowed a thorough reconstruction of the stratigraphic sequence and depth of the archaeological layers.
- Archaeological monitoring of the dredging, following a regular squared grid accurately positioned with GPS and multibeam surveys; and
- Data entry in a GIS (Geographical Information System) developed for this kind of project.

Geological, geomorphological and palaeoenvironmental background

Seismic profiles and analyses of core samples from Vado Ligure's harbour have made it possible to reconstruct the evolution of the landscape since the last ice age when the sea level was about 100m lower and a broad plain stretched about 900m towards the sea. The layer from this phase is readable in the cores in the form of Würmian rudites: the activity of the River Segno eroded in this phase the Tyrrhenian older sediments up to the Pliocene substrate (Carobene *et al.* 2008: 444). Over the next 3000 years, as the post-glacial eustatic level rose, the plain was covered by the sea. It entered the Segno Valley, moving the coastline inland about 700–800m from the current one. Between 6000 and 5000 years ago, the River Segno's deposits formed mouth bars and beach ridges bordering large marshes. These were gradually filled by coarse alluvial deposits while finer sediments, consisting of clayey silts and dark pelitic clays, were deposited at sea.

By between 5000 years ago and the pre-industrial age, the River Segno had filled the internal plain as far as the offshore bar. Solid material transported in suspension caused the coastline to advance some 600–700m (about 100m inland from the present one). This activity appears in the cores as sand and gravel sediments, on which vast plains of sea grass (*Posidonia oceanica*) were rooted (Bulgarelli 2011: 238–39).

Ancient maps provide reference points for the area prior to the modern changes that have heavily modified the original coastline. Unfortunately, the historical maps are not always to scale and might show significant distortions. For this reason, we tried overlapping on a selection of maps more suitable for the purpose. We used as connections the post-medieval forts of San Lorenzo and Santo Stefano, the mouth of the River Segno and the church of Santo Stefano, which are significant elements visible on most of the maps examined (Figure 2).

Fieldwork

Despite difficult working conditions, the 16 archaeological surveys have provided enough information to reconstruct reliably the anthropic stratigraphical sequence. After thousands of years of sea-bed accretion the ancient layers are about four or five metres below the present sea-bed. This caused obvious problems for the preventive excavations, conditioned by technical and safety needs, as well as by the poor visibility in which the operations were held.

Despite this, a geological and chronological stratigraphic sequence has been pieced together. This is mainly represented by four phases, repeated with few variables in all the surveys (Figure 3). The data processing, and the interpolation with those obtained from geoarchaeological investigations, helped to plan and complete the successive dredging phases.

[4] The promoter is Savona's Port Authority. The work is being carried out with project financing provided by a consortium led by APM Terminals (AP Moller Maersk group) and the Società Grandi Lavori Fincosit, whom we wish to thank here for the support provided for each phase of the work so far.

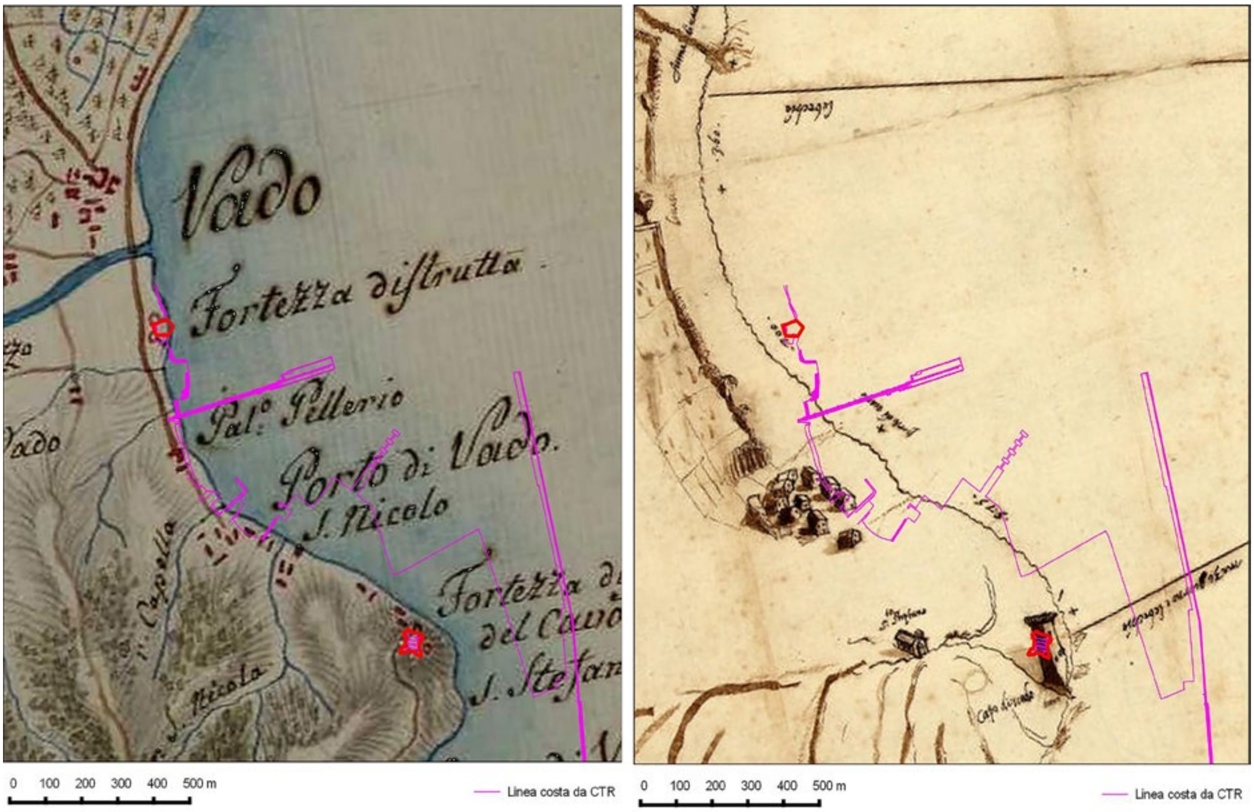

Figure 2. Georeferred superimposition of the current coastline on charts of the 1700s and 1800s.

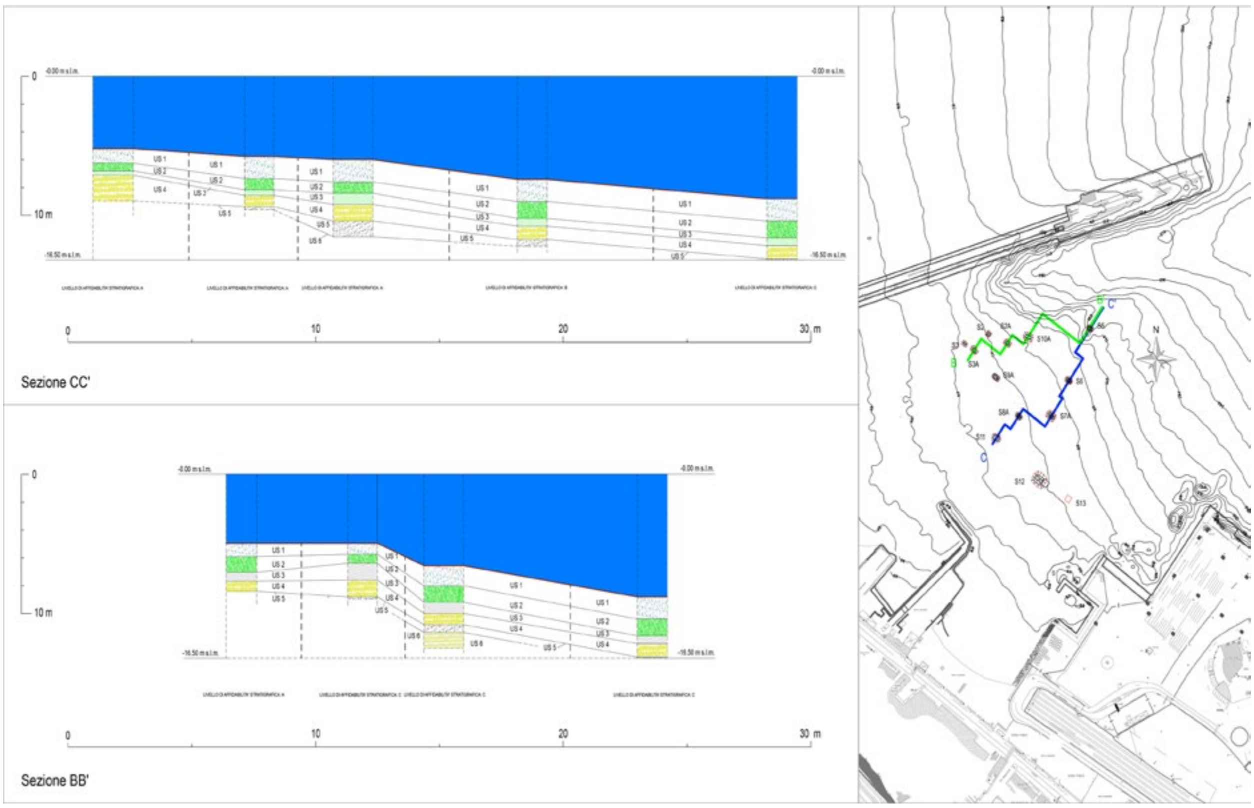

Figure 3. Reconstruction of the stratification on the basis of the sixteen surveys carried out.

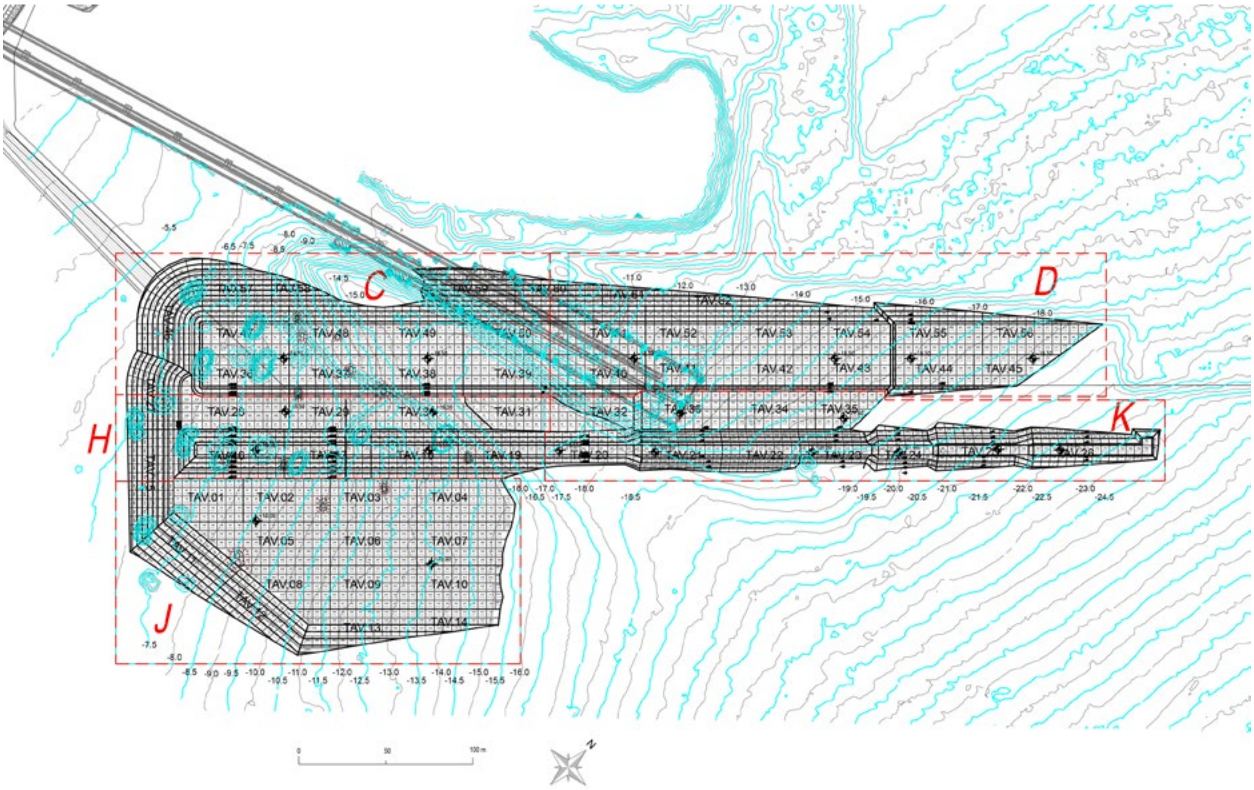

Figure 4. Subdivision of the intervention area into a grid of 5m side squares.

The area in question was about five hectares wide. It was divided into 5m^2 boxes (Figure 4). Archaeological monitoring took place from the bridge of the dredger where each load could be inspected and the presence of archaeological material verified. The sites were positioned thanks to on-board instrumentation, including a GPS repeater placed on the bucket arm. The onboard computer processed its signal and immediately marked the excavation site on screen.

Depth information was taken from references placed on the cable. These were calibrated with weekly bathymetric multibeam surveys (Figure 5). A clamshell bucket can excavate 1.5m^3 of stratigraphy in an area of 2 by 3m, much like a small test pit. Inside the bucket, the collected sediment suffers only partial mechanical deformations related to the pressure exerted during the closure and due to water loss. During the release phase the dredged material expands. The original stratigraphy is partially altered but remains recognisable thanks to the geo-archaeological and sedimentological features.

This operation provides a precise enough position for each bucket load and the layers and finds that it contains. These are more easily excavated and sifted once ashore.

The collected data, together with that from the finds study, geological surveys and historical and cartographic information, are then inserted into a specially designed database, feeding a GIS. This form of storage, responsive to the needs of an objective transmission of the investigation results, has the enormous advantage of allowing the processing, extrapolation and interrogation of data functional to the specific needs of the archaeological research. This method of stratigraphic reconstruction of the context, the study and evaluation of the finds and their historical context provides an applicable and effective way of moving ‘from the excavation to the museum’.

The archaeological stratification and finds

Calibrated 14C analysis was conducted on samples of sea grass (*P. oceanica*) found in the most recent seemingly non-anthropic pre-Roman layers. This indicated a date between 320 BC and 210 BC (Bulgarelli *et al.* 2010). This coincides with data deduced from the pottery analysis. It would imply a significant commercial development of the bay from the 2nd century BC.

The Roman deposit is a layer with rhizomes of sea grass (*P. oceanica*) about 1.8m thick. It contains a dense sequence of silty-sandy micro-levels of growth, interspersed with sandy interfaces with gravel and malacological finds documenting the alternation of the depositional cycles. The deposit has formed over the centuries through constant deposition of riverine

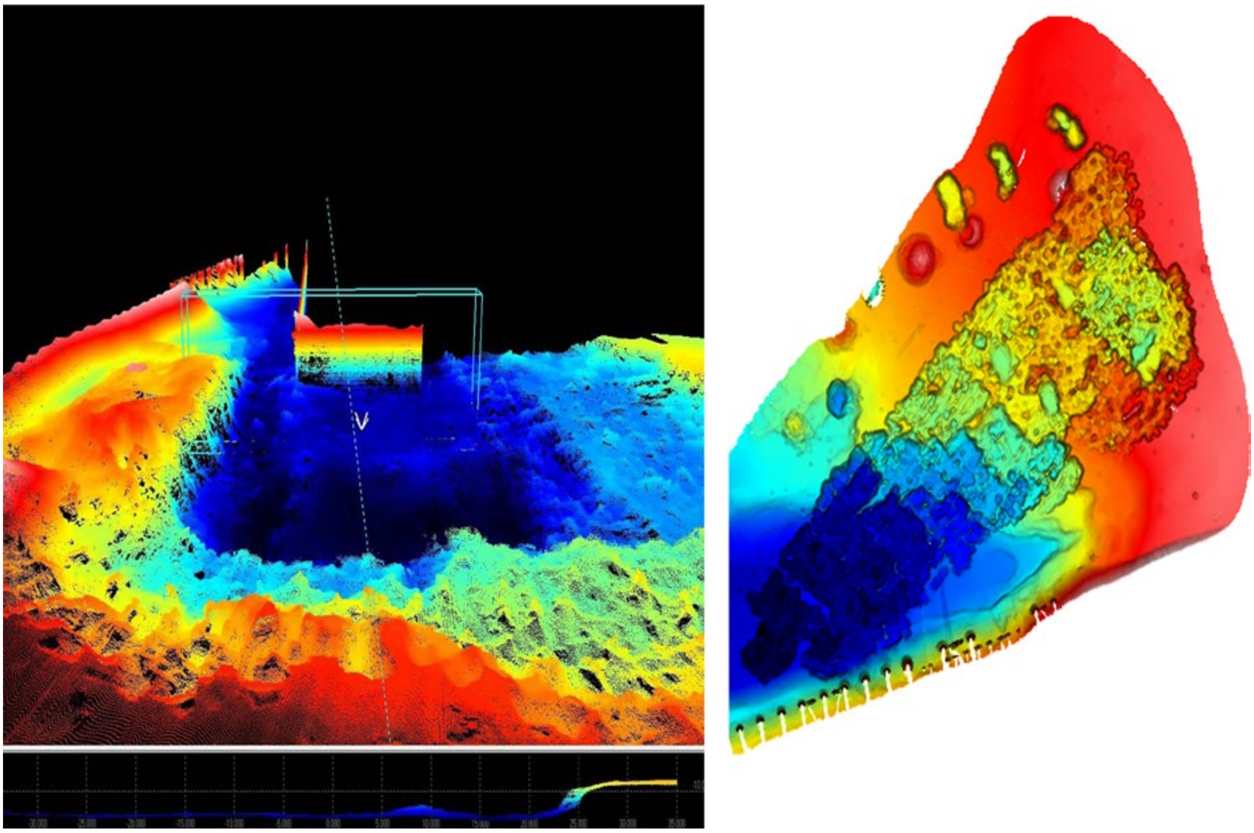

Figure 5. Digital mapping of multibeam surveys.

sediments, marked by sandy and gravel horizons on which contemporary beds of *P. oceanica* have grown. This plant, extended all over the harbour, has also provided a good grip for ships' anchors.

The vast majority of the archaeological finds are fragmented transport containers. None of them come from a shipwreck but were dumped from ships berthed in the harbour. Despite the discovery of three Republican amphoras together with black glazed pottery and wood, interpreted as belonging to a wreck, it was not followed by archaeological investigations to determine the nature of these elements (Riccardi and Ciciliot 1997: 37).

The finds tend to be scattered but there are some significant concentrations. One of these semi-circular shaped concentrations was fully excavated during the survey. It contained chronologically contemporary pottery that we find simultaneously present in wrecks from the middle of the first century of the present era (survey 1/2015)[5]. The assumption is that it was thrown overboard from a single vessel. Some of these concentrations may also have been formed by the irregular shape of the sea-bed, with depressions caused by different degrees of sea grass growth, trapping the dumped material.

The finds date the harbour's origins to the 2nd century BC and place its heyday in the 1st century AD. It continued to be used, on a smaller scale, into the following century. The number of finds from the 3rd and 4th centuries AD drops off considerably, but there are some from at least as late as the 6th century AD.

The finds from the 2nd century BC are few, but they are significant black glazed pottery fragments and provide evidence for contact with the Tyrrhenian world (Martino and Bracco 2010: 123). However, the commercial port of Vado Ligure seems to have flourished during the second half of the 1st century BC and throughout the following century. It was part of a network that stretched between the Gallo-Provence, Iberian and, to a lesser extent, eastern worlds. The wine amphoras are mainly Tyrrhenian (Dressel 1 and mostly Dressel 2/4: Figure 6B) and Iberian from Tarragona (Dressel 2/4, Pascual 1) along with Baetic examples for oil (Dressel 20), wine (Haltern 70) and fish sauce (Dressel 7/11, Beltran IIA).

Some examples of wine amphoras are from Gaul (Gauloise 4). The Dressel 6A is a product of commerce

[5] In this survey a black glazed cup datable to the mid-2nd century BC (Campana B, Lamboglia form 1-Morel 2320) was discovered at a depth of 35cm below the 1st-century AD layer. It clearly shows the constant and gradual growth of the sea-bed in Roman times.

Figure 6. Pottery specimens from 2015–2016 surveys. A) Amphora Ramon 25 inscribed *DOMETIANI EX(cellens?)* (Survey 1 /2015); B) Iberian Amphora Dressel 2/4 from Tarraconensis; C) Sicilian Amphora S. Alessio/Ostia II, n. 523 type; D) Sigillata italica Conspectus 20 type, with engraved inscription *AEM*(*ili*?); E) Sigillata italica Conspectus 36/37 with engraved inscription *PIRANI* (?).

with the Middle Adriatic area, while at least one example of flat-bottomed amphora has Sicilian origins (S. Alessio/Ostia II, n. 523: Figure 6C). The eastern Mediterranean wine amphoras tend to be Aegean-Cretan (Dressel 2/4, Amphore Cr*é*toise 2). There are also containers from inland Asia Minor used to transport more valuable goods (such as the small single-handled flat-bottom Mid Roman Amphora 3). The latest imports consist of African products, represented by the African I and by medium-sized containers (Keay 25 and Keay LVII.B), which indicate the vitality of the harbour at least until the 5th–6th century AD.[6]

There is a particularly important amphora from Ibiza, Ramon 25, from survey 1/2015. It has a *DOMETIANI EX(cellens?)* inscription (Figure 6A). This was engraved on its shoulder after it was fired. We know that the Domitia *gens* had strong interests in Gaul, Spain, and in maritime trade in general[7]. Cicero (*Ad Familiares*, VIII, 15, 2) writes that during conflicts around 49 BC in the Ligurian town of Albintimilium, Domitius, an illustrious local nobleman, was in direct contact with Caesar.

Evidence of the existence of this family dies out in Regio Nine together with the Valerii; their dynastic intrigues within the Claudian-Neronian Imperial family are well documented. In Liguria the political and economic influence of *gens Valeria* was strong and widespread and also they had a particular interest in the Tanaro basin, a natural route to the western Riviera and the western hinterland of the Po basin (Mennella and Pistarino 2004: 87–88).

Fine tableware shows that there were strong commercial interests with the Tyrrhenian, Gallic, Spanish and, later, African areas. Many examples of Italic sigillata

[6] The study on amphoras has been carried out by Elena Quiri, while the one on other pottery typologies has been carried out by Angela Deodato and Anna Lorenzatto.

[7] If Domitianus is considered as a cognomen the ending might be referred to an adoption or to the maternal gentilicial. In any case the cognomen might indicate the importance given to the relationship of this person with the illustrious Roman family. We can also mention, because of their vast political-economic interest in the western Mediterranean, the admirals of the conservative faction during the civil wars, L. Domitius Ahenobarbus (consul in 54 BC) and Cn. Domitius Ahenobarbus (consul in 32 BC); for a description of the characters mentioned, see Manacorda 1980. We can also mention C. Domitius Calvinus, who between 39 and 37 BC, as proconsular governor of Spain, could grant Roman citizenship (it has been conjectured that for this reason he gave rise to the Domitia family in Spain).

have been engraved, or maybe better described as scratched on by their owners; these were possessions taken on board, perhaps by some of the port hands or sailors of the port of Vado Ligure. Apart from *Domitiani* on the Ibiza amphora, we have other two probable gentilicials. These are particularly significant for an interpretation of Roman trading in the first half of the 1st century BC. They consist of an *AEM (ili?)* and more importantly a *PIRANI*[8] (Figures 6D–E). The Pirani were a well-known important Italic family from Minturnae, a Roman colony in southern Latium. They produced and probably sold the containers found in the majority of the *dolia* wrecks found so far.

The archaeological record of the Pirani in Vado Ligure documents the importance of this port along a trade route reaching as far as Spain. The coastal route may have been favoured by mid to late Republican wine traders, primarily heading for Gaul. The Diano Marina (Imperia, Liguria) wreck loaded with Pirani's *dolia* and Dressel 2/4 from Tarragona, not to mention the recently discovered Alassio (Savona, Liguria) wreck[9] and the above-mentioned Dressel 14B from Bergeggi, clearly indicate that the Ligurian coast and its ports were closely linked to deep-sea routes as part of the widespread commercial traffic also in the Early Imperial age. In this regard, the high proportion of both Italic and Spanish wine amphoras Dressel 2/4 (complementary cargoes of the *dolia* wrecks), which are the most widespread typology of transport containers documented in Vado Ligure, is worth noting.

Among the most significant material from this period there are two *pots trapus*, little ceramic containers primarily intended for on-board use. These were sealed with pitch on the inside and are not widely diffused in Italy, but are well attested in some Claudian-Neronian river and sea contexts in Gallia Narbonensis. This evidence from Industria, a Roman centre on the Dora Baltea a few kilometres east of Turin, is very significant as it confirms the importance of Vado Ligure for its contacts with inland Piedmont (Bulgarelli and Dell'Amico 2013; Bulgarelli *et al.* 2015).

The stratigraphic sequence marks a clear break in the gradual growth of the sea-bed, represented by a uniform layer of grayish sandy-clay silt. It is free of sea grass and archaeological finds. The average thickness is between 20 and 50cm, but in some cases exceeds a metre. This horizon can be interpreted as a phase of major alluvial deposition, datable to between late Roman times and the Medieval period. It may provide evidence of the phase of climate deterioration known to have accompanied the end of the classical period and the beginning of the Middle Ages.

Later the *Posidonia* reoccupied the Vado Ligure harbour, and grew with the same dynamics as in the previous era. Alternate layers of rhizomes and micro-levels of sand and gravel were formed. The abundance of late medieval and modern pottery present in these layers is a sign of the vitality of the port. Local chronicles, starting from the 16th and 17th century AD, report that Vado Ligure harboured numerous military and commercial fleets: from AD 1510 to 1512 the galleys of the Pontifical League-Army; in AD 1529 the army of Charles V (120 craft including galleys and vessels, (10,000 foot soldiers and 1000 horses needing supply). In AD 1533 Pope Clement VII arrived in Vado Ligure on French galleys and in AD 1539, 16,000 mines of wheat were landed to supply Turin. In AD 1544 Barbarossa's fleet was stationed here, with 150 ships. In AD 1548 the army of Philip II docked with 44 galleys, while between AD 1593 and 1633 Vado Ligure was used by Spanish and Neapolitan contingents on their way to Milan (Riccardi and Ciciliot 1997: 20–25).

The latest materials, datable between the 18th and 19th century AD, witness the vitality of Vado Ligure's port in this period, when the bay was chosen as the base for the English fleet led by Commodore Horatio Nelson from July AD 1795 to May AD 1796. HMS *Agamemnon* carried 54 cannons. She was accompanied by the frigates HMS *Ariane* and HMS *Meleager*, the sloop HMS *Moselle* and a cutter, HMS *Mutine*. Their mission was to prevent French troop supplies getting through by sea (White 2005: 167–79).

The presence of Nelson in Vado coincided with the first phase of Napoleon's Italian Campaign. For two years the Austro-Piedmontese army opposed the French advance in this strategic area of western Liguria. The Austro-Piedmontese front was broken at the battle of Loano in November AD 1775, followed by another French victory at the battle of Montenotte in the following April. These successes allowed Napoleon to conquer northern Italy, along the same road network that linked the port of Vado Ligure to the Po valley during Roman times.

The upper layer, showing the major industrial transformations of the 20th century AD, is composed of a dense sequence of micro-levels, indicating a rapid growth of the seabed. It shows a loose texture which causes it to slide down during the excavations: this process results in the contamination of the earliest layers and in a quick filling of the test-pits. It is sometimes possible to find, in the deepest part of the deposit, ferrous accumulations, slags and metal concretions documenting the activity of the scrap yards in the post-war period.

[8] The graffito, interpreted as PIRANI assuming the ligature of the last three letters, is located on the bottom of a hemispheric cup type Conspectus 36 or 37, which also shows internally an illegible stamp.

[9] The Alassio wreck, recently discovered by the Genoa Carabinieri divers at a depth of 200m, has a cargo entirely consisting of Baetic garum amphorae Beltran IIB.

Conclusions and prospects

Archaeological monitoring during the dredging of the harbour of Vado Ligure allowed a detailed reconstruction of the stratigraphic sequence and the phases of this important natural port, connected at least since Republican times to the great Roman-Mediterranean trading network

The next phase of the fieldwork, which was to probably last for the whole of 2017, would include new stratigraphic surveys aimed at the analysis and discovery of further archaeological finds. Any finding of significant stratigraphic sequences, especially wrecks, will necessarily lead to extensive archaeological excavations. The study of materials will result in a digitised archive organised as an interactive database. This system enables the insertion of a large number of data—also in separate tables—that can be related, compared and analysed according to the various requirements of compilation, publication, availability to the wider public, etc. In particular, through the sum of the individual weighted averages it will be possible to obtain a curve reflecting the chronological distribution of the materials (Terrenato and Ricci 1998: 92–93).

Finally, re-processing of the acquired data gradually entered into the GIS will allow further refining of specific aspects, such as the intended use of each area of the harbour or the trade routes followed through the various historical periods.

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The Adriatic Communication Area: Studies in the Archaeology of Roman Port and Harbour Cities

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Abstract

After the establishment of the province of Dalmatia by Augustus in AD 9 and the decline in piracy, some Italic *familiae* expanded into the port cities and the hinterland of the eastern Adriatic. Related to local elites, their economic activities contributed significantly to the prosperity of the region. Favourable environmental conditions, established technological knowledge and existing terrestrial trade routes connecting the sea and the hinterland may have played an important role in the process of establishing an 'Adriatic communication area', which was based on trans-Adriatic economic, political and social relationship. This project seeks to analyse the role of coastal ports in the east and west Adriatic with a focus on resources, trades and actors. To assess the economic value of these ports, the study first concentrates on archaeological remains of harbour buildings and their infrastructures related to the settlements. Secondly, the research focuses on trade, considering the routes and accessibility to resources in the hinterland. Thirdly, it works out the role of the players involved in the coastal activities and trade in the 'Adriatic communication area'. The paper presented here will, within the context of the overall aims of the research, develop some preliminary ideas about the role of Roman *familiae* as actors in the process of migration and in harbour affairs.

Keywords

Adriatic Sea, Roman harbour cities, communication and trade, *familiae*

Introduction

The project 'The Adriatic communication area' deals with Roman harbours and landing sites in the Adriatic area. It aims to analyse Roman harbour building strategies and the role of their initiators in order to establish how significant these ports were economically for regional and long distance trade. The study is part of the Special Research Programme 'SPP 1630 Harbours—from the Roman Period to the Middle Ages', set up by the German Research Foundation (DFG).[1] This interdisciplinary programme launched in 2012 consists of 15 individual regional projects stretching from Iceland to the Aegean. The projects concentrate on interdisciplinary research on the phenomenon of harbours, most with a strong natural-science component. They all contribute to the development of new processes through fieldwork and fundamental research on methodology. In an overarching comparative analysis, the programme seeks to understand ports as highly complex systems by defining and analysing their system-relevant components. The project under discussion started in October 2016 and is based on intensive desktop studies. It combines research on topographies, environment, archaeological evidence and written sources. The aim is to work out parameters for identifying and characterising forms of human impact and environmental factors on port hierarchies in the area of the Adriatic Sea.

Due to its special geographical location, the Adriatic Sea was already of great significance in coastal and trans-maritime trade during pre-Roman times. A trade route along the eastern Adriatic coast already existed in the 6th century BC (Aischylos *Prom*. 829; Sanader 2007: 11–12, 37–38). In Roman imperial times, four Italic *regiones* and one *provincia* surrounded the northern part of the Adriatic Sea. The *regiones* of Picenum, Umbria and Aemilia were situated on its western coast, while in the north was Venetia et Histria, followed by the province Illyricum and, later on, Dalmatia, in the east. According to the written sources, the province of Dalmatia and the *regio* X *Venetia et Histria* belonged to a transport network, which used the coastal and inland port cities as related nodes (Strabon *Geographika* 5, 1, 8; Panciera 1972: 99–100). The process of the so-called 'pacification' of the province of Illyricum ended finally under Augustus in AD 9. Already in the 2nd century BC, the former Greek colony of Issa established a Republican trading centre including two outposts in Tragurium and Epetium. Geographically located

[1] www.http://spp-haefen.de/ - headed by Claus von Carnap-Bornheim, Falko Daim, Peter Ettel and Ursula Warnke.

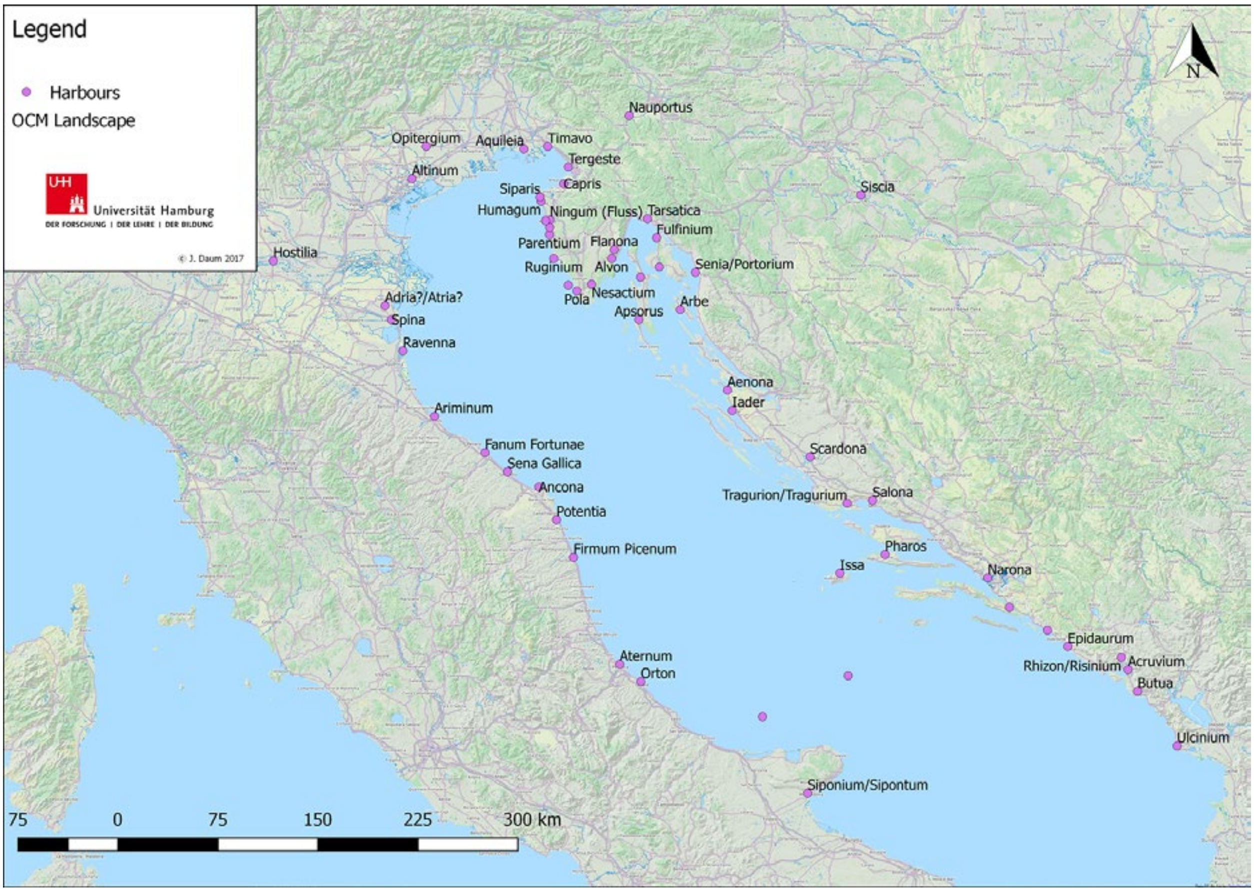

Figure 1. Roman ports in the Adriatic Sea and selected river harbours in the hinterland.

between Tragurium and Epetium, the biggest ancient Adriatic port city of Salona was the place of origin for ambitious traders from AD 9 at least. The establishment of the province of Dalmatia also significantly curtailed piracy in the Adriatic area (Wilkes 1969: 49–77). Earlier research suggests that settlers from northern Italy subsequently came to the new territories (Alföldy 1965: 78–79). During the early and middle Imperial period, native Italic settlers, mainly from Aquileia, appear to have settled in the economic centres of Dalmatia as well as the fertile hinterland (Alföldy 1965: 82).

The topographical setting with its strong separation of the littoral and the hinterland, which characterises the Adriatic coastal area, certainly attracted the settlers. The landscape is limited by the Apennine mountains to the west, the Alps to the north and the Dinaric Alps to the east. Hundreds of islands near the eastern coast favour shipping as the most important means of transport. While the topography of Dalmatia would have led to the development of trade routes to Pannonia and the east, its coastal settlements suggest maritime routes to western Italy. In Roman times, the two most important port cities, Ravenna and Aquileia, controlled the north-western region. From Aquileia, traffic would have crossed the eastern Alps using a most important ancient route: the Postojna Gate with, further east, the river harbour of Nauportus on the Ljubljanica which ultimately flows into the Danube. Several smaller harbours and landing places extended over the Italic western coast and they were strategically placed at nodes where trans-Apennine routes encounter the seaside (Auriemma/Karinja 2009: 307; Cambi 2001: 3; Figure 1).

Issues and method

Scholarly work to date has concentrated on the Greek colonisation of the Adriatic region and the Roman conquest, as well as on problems of demography and economy in Histria and Dalmatia under the Roman Empire (Cons 1881; Mommsen 1886; Alföldi 1965; Wilkes 1969). The previous mapping of port cities has been based on fundamental anterior studies (Degrassi 1957; Lehmann-Hartleben 1963: 177–78; Blackman 1982: 187, 189–90, 204), but there has been as yet no comparative analysis of the Adriatic regions, which summarises and contextualises the results of the numerous smaller-scale studies since the 1990s (see e.g. Juršić 2006; Pavan 1991; Shiel/Chapman 1991; Škegro 2006; Radić Rossi

2006). As the most intensive studies, the international Adriatic Islands Project[2] (cf. Gaffney et.al. 2000), the Anaxum River project[3] and Belgian research at Potentia (Vermeulen/Verhoeven 2006) must be considered. The extent of what remains to be done in recording ports and harbour sites along the eastern and western Adriatic coasts can be clearly seen on the mapping in the DARMC database of the Harvard University (see http://darmc.harvard.edu/icb/icb.do?keyword=k40248&pageid=icb.page188868).

One key approach to working out the inter-Adriatic transport and trade relationships taking into account the role of the actors in harbour affairs is to describe, catalogue, map and visualise the important sites in question in a GIS. The exploration of the eastern Adriatic ports is hindered by the sea level having changed by up to two metres and the fact that modern cities overbuild most of the ancient ports. The heterogeneous topographic and geomorphological settings along the western coast reveal that, besides ports, a large number of smaller harbour sites and landing places also existed. To sum up, a few developed, well-preserved and published port cities such as Aquileia, Ancona, Ravenna, Salona, Epidaurum and Dyrrhachium should be contrasted with countless undeveloped or unexplored landing sites. To anticipate one shortcoming of this study: the intention of the SPP 1630 not to investigate military ports will result in a serious lack of information with regard to the interpretation of the Adriatic port cities.

The hierarchy of ports and harbour sites addressed by the project 'The Adriatic communication area' complies with Rickman's classification of ports for short-range, middle-distance or long-distance trade (Rickman 1985: 105–14). As the territory under discussion is vast, this study deals with the concept of microregions (Zimmermann 2015: 404) or microecologies (Horden/Purcell 2000: 80). A 'microregion' can be defined by the natural environment and regions of political, social and economic activity, but is not necessarily restricted by political borders, administrative boundaries or topographic landmarks. Microecologies describe the interaction between different forms of management, planning and their integration into larger redistribution networks. It would be of great interest to examine Roman provincial culture in all sorts of significant relations with reference to this concept. The analysis of archaeological material from that period has shown that the process of Romanisation was rather selective (Stipčević 1977: 58; for a critical review of theories of acculturation or Romanisation, see Wodtke 2016). Urban centres, both coastal and inland, seem to have been fully adapted to Roman values and customs whereas the situation in the countryside was entirely different (in contrast to Mommsen 1886: 187, who argued that coastal Dalmatia and its islands were fully Romanised and Latin-speaking by the 4th century AD). To evaluate such statements, there is also a need to think about approaches to analysing and interpreting space-related data. A considerable amount of literature has been published on theoretical tools dealing e.g. with space (cf. Bachmann-Medick 2006: 284–328; Harvey 1973; Lawrence/Low 1990: 453-505; Lefebvre 1974: 154; Parker Pearson/Richards 1994: 1–37) and place (cf. Bekker-Nielsen 2014: 13–14; Hayden 1995; Lippard 1997; Tuan 1974). A physical mapping of landscape data in a GIS figuratively provokes a shift from space to place (see the discussion on space versus place in Agnew 2011: 316–22; Casey 1993: 22–33, 317–23). Spaces occupied by social or political groups, for example, turn into places, because 'places' organise 'spaces' into centres of meaning in many different ways (see Tuan 1974: 239). This project aims to analyse the role of coastal ports on the eastern and western Adriatic coasts with a focus on resources, trades and actors that means it deals with spaces, places and communication processes. In this study, 'communication' requires contact situations between actors. These can be established, for example, by means of transport linked by land and sea, with ports and landing sites as traffic areas and lived contexts for human interaction and experience.

These discussions reveal the general conflict generated by deductive and inductive approaches when talking about long-term developments (see Ma 2015: 3–6). The challenge is to connect overall research questions to specific archaeological or epigraphical evidence starting with limited observations to build up general propositions of greater validity. The methodological propositions outlined above do not describe fixed positions but working hypotheses in ongoing conversations.

Familiae, tradesmen and harbours

The following paragraphs concentrate on the potential players in Adriatic trade, e.g. as actors in the processes of migration and in harbour affairs. The underlying idea is based on the epigraphical observations of Wilkes (Wilkes 1969) who mentioned some senatorial individuals traceable in Dalmatia over several centuries. Coming from Italy, they are presumed to have arrived at Salona, from there settled in the coastal region and, after some decades, established themselves in the hinterland. These general observations gave rise to the assumption that after AD 9 some Italic Roman *familiae* expanded into port cities and the hinterland of the eastern Adriatic as well. Related to local elites, their economic activities may have contributed significantly to the prosperity of the region (Figure 2).

[2] http://iaps-s.zrc-sazu.si/Files/File/Publikacije/adriatic_islands_project.pdf;
[3] http://nauticalarch.org/projects/all/southern_europe_mediterranean_aegean/anaxum_project/introduction/

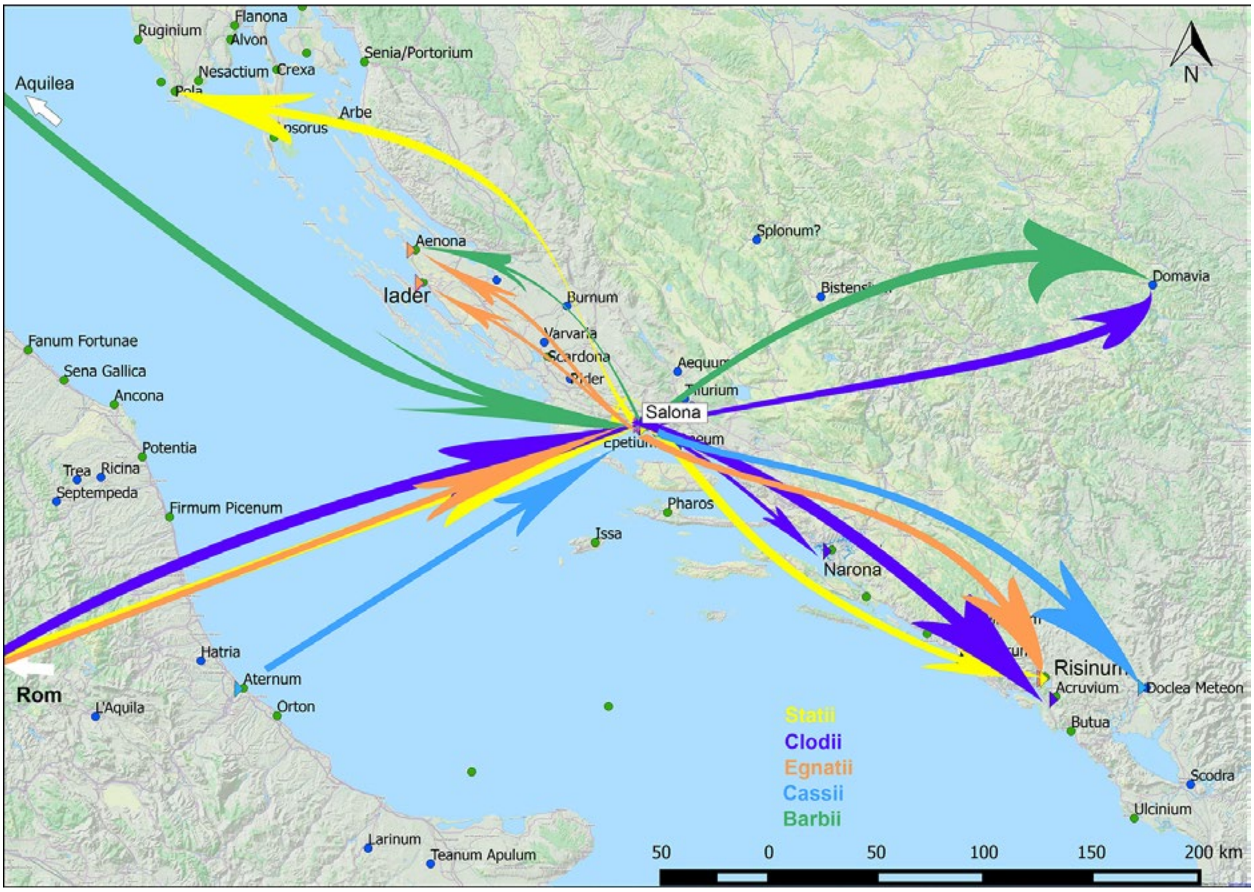

Figure 2. Immigration of selected Roman *familiae* into Dalmatia and their distribution within the province between 1st and 4th AD.

A previous study in the SPP 1630 dealing with Roman port cities on the Tyrrhenian coast written by Daum and titled 'Efficiency and competition between Italic port settlements' (Daum 2016) underlines the role of Roman *familiae* as actors in migration processes. It generally worked out the functional structure of Italic port settlements and their harbours during the Imperial period of the Roman Empire. The study particularly discussed the port building policy of the Roman emperor Trajan, and cast light on the enlargement of several port facilities near the city of Rome. Archaeological remains and epigraphical records indicate the impact important Italic *familiae* had on harbour issues along the Tyrrhenian coast. Obviously, these *familiae* possessed the political and financial power to participate in the development of related harbours. Unfortunately, there is no evidence to support the hypothesis that at least one senatorial *familia* from the Tyrrhenian coast was involved in the expansion of and urban decision-making processes in each port city. Selected case-studies showed that a whole range of aspects such as geological conditions, technical knowledge and trade routes to important regions and to the hinterland determined where such people would choose to settle.

The project team therefore decided to analyse *inter alia* the individuals thought to be Italic migrants on the Dalmatian coast as attested by epigraphical evidence. In this analysis, the term '*familiae*' is used in its widest possible sense to classify an individual's affiliation. It reflects the Roman concept of *familia* comprising the members of the household: the nucleus of the family (parents and children), more distant relatives, as well as servants and slaves (Leisner 2016: 179). The epigraphical sources mainly derive from burial contexts, which often mentioned the status and the profession of the deceased. Previous research has not tended to focus on individual family members but rather names the locations the families appear. Only some studies list the number of family members related to a particular city. In the case of Salona, for example, 37 Cassii, many of them *liberti*, are mentioned, but no information was given either about the date they were in Salona or when they relocated to other port cities or the hinterland. One big challenge of this study will be to work out a chronology because our evidence for these connected historical events mainly derives from historical and epigraphic sources, not from dated archaeological contexts. Our approach to identifying Roman family meshworks is first to describe trade

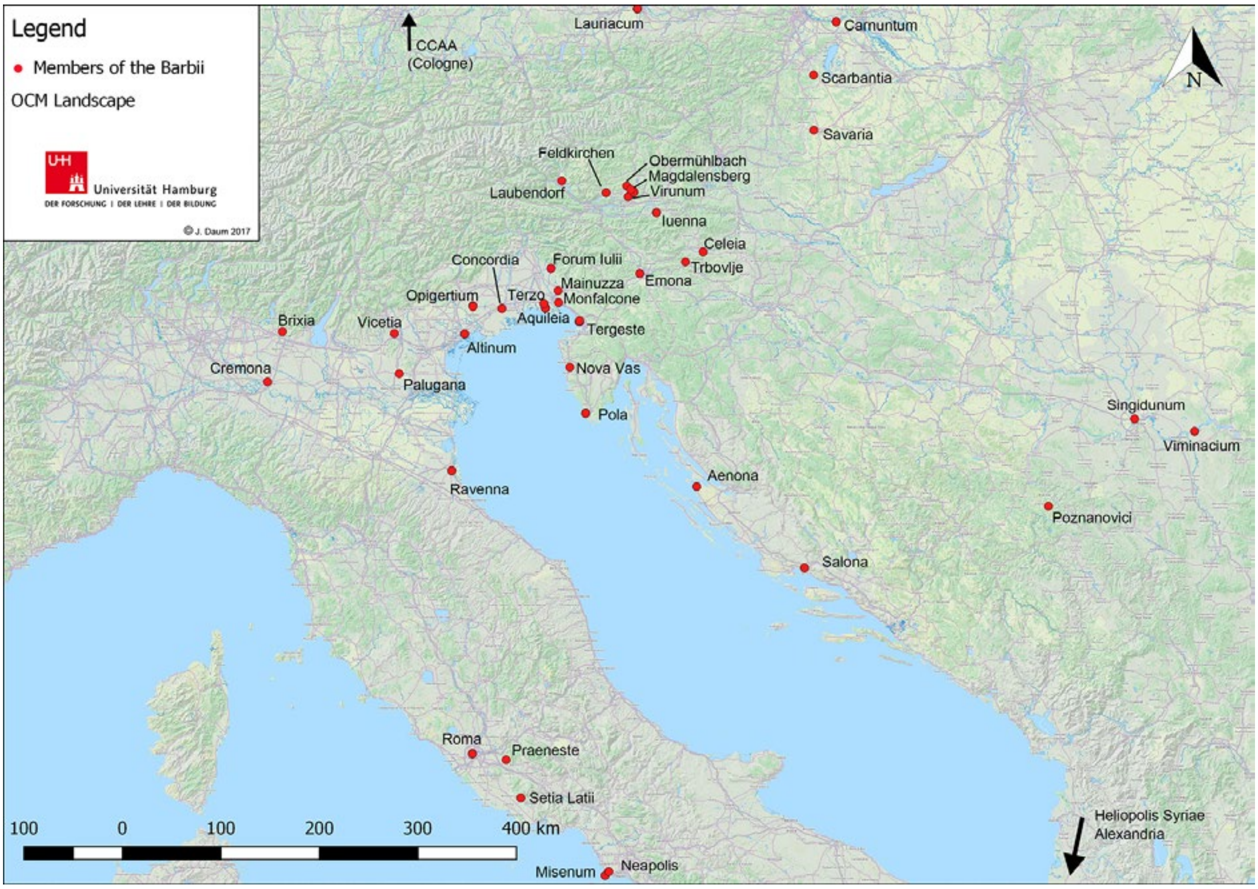

Figure 3. Preliminary distribution of members of the *familia* Barbius.

activity and migration zones both within the Adriatic and in the province of Dalmatia. We will focus on epigraphic evidence for players potentially involved in trade and harbour affairs in order to establish a preliminary link between the western and eastern sides of the Adriatic and then study the role of the Adriatic Sea as a connecting factor.

The main working tool is the epigraphic database EDH from Heidelberg University[4] comprising more than 7600 inscriptions from Dalmatia. To avoid misunderstandings: at this point of the investigation, our methods do not allow a deeper understanding e.g. of the interrelationships between individuals who bear the same name. The collected samples deliver a first impression by positivistic means. Bearing in mind that the study has only just started, future research will reveal if '*familia*' is a term appropriate for this context at all.

The *familia* of the Barbii (Šašel 1966: 117–37) has already been the object of an intensive prosopographic study. Originally, they were tradesmen located in Aquileia (e.g. Brusin 1991: 388–89). The Barbii appear as individuals or in small groups at several places in the northern Adriatic and the Alpine region. There is epigraphic evidence for two large groups comprising 22 individuals at Magdalensberg and 33 individuals in Aquileia. In total, 164 Barbii come from known locations throughout the Roman Empire. Classified by profession, civil and military duties, the distribution of individuals delivers some interesting information: 14 persons of different military rank belonged to the military service. Mostly documented in Rome, they were *vigili* or praetorians (e.g. *CIL* VI 2571). What sort of active role the *vigili* or praetorians might have played in the Barbii meshwork is not quite clear yet. The soldiers would have depended on orders and would not have belonged to the group of decision-makers. There is more detailed information about the craftsmen who appear near the sea in the northern Adriatic (Gregorutti 1888: 353, 30); some of them also are traced in Magdalensberg (e.g. *CIL* III11563), one in Viminacium (*CIL* III 12660) on the Danube and a shipbuilder on the Tyrrhenian Sea in Misenum (*CIL* X 3426). Tile and amphora stamps attest to a reliable number of *liberti* and ten *tegularii*. The craftsmen of the Barbii spread over 13 places; six locations are port cities, while two are situated in the vicinity of port cities. With the exception of two *tegularii* from Aquileia datable to the 1st century BC, the individuals mentioned can be

[4] http://edh-www.adw.uni-heidelberg.de/home?lang=de.

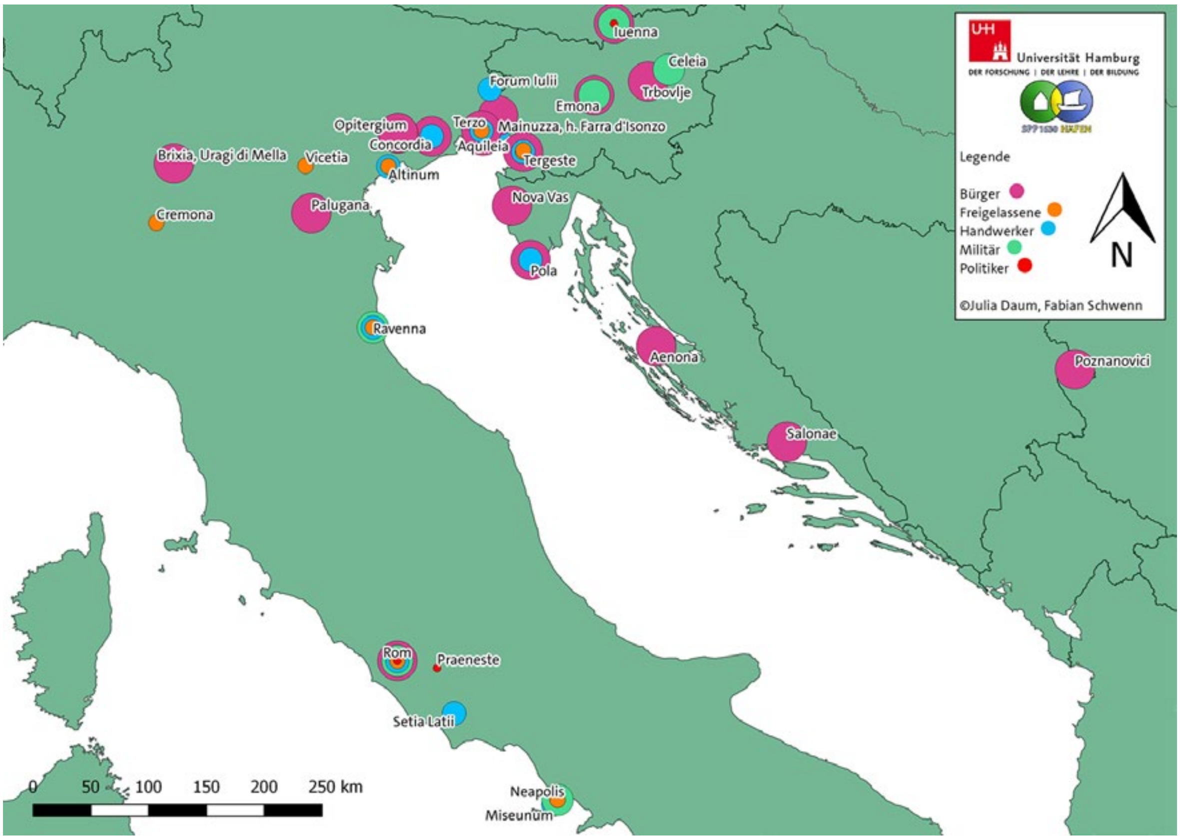

Figure 4. Preliminary distribution of Barbii: evidences in chronological order.

traced over a period from the 1st to the 3rd centuries AD (Šašel1966: 117–37; Figure 3).

Some of the Barbii, politicians and public officers, formed a small group of potential decision-makers. There is one prominent individual, who was a Roman consul in the year AD 140 (*CIL* XVI 177). Between the end of the 1st century BC and the beginning of the 4th century AD, six Barbii are known to have held major municipal public offices, for example, a *duomvir* in Scarbantia (*CIL* III 14068, p. 2328, 21), and a *quatrovir* in Altinum (*CIL* V 2169). Unfortunately, there is no evidence as to whether they were involved in their own trade affairs at the respective ports or in the development of the harbour infrastructure.

In contrast to the examples above, the evidence does record the involvement of *liberti* and *incolae* in activities in the harbour context. The *incolae* seem to be accepted members of the *familia* Barbii; they are attested from Alexandria in the south to Carnuntum in Pannonia in the north. They appear in port cities and settlements near shipping routes. Epigraphic sources show them to have been prominent inhabitants of both Aquileia and Magdalensberg. In the Adriatic region, the Barbii were also present in Tergeste (e.g. *In. It.* X 4, 81), Pola (e.g. *In. It.* X 1, 227), Aenona (e.g. *CIL* III 2979 + p. 1037) and Salona (e.g. *CIL* III 2489, 8947). Moreover, they can be traced in inland river ports, e.g. in Lauriacum (*CIL* III 5680) and Carnuntum on the Danube (Vorbeck 1980: 61 no. 255) and in Emona (Hoffiller-Saraia 1970: 165) and Trbovlje (Hoffiller-Saraia 1938: 23) on the River Sava. The epigraphic evidence shows one Barbius from a settlement near Domavia (*CIL* III 12743), a city related to the procurator of the public gold and iron mining's office (Figure 4).

As a second prominent group, the study identified the *liberti*. These were individuals of particular wealth who maintained strong links with their patron and the *familia*. In the 1st and 2nd centuries AD, the *liberti* under discussion appear mainly in Aquileia (e.g. Brusin 1993: 1203–04, n. 3401) and Tergeste (e.g. *In. It.* X 4, 94). Some are individuals located in important port cities some distance from the Adriatic Sea: on the Tyrrhenian Sea, on the Danube and in the Po Valley (e.g. Neapolis: *CIL* X 212162).

Preliminary conclusion

Because of the methodological limitations mentioned earlier, the following conclusion is hypothetical and describes a positivistic distribution of the Barbii in a chronological order. Four individuals in the 1st

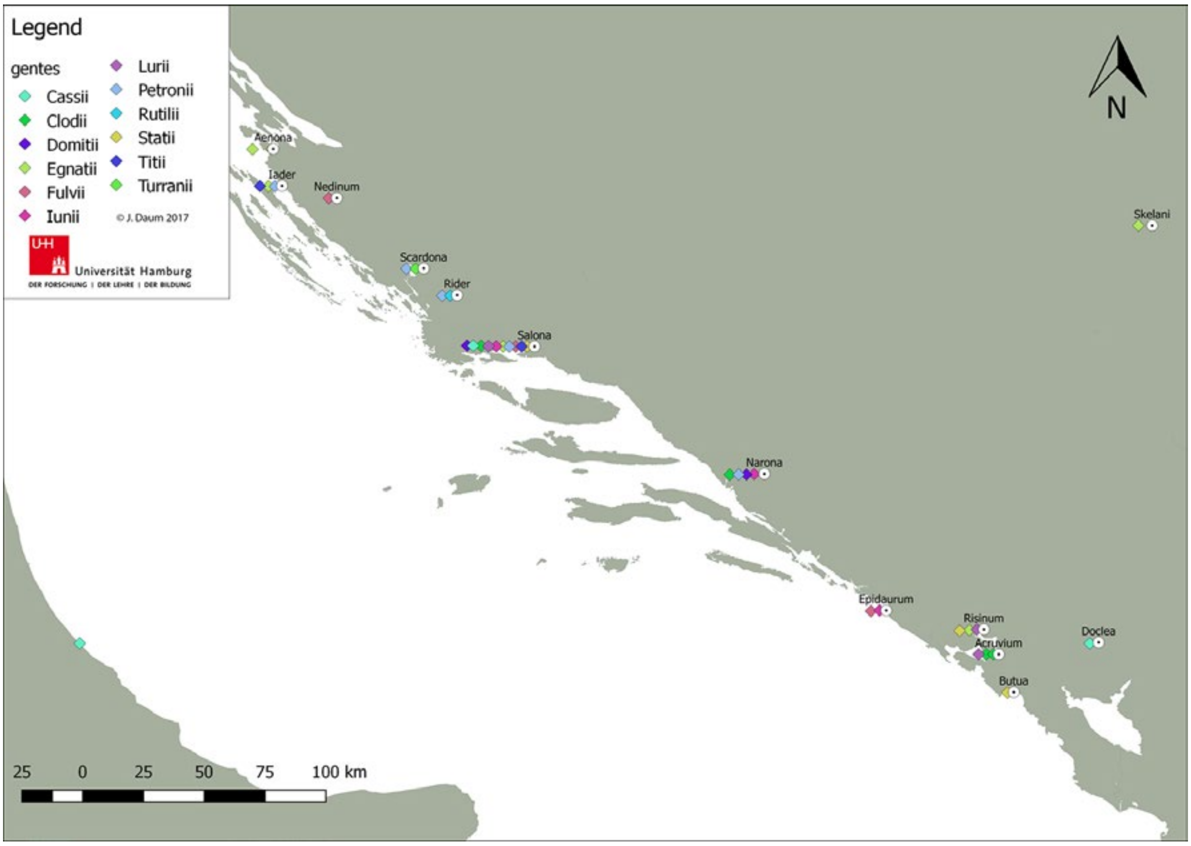

Figure 5. Appearance of selected Roman families in Dalmatia after Wilkes 1969.

century BC (Brusin 1993: 1203–04, no. 3401) originate in Aquileia. The epigraphic evidence attests one *quattrovir* at Altinum (*CIL* V 2169), which is situated 113km west of Aquileia. Several family members were located in settlements across the Alps near the modern city of Klagenfurt and one in Laubendorf (*AE* 1961, 73). Later on, in the 1st century AD, the Barbii appeared in the greater port cities in the north and the west, for example, in Salona, Pola and in Tergeste. To determine the timespan precisely is difficult because the epigraphic evidence can only be dated to a broad period between the 1st and 2nd centuries AD. In Padua, Aenona and Poznanovici, which is near Domavia, a small number of undatable inscriptions exist. In the 2nd century AD, the Barbii spread over the northern Adriatic Sea, but there is also evidence for some Barbii along the Tyrrhenian coast, in the Po Valley and near the Danube. It is a striking observation that the Barbii did not appear in Aquileia during the 3rd century AD but still were present in the port cities of Tergeste, Pola, Salona, Ravenna, Misenum, Singidunum (Belgrad) and Trbovlje on the River Sava.

The appearance of the Barbii in the northern and eastern Adriatic regions over many decades, following a range of different professions, provides an example for both Roman migration and colonisation. They mainly occur in harbour settlements and port cities but their role in decision-making processes, especially with regard to harbour development affairs, remains as yet unclear. One may assume that they were attracted by traders' networks as well as by resources and the political environment.

Further research

In addition to the Barbii, in Augustan times literary and epigraphical sources mention several prominent Roman families settling in the Adriatic region: the Egnatii, Cassii, Statii and Clodii arrived from different parts of Italy, for example from Campania or the Apennines (Amiternum). The further mapping of the epigraphic records puts family names in a chronological order with a detailed description of professions and activities. The next step is to complete this case study in order to gain information about the social structures in ancient port cities and harbours in the Adriatic region; this is still work in progress. In this context, a critical examination of the data on the GIS database which should yield valuable information is in progress (Figure 5).

Considering previous results, the framework of research will focus on the imperial policy of harbour construction in its economic and political context.

With regard to the historical events, five more or less artificial historical periods will be evaluated: the consolidation phase (1st century BC to 1st century AD), the time of prosperity (2nd century AD), the so-called 'crisis' (3rd century AD), the phase of defending the province borders (4th century AD) and the time of reorientation (5th and 6th centuries AD).

First, the study catalogues published archaeological and epigraphic records. Significant case studies from coastal spaces and river ports which are situated at presumably important transport nodes within the Augustan regions X (Venetia et Histria), V (Picenum), VI (Umbria) and VIII (Aemilia) will be analysed. This analysis will focus on ports and their associated infrastructure, natural resources and transport networks in the province of Dalmatia. The next phase of investigation comprises information about economic resources and the Roman owners of *villae maritimae* / *villae rusticae*, which indicate a relationship to potential harbour developments in the Adriatic Sea. One important part of this framework will be to analyse the archaeological evidence for harbour facilities, pottery statistics and, for example, trade goods, both in the littoral and in the hinterland. After all, this information should provide a detailed overview of the people living and working in the Adriatic ports and harbour cities, and their relationships.

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Living at the Coast and Working at Sea—Some Aspects of Social Archaeology of a 15th-Century Fishing Settlement Along the Coast of Flanders (Ostend, Belgium)

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Abstract

During the last three decades intensive archaeological work (excavation and post-excavation analysis) has been carried out on the site of the deserted late medieval fishing settlement of Walraversijde (Figure 1). This settlement, actually situated in the central part of the Belgian coast (Figure 2) next to Ostend (Belgium), saw its heyday in the 15th century. The archaeological excavations produced a wealth of material evidence that can be interpreted in terms of social and cultural aspects of life in a medieval fishing settlement in the southern part of the North Sea area. This contribution will focus on some of the social and cultural aspects (coping with danger, presence of 'luxury' items, aspects of gender and the socio-economic characteristics) in the late medieval maritime community of Walraversijde based on the excavation and subsequent archaeological analysis of about two hectares of this settlement between 1992 and 2005.

Keywords

Fishing settlement, 15th century, material culture, gender, social archaeology

Introduction

Between 1992 and 2005 about two hectares of the late medieval (14–15th centuries) and early modern (16th-century) occupational phases of the fishing settlement of Walraversijde (Ostend, Belgium) have been excavated archaeologically (Pieters 2006; Pieters *et al.* 2006; Tys and Pieters 2009; Pieters *et al.* 2013). These excavations produced a wealth of material evidence that can be interpreted in terms of social and cultural aspects of the life in a medieval and early modern fishing settlement in the southern part of the North Sea. Topics that will be discussed in this paper relate to coping with danger, access to and presence of 'luxury' goods and gender and socio-economic aspects of this maritime society.

Coping with danger

Living on the coast and working at sea in medieval Europe was dangerous in many ways. First of all there is the overwhelming power of the sea that can during storm surges easily and suddenly break through natural or human-made coastal defense systems and inundate and destroy coastal settlements at any moment especially when they are situated within low-lying reclaimed tidal flats or on reclaimed saltmarsh areas like most of the coastal settlements in the medieval county of Flanders. If the water itself is not a direct threat, the wind can also be an important destructive factor during storm surges. One way to defend yourself against these natural elements in coastal areas is to construct houses in a somewhat climatically sheltered area close to the dune belt, and as close as possible to one another so they give mutual shelter to each other. If we look to the spatial layout of the medieval settlement in Walraversijde (Figure 3) it reveals that the houses are constructed in rows and indeed very close to each other and in a zone close to and as such more or less protected from the sea by a dune belt. A related observation is that there is in the immediate vicinity of the settlement absolutely no room for agricultural or animal husbandry activities.

Another major danger is anthropogenic in nature. If you live on the coast, you are among the first victims to be struck during foreign military incursions. In the county of Flanders the threat of an English or a French invasion in late medieval times was always present. A way to defend yourself against such danger was to set up some kind of lookout system so as to be able to warn people in advance of oncoming danger. An underground and well preserved safe made with a little recycled wooden cask probably used to hide valuable items discovered in one of the houses of Walraversijde can probably be attributed to the above-mentioned dangerous aspects of living near the coast. The presence of a lot of items related to military activities (stone cannon balls, crossbow bolts, kidney daggers, fragments of chain mail, etc.), on the other hand, refers to a more active way of defending oneself against intruders. This archaeological evidence proving the presence of

Figure 1. Aerial picture showing the geographical position of the site (1) in a reclaimed tidal marsh area behind a late medieval embankment (2) and additionally protected from the sea by a relatively narrow dune belt (© Flanders Heritage Agency) (Kris Vandevorst).

Figure 2. Location of the deserted late medieval fishing settlement of Walraversijde. The site has yielded a lot of commodities coming from all over the coloured area on the map (© Flanders Heritage Agency). Illustration Marc Van Meenen.

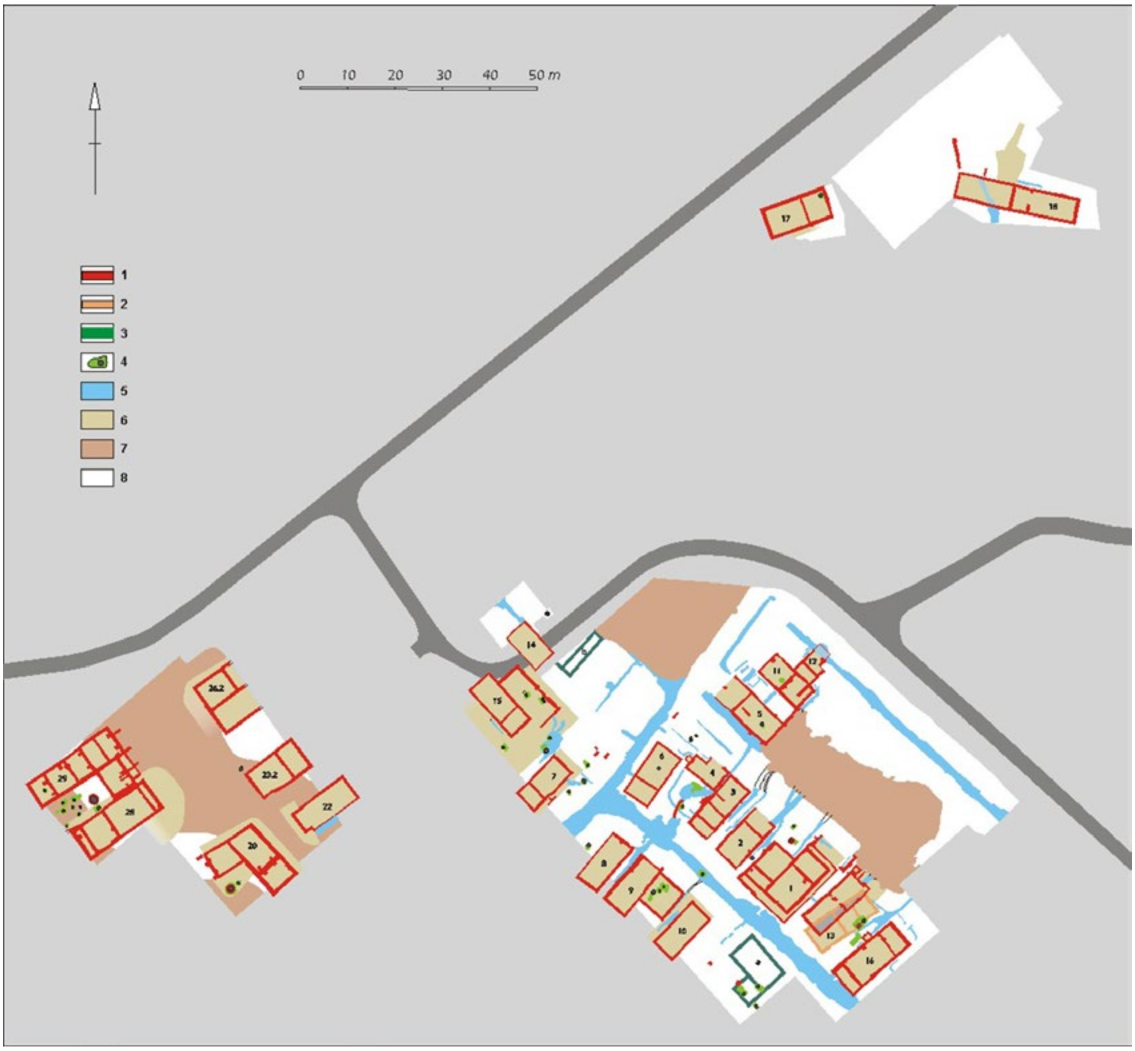

Figure 3. Spatial layout of the medieval settlement of Walraversijde. Legend: 1 & 2: brick buildings, 3: wooden building, 4: cask wells, 5: drainage ditches, 6–7: peat extraction pits (© Flanders Heritage Agency). Illustration Marc Van Meenen.

weapons in the medieval settlement can of course point to a use both on land and/or at sea.

Besides these practical reactions to danger (the use of weapons, the installation of underground safes, the careful seeking out of sheltered areas to position the settlement, etc.) there is also an immaterial or spiritual way of taking care of danger. This is clearly shown by the numerous pilgrimage badges found among the material remains of the site of Walraversijde (Pieters *et al.* 2002). If you cannot yourself entirely cope with the danger (i.e. the sea is too powerful) another valuable solution is to look for help from more powerful actors. In medieval Christian Europe people would turn to God via numerous saints that were considered as efficient mediators with God. In this respect it is very striking that a lot of the pilgrimage badges found at Walraversijde are related to saints that had either a special relationship with water or had special powers related to water, like Christ and also Blasius who could walk on water. Being able to walk on water would be indeed a very interesting asset for a fisherman. It is also striking that in some of the shrines represented by the pilgrimage badges at the site of Walraversijde the biography of the venerated saint mentions that his body was dragged from the water by an anchor or brought on land by a dolphin, implying that the saint could finally get a Christian burial (Vincentius, Adrianus) after all the trouble he went through. This seems to suggest that one of the preoccupations of fishing families was that in case of a disaster at sea (natural or human-caused) the fisherman could at least, hopefully, get a Christian burial. Fortunately, the sea is not only a source of problems and terror but can provide communities with some opportunities as well, as is discussed in the following section.

Access to luxury commodities

One of the striking aspects of the archaeological research of the 15th-century fishing settlement of Walraversijde is the presence of numerous items such as Spanish majolicas from various production centres in 15th-century Spain (Valencia, Málaga and Sevilla [Pieters and Verhaeghe 2009]), pomegranates (Pieters *et al.* 1999), exotic spices (black pepper, melegueta pepper), ivory combs, etc. that are usually seen as demonstrating luxury. Besides the commodities generally associated with or interpreted as signs of luxury a lot of other commodities from all over the known world in 15th-century Flanders could be detected archaeologically such as cork (for making floats and shoes) and honey from the Mediterranean, wood, tar and casks from the Baltic (Figure 4), pit coal, Purbeck marble, unworked stone (De Paepe and Pieters 1995) and ceramics from England and ceramics from the Rhine area to name but the most important identified commodities. This clearly allows us to deduce that all the commodities available on the 15th-century 'European' market were also present in the 15th-century settlement of Walraversijde. But this does not automatically mean that we should consider this fishing settlement as being 'rich' in monetary or socio-economic terms. Above all, the main factor that explains the presence of all these items and those readily associated with 'luxury' is the easy access fishermen had thanks to their many fishing-related or combined activities such as piloting merchant vessels to the international port of Bruges, serving in the navy of the Burgundian dukes as there was in that era no standing navy, combing the beaches, changing over from trade to piracy if circumstances allowed. Merchants coming from the Iberian peninsula relied on fishermen to pilot them through the Flemish banks to the harbours of Bruges; this could explain the high number of Spanish majolicas and other Iberian commodities such as honey and cork.

One aspect related to the presence of numerous Spanish majolicas is very important and revealing namely its spatial distribution across the settlement. The general distribution map (Figure 5) shows this commodity to be present all over the settlement. This clearly signifies two things: its presence is not limited to the happy few in the community but every household seems to possess at least some objects in Spanish majolica. The fact that every household seems to possess Spanish majolica could furthermore be interpreted as an indication that this maritime community is more egalitarian than the contemporaneous rural and urban communities in late medieval society and that Spanish majolicas had a different meaning in the fishing communities. In standard rural and urban contexts objects generally identified as indicators of luxury are mainly limited to a few sites with a presumed higher socio-economic status such as palaces, abbeys and rich merchants premises which is clearly not the case in Walraversijde. This brings us to the next topic of gender and socio-economic position in and of the community of Walraversijde.

Figure 4. Cask well realised with at least four superposed recycled herring casks made of Baltic oak (© Flanders Heritage Agency) (Marnix Pieters).

Aspects related to gender and socio-economic position

We can deduce that fishing settlements must have been supposedly dominated by women and children during most of the year as the fishermen were absent for long periods as a result of their work at sea. It can be argued that this can be observed in the archaeological record of Walraversijde. First of all there is a striking presence of children's toys and secondly a lot of archaeological indicators point to the care taken to hygiene, which the author tends to associate with the leading role of women although admittedly no hard evidence of this can be found.

Figure 5. General distribution map of Spanish majolicas over the excavated zone (1992–1998) clearly showing that this commodity occurs everywhere in the archaeological deposits of the site (© Flanders Heritage Agency). Illustration Marc Van Meenen.

A lot of children's toys are present in the archaeological archive of Walraversijde, however actually nearly no archaeological data is available from other settlements or types of settlements that would allow the required statistical comparison. So far 1x1 ha of soil archive at Walraversijde has produced 231 children's toys. A late medieval site in France, La Grange du Mont (Beck 1989), has for example only produced three children's toys on an area of 0.15 ha of soil archive. This gives some idea, but needs further statistical underpinning. One aspect, however, related to the children's toys is very clear, namely that children dominantly played with objects that reflect the activities of their parents. In the case of Walraversijde, common toys such as marbles, gaming discs and dice are widespread, as are miniature baskets, miniature boats and miniature whistles that are all miniature versions of objects used daily by parents. Children's toys thus reflect very well the economic activities of the parents and as such allow identification of the nature of the studied settlement on the basis of material sources and independently from the written sources.

Two aspects eventually related to the role of women will be discussed in a little more detail—the importance given to hygiene and the presence of numerous sickles. One of the best preserved houses still had some of the original features of the entrance preserved and showed that the floor of the house was paved with bricks only in the axis of the entrance of the door (Figure 6) and not in the rest of the rooms that had a floor in beaten earth. This could suggest that people entering the house had to or were used/supposed/invited politely to change shoes immediately after entering the house. This makes sense in an area with clayey soils that quickly become muddy during wet and rainy periods. Entering a house wearing wet shoes with a floor of beaten earth would completely destroy the carefully managed interior of the house by the female chief of the household (?). The same preoccupation with hygiene and/or safety can be observed in relation to the heating devices present in the houses. During the 15th century an evolution is seen from the central stove/oven directly posed on the soil of beaten earth to a stove/oven put on top of a brick floor again indicating the care given to hygiene. Another aspect but unluckily also without statistically validated data from other excavated settlements is the large number of heather brooms (26 heather brooms or fragments thereof are listed in the database) that have been preserved in the archaeological soil archive of the site. The fact that brooms in organic material notwithstanding the fact that they are not very likely to be preserved in the archaeological record for many reasons (fragile, easily recycled as fuel), are very regularly identified at Walraversijde is a reasonable argument to conclude that lots of them were used in the 15th century. This is also an argument in favour of the importance attached to a clean environment and, in fact, is in full disagreement with the generally accepted notion that medieval dwellers did not care much about hygiene.

Figure 6. Well-preserved entrance of one of the 15th-century houses of Walraversijde with a brick pavement exactly at the axis of the entrance to the house (© Flanders Heritage Agency) (Marnix Pieters).

The last aspect to be discussed in relation to gender is the high number of iron sickles present; 16 of them have been registered in the finds database. Sickles are usually interpreted as harvesting tools. So these objects would, if interpreted as such, tend to demonstrate the importance of agricultural activities in the maritime community. However, archival research indicates that in 15th-century Flanders sickles were long since replaced by scythes (Verhulst 1990) and were no longer used for harvesting cereals except maybe by women and/or children eventually when helping farming communities in the neighborhood during the harvesting period (July–August) which is not unimportantly exactly coinciding with a very busy period in the herring fishery. The fishermen themselves were, thus, not available to help with harvesting cereals. As such the presence of numerous sickles is probably an argument to conclude that at an earlier date all women and/or children were helping with the harvest of cereals. Furthermore, it was precisely the introduction of the scythe as the new and main harvesting tool that eliminated women (Sigaut 1998) as the central persons in harvesting activities in medieval Europe.

The last aspect to touch upon in relation to socio-economic aspects of the settlement is the size and nature of the brick buildings of the fishing settlement of Walraversijde. They are all very similar in nature and size (Figure 3). The largest one has only about twice the surface of the smallest one and the main characteristic is, thus, their similarity in size and also in internal organisation. This is another important argument in favour of the probably more egalitarian nature of a fishing settlement versus an urban or agrarian settlement in medieval Flanders. Both arguments: similarity of the houses and the equal distribution of majolicas are entirely and independently based on the material record. Before concluding, below are a few additional words on a special find.

A spectacle frame

Three fragments of the same bone spectacle frame found in the backfill of a 15th-century drainage ditch merit special attention as they clearly reveal the specific nature of the settlement. The spectacle frame proves that at least some people in the fishing settlement felt the need to read. The spread of the spectacle frame from the 13th century onwards clearly identifies the fishing settlement as a settlement connected to trade and commerce. Such objects are in the first period after its invention mainly found in ecclesiastical contexts and contexts linked to international commerce (Steuer 1993). It is precisely this last context that is revealing for describing the nature of the settlement: fishing settlement, yes, but with an additional focus on other activities such as trade and commerce.

Conclusion

In this paper some aspects of the archaeological research of a medieval and early modern fishing settlement have been briefly explored in some detail especially those in relation to what could be called social archaeology. The short list of references at the end of this paper allows further exploration of the archaeological context of this site.

The archaeological analysis of some of the excavated features and finds supports arguments in favour of the existence of a specific material culture (Pieters 2016) related to the work at sea and to the location of the settlement at or very near to the coast. Both aspects present an important degree of danger that called for specific reactions physically as well as spiritually as explained above. These fishing communities furthermore seem, based on the archaeological data, to be more egalitarian than their contemporaneous rural or urban communities. Furthermore thanks to their variety of activities they also seem to be intensively connected to the commercial networks at play in their zone of activity. This results in the presence in the settlement of so-called 'luxury' items such as imported ceramics and exotic spices and specific objects such as a 15th-century bone spectacle frame. The word 'fishing' is in this context indeed an oversimplification of their activities that can consist of piracy, piloting, beech combing, trading, warfare, hunting seabirds and extracting peat to name but the most important ones.

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Landing Sites—Trading Sites: Maritime Hotspots of the Ancient Mediterranean

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Abstract

When dealing with the ancient Mediterranean and its harbours, the *emporion* emerges as a phenomenon which has remained unexplained in the relevant theoretical discourses and lacks a coherent definition. When dealing with ports, harbours and maritime cities, it seems that many of them had an *emporion*, or were one.

Systematic research into the archaeological record not only offers a way out of the definitional dilemma regarding this type of harbour, but also draws our attention to a further interesting aspect. The hypothesis put forward in this paper assumes that *emporia* were places that allowed cultural relationships between different ethnic groups: 'Anyone who uses the term *emporion* means ethnic and cultural confrontation as a socially successful economic goal.' (Gras 1993: 106).[1]

But what exactly was an *emporion* and how do archaeological remains give evidence of this mingling of cultures? Assuming that *emporia* were commercial hotspots in the Mediterranean this paper deals with their architectural, cultural and institutional aspects and their material culture of trade networks in the ancient Mediterranean. In order to understand the interdependency of human impact and social networks, archaeological case studies will analyse the socio-spatial and socio-economic dimensions of trade networks in ancient Greece and its colonies in Asia Minor and Magna Graecia.

Keywords

Harbours, trade, *emporion*, cross-cultural exchange, maritime hotspots

Introduction[1]

Maritime hotspots of the ancient Mediterranean

Harbours form an inherent part of the cultural landscape of the ancient Mediterranean. They play a key role in cultural contacts, relations and migration movements in Mediterranean history. Different needs gave rise to different types of harbour and *landing sites* could develop into *trading sites* over time. As a result, artificial harbour constructions with different functions emerged. From ancient sources it can be deduced that they were important agents in the communication space of the ancient Mediterranean. So-called '*emporia*' became a synonym for overseas trade.

The aim of this article is to look at the phenomenon of the *emporion* from an archaeological perspective and to expose and highlight new considerations when approaching this subject, which is still a matter of much uncertainty. Due to the terminological problems that determine the scholarly debate, the question arises: what actually was an *emporion*? Previous theoretical definitions and analyses of *emporia* on a historical basis do not provide adequate answers to the question or a coherent definition.[2] But new research into the archaeological record could open new perspectives on the matter.

The term *emporos* in the sense of a 'passenger' makes its first appearance with Homer (*Odyssey* 2, 318–20). The use of the term *emporion* can be found in Hesiod's *Works and Days* (645). Later, ancient authors mention a variety of places as *emporia*; these possess quite different characteristics from an archaeological point of view (Bresson and Rouillard 1993: 17–18; Lehmann-Hartleben 1923: 28–45). At the start of the Common Era, Strabo reported about 48 *emporia* in his *Geographica* (Bresson and Rouillard 1993: 10; 24–26).[3]

In modern times, the topic of the *emporion* was initiated by Lehmann-Hartleben starting a scholarly debate on terminology and traits that has lasted up until the present day (e.g. Bresson 2016: 306–38; Demetriou

[1] 'Qui dit *emporion*, dit donc confrontation ethnique et culturelle, réussie socialement dans un but économique.'

[2] For the purpose of this article, important aspects of this debate will be discussed and highlighted hereafter. A detailed summary and bibliographical references on the scholarly debate can be found in Demetriou 2011. Furthermore, Demetriou 2012, Bresson 2016 and Eckert 2016 offer the latest insights regarding this topic.

[3] However Hansen notes 46 *emporia* according to Strabo since he does not explicitly mention two as *emporia* (Hansen 2006: 3, footnote 10). Whereas Daniels, being aware of Hansen's observation, seems to agree with Bresson and Rouillard 1993 talking about 48 *emporia* (Daniels 2015: 300).

2012; Eckert 2016: 63–70; Lehmann-Hartleben 1923: 28–45). According to Lehmann-Hartleben an *emporion* was a 'typical Greek creation', which was an important part of Greek urban life and a necessary element of it (Lehmann-Hartleben 1923: 28).[4] Furthermore, he points out that *emporia* are concrete fenced-off areas within or outside the city walls offering security (Lehmann-Hartleben 1923: 29–30).[5]

According to Karl Polanyi, however, harbours and harbour cities were the origin of trade, especially sea trade (Polanyi and Arensberg 1957: 3, 38–63; Polanyi 1963: 30).[6] Subsequently, he developed the 'port-of-trade' concept that is based on the ideas of Lehmann-Hartleben with the primary focus on the neutrality of the trading stations.[7]

The increased interest in ancient harbours of the Mediterranean has encouraged the *emporia* debate and resulted in the work *L'emporion* edited by Alain Bresson from 1993.[8] The basis of this research was an analysis of Strabo's *Geographica* describing 48 so-called '*emporia*' in the ancient Mediterranean. After Etienne's synthesis, conclusions about locations and hierarchies were reached, recognising the common denominator of those *emporia* to be communication over long distances. Moreover, he realises that important *emporia* were built next to rivers, supply canals and at the seaside (Etienne 1993: 29). Finally, Michel Gras examines the topic from a different angle and emphasises the meaning of *emporia* for cultural contacts in the Mediterranean. He concludes, 'Anyone who uses the term *emporion* means ethnic and cultural confrontation as a socially successful economic goal.' (Gras 1993: 103, 106).[9] Following his approach, material evidence offers tangibility for migration movements and cultural contacts within these maritime hotspots.

This paper will focus on three case studies: the normative example of the harbours of Athens, the harbours of ancient Delos and the south Italian Pithekoussai. The approach is to distinguish between ambiguous and unambiguous archaeological evidence. To start at the beginning, the commercial port of Athens will be revisited—an *emporion* that has been described as a prime example (e.g. Lehmann-Hartleben 1923: 28). The archaeological evidence seems to be unambiguous here.

Landing sites and trading sites

The harbours of ancient Athens

The ancient ports of Athens have been discussed in several publications. In the course of the movement of the harbour from the Phaleron bay to the Pireaus during the 5th century BC and the rise of Athens as a sea power, the bay of the Kantharos harbour became the major maritime trading centre in antiquity (Figure 1). Prior to the relocation conducted by Themistocles, the port of Athens was situated in the bay of Phaleron (Pausanias 1, 1, 2; Diodorus 11, 41, 2).

From the 10th to the 6th century BC, Greece's trade in the ancient Mediterranean increased rapidly due to improvements in ancient shipbuilding (Eckert 2015: 32–39, 56–59; Sherratt and Sherratt 1993: fig. 1). The bay of Phaleron had been serving as the original landing and trading site of Athens since the Bronze Age and it played an important role in Athens's trade before the expansion towards the Piraeus, as mentioned earlier. The exact position of the harbour within the bay of Phaleron is controversial (e.g. Dimaki 2014: 48; Eckert 2007: 21–22; Judeich 1931: 376; Lehmann-Hartleben 1923: 247; Negris 1904: 350–52; Travlos 1988: 340; Ulrichs 1863: 156–208; Wachsmuth 1874: 151, 306). According to Herodotus, Phaleron was the primordial harbour of Athens, and Pausanias mentioned moreover that the harbour was located where '...the sea comes nearest to Athens...' (Herodotus 6, 116; Pausanias 1, 1, 2). Diodorus also implied the existence of harbour installations at Phaleron when mentioning it to be small in comparison with the Piraeus (Diodorus 11, 41, 2). In 1904 Negris reported moles and a series of other parallel aligning structures, which he interpreted as the harbour installations of Phaleron (Negris 1904: 350–52; cf. Lehmann-Hartleben 1923: 247). The existence of these potential harbour structures has been discussed and questioned by scholars, but has not been researched yet.[10] The area of the excavations conducted by the Ephorate in 2004 in connection with the construction of a new shopping centre in the 'Delta Palaio Faliro'

[4] Moreover, he emphasizes that the *emporion* has been portrayed as a characteristic of a sophisticated Greek city (Lehmann-Hartleben 1923: 28).

[5] He refers to boundary stones in the Piraeus, fencing off the area.

[6] He understands emporia as a characteristic of prehistorical harbours and refers to Lehmann-Hartleben.

[7] The 'Port-of-Trade' after Polanyi was a 'commercial harbour' as an economic institution for trade on neutral ground (Polanyi 1963: 30). Hansen describes it as the key concept when approaching commercial and sociological theories of ancient societies (Hansen 2006: 1). Polyani's equating of *emporion* with 'Port-of-Trade' has been already discussed; Bresson points out that this equation is rather problematic due to rigid criteria of the 'Port-of-Trade' that are not necessarily applicable to emporia (Bresson and Rouillard 1993: 165-167).

[8] This publication refers to the use of the term *emporion* by ancient authors. The result of this seminar was a publication from different perspectives about emporia (Bresson and Rouillard 1993: 8). Moreover, definitions and descriptions from an historical and sociological view open further discourses about the phenomenon *emporion*, apoikia and polis – with and without an *emporion* (Bresson and Rouillard 1993: 104).

[9] 'Qui dit *emporion*, dit donc confrontation ethnique et culturelle, réussie socialement dans un but économique.'

[10] Lehmann-Hartleben 1923: 247 doubts the existence of harbour installations observed by Negris. Eckert 2007 offers further insight in this debate (Eckert 2007: 21-22).

Figure 1. The coastline and the potential area of an *emporion* in the Piraeus (Schematic Maps after (a) Verneda 1687, (b) Curtius 1841, (c) Milchhöfer 1881, (d) Judeich 1931, (e) Steinhauer 2000 (© Aylin Güngör)).

close to Hagios Georgios was associated with the 'use level' of the port of Phaleron. During the excavations a part of the coastline was identified. Moreover, finds from Mycenean to Classical times appeared, along with hearths made of stones and some elongated structures as well as parallel ones of unknown purpose. In conclusion, it was proposed that the ancient harbour area of Phaleron bay had been extended, but this still remains unconfirmed (Dimaki 2014: 48). However, the former landing site of Athens was relocated to the Piraeus for strategic reasons. The need for a sheltered harbour area can be explained by an increased need for protection in face of the threat of the Persian war.

Moreover, Themistocles's vision of Athenian sea domination entailed the relocation of the harbour from the bay of Phaleron to the Piraeus, with its natural dimensions that allowed bigger harbour installations, and military considerations played a pivotal role in connection with the transfer (Diodorus 11, 41, 2; Eickstedt 1991: 4; Garland 1987: 14–15; Steinhauer 2000: 14). The move not only underlines the strong need for marine expansion, but also emphasises the importance of the harbour for the development of Athens and its aspiring status as a maritime community.[11]

The development from a landing site to a trading site cannot only be explained with reference to Themistocles's building programme, but also an increase in trade, change of power-structures and the expansion of the Pireaus. It can be seen as a gradually

[11] This article focuses on commercial aspects of ancient harbours. Military considerations play an important role in the history of Athens and the military harbours of the Piraeus have been studied recently (Lovén 2011; Lovén and Schaldemose 2011).

advancement on various levels: from abandoning the old landing site in the bay of Phaleron to planning, completing and commissioning the new trading site in the Piraeus. The trading site of the *polis* of Athens moved to a site which has been demonstrated to be the prime example of an *emporion* (Lehmann-Hartleben 1923: 28). The former landing site was later converted into a trading site because of changing needs, and subsequently the construction of artificial harbour installations played an important role in the development of a vibrant maritime trade. The new trading site of Athens provided moles, jetties, quays, port halls and market-places (e.g. Eickstedt 1991: 61–68).

The importance of locating the precise site of the *emporion* can be seen from the continuing search for it. Ulrichs already discussed the Athenian *emporion* in 1863, and Milchhöfer's map *Die Halbinsel Peiraieus* published in 1881 was the first one to visualise a distinct area of an *emporion* in the Piraeus. This location for the *emporion* on the eastern slope of the Kantharos harbour has been discussed ever since (e.g. Eickstedt 1991: 62–68; Lehmann-Hartleben 1923: 28–29, 40–42; Milchhöfer 1881: sheet IIa; Steinhauer 2000: 79–96; Ulrichs 1863: 156–208; von Alten 1881: sheet II; Wachsmuth 1874: 306–24). Depending on different interpretations, the reconstructed area was supposed to be defined by the *horos*-stones found there (Eickstedt 1991:62–63, note 262; Judeich 1931: plan III; Milchhöfer 1881: sheet IIa; Steinhauer 2000: 89). Lehmann-Hartleben described the *emporion* as 'a certain, more or less sharply defined area' and the Athenian *emporion* on the eastern side in the Kantharos harbour as a prime example of it (Lehmann-Hartleben 1923: 28). The discussion culminated in the interpretation of two foundations formerly identified as harbour halls that were now linked to an enclosure of the *emporion* (Eickstedt 1991: 62–68; cf. Steinhauer 2000: 91). Nonetheless, the need for the concurrence of walls and boundary stones could be scrutinised and the extent of the enclosure to the north is a matter of much uncertainty.

A noteworthy observation has been made by Steinhauer regarding the shape of the Kantharos harbour based on old maps of the harbour basin before the modern modifications were carried out (Steinhauer 2000: 83). According to Verneda's map from 1687, the shape of the bay was less linear and sharp-edged (Figure 1, a). Similar observations can be made on Curtius's map from 1841 (Figure 1, b). Milchhöfer's map from 1881 implies a basin subdivided by a rather hard-edged formation (Figure 1, c). Unfortunately, this is a matter of uncertainty, but Steinhauer emphasised the significance of this question when recreating the ancient coastline of the Kantharos harbour (Steinhauer 2000: 83–91). This is also an important aspect of the *emporion* debate, which was explicitly visualised for the first time on the map of Milchhöfer from 1881, apparently showing the harbour after the modern boxing of the basin (Figure 1, a-d). To conclude, therefore, it seems that the *emporion* debate has been framed by a prime example that has been reconstructed after a modern coastline.

If the archaeological record is as ambiguous as this, how is it possible to trace an *emporion* through the archaeological record?

Landing sites and trading sites on the island of ancient Delos

In considering landing sites and trading sites under the scope of maritime hotspots, the ancient island of Delos played a pivotal role in the ancient trade across the Mediterranean. Not only was its location favourable in the Aegean Sea, but also its political and religious allies and advantages were significant. From an agricultural point of view the island seems insignificant due to its barren surface, but since it is surrounded by various bays it was suitable for maritime trade, and being endued with a religious climate with its thriving sanctuary of Apollo was also a great asset (Philippson 1959: 110–14).

The passage from East to West had a favourable interstation on the island of Delos. The shape of the island has changed due to sea level rise and siltation (e.g. Desruelles *et al.* 2007: 231–39). The outline of Delos is determined by several bays that functioned as landing sites for the island (Figure 2). In its northern part lies the bay of Skardana, followed by the so-called sacred and merchants' harbours. On the south-western side of the island lies the bay of Fourni and in the north-eastern area lies the bay of Gourna (e.g. Bruneau and Ducat 2005: 29, leaflet VIII; Duchêne and Fraisse 2001: doc. III, V, VI, VII.; Papageorgiou-Venetas 1981: figs 65, 79, 84, 85, 103, plate 7; Zarmakoupi 2015: fig. 132).

The main port stretches across the western coastline from north to south. To the north lies the so-called Skardana port and southwards the bay of Fourni (Papageorgiou-Venetas 1981: figs 79, 84; Pâris 1916: 62). Basin 1 of the main port was mentioned as a sacred harbour, open to the south and having a flat beach where ships could land and be pulled on shore in early times (Bruneau and Ducat 2005: 161; Philippson 1959: 111–12). The close connection between the harbour and the sanctuary has been emphasised and explained by the interdependence (Philippson 1959: 111–13). Furthermore, Philippson suggests that a small and unproductive island such as Delos was chosen to serve as a sanctuary and market-place due to its neutrality, and trading continued even during ceremonies (Philippson 1959: 113). The quays of the commercial harbour

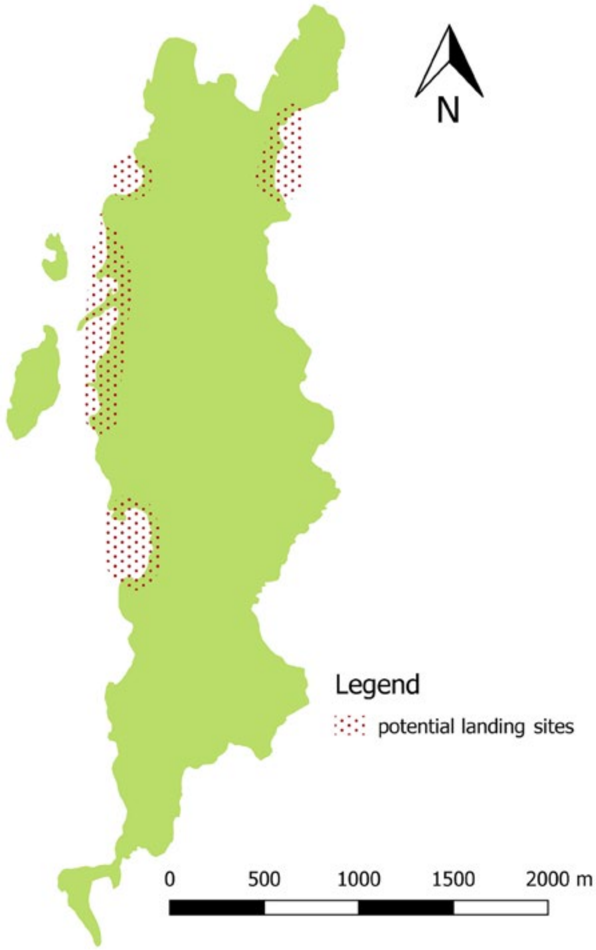

Figure 2. Landing sites on the island of Delos (coastline after Google earth and QGIS, 2017; landing sites after Papageorgiou-Venetas 1981: fig. 65, fig. 79, plate 7, fig. 84, fig. 85, fig. 103 (© Aylin Güngör)).

extended over the length of five basins (Papageorgiou-Venetas 1981: 99). However, only the sacred harbour provided good protection for the ships during landing. Basin 2 could only be used when there was hardly any wind (Papageorgiou-Venetas 1981: 99–100, fig. 79). The port is surrounded by *agoras* to the north and south. Quays and magazines extend further southwards (main port and basins e.g. Duchêne and Fraisse 2001: doc. III, V; Papageorgiou-Venetas 1981: 99–111, fig. 79). Towards the north lies the 'great mole', an architectural feature that has been a controversial subject among scholars due to its alleged archaic dating (e.g. Desruelles *et al* 2007: fig. 3; Duchêne and Fraisse 2001: doc. VIII; Lehmann-Hartleben 1923: 154, Plan XXIV; Pâris 1916: 19–21). Adjoining constructions, such as the two *agoras*, the commercial district and magazines, are all connected to commerce (e.g. Karvonis 2008: 218–19; Papageorgiou-Venetas 1981: 99–102; Philippson 1959: 112; Zarmakoupi 2015: 116–20). The bay of Fourni to the south of the main harbour is today protected and has a coastline with fine pebbles and sand (Bruneau and Ducat 2005: 161, 316–17; leaflet VIII; Duchêne and Fraisse 2001: doc. VII). The bay of Gourna was the first site noticed by Pâris to have ancient structures and a survey of the stadium district has been undertaken recently (Pâris 1916: 62; Zarmakoupi 2015: 124–26). The remains of a quay and a building to the west of it have been identified and associated with trade and commerce activities (Papageorgiou-Venetas 1981: 106, fig. 85; Zarmakoupi 2015: 124–26, fig. 132).

In the search for *emporia*, Delos has been revisited and considered as well. In the years 1986–1989 Duchêne carried out three sondages in his search for the *emporion* of Delos (Duchêne 1993: 124–25). Even though the inscriptions and ancient sources indicate that Delos was an *emporion*, it has not been clearly defined yet (Hasenohr 2012: 259; Strabo. 10, 4–5 and 14, 2; Zarmakoupi 2015: 126). Nonetheless, the presence of a maritime trading centre on Delos is well known. In this context, recent research has embraced a different understanding (Zarmakoupi 2015: 116–26). Zarmakoupi pointed out commercial activities not only in the area of the main harbour, but also in the area of the stadium district and stresses this was an 'integral part of the Delian *emporion*' (Zarmakoupi 2015: 124). Bearing in mind the difficulties in entering the main harbour under certain weather conditions described above, this suggestion seems quite plausible. After all, this observation not only affects the understanding of the harbour constructions on Delos, but also the search for an *emporion*. With regard to Delos's landing and trading sites, it casts an interesting light on the organisation of the whole island and its operating harbours. Zarmakoupi also stressed that the island of Rheneia should be involved in this research, since it might have functioned in connection with the *emporion* of Delos (Zarmakoupi 2015: 126). Whereas research has traditionally focused on the area of the so-called main harbour, this approach would change our picture of 'island *emporia*' significantly and further research will certainly contribute towards our understanding.

Another interesting feature was reported by Strabo, who describes the fast process from unshipping to selling the goods: 'Merchant, sail in, unload your ship, everything has been sold' (Strabo 14, 5, 2). This indicates a well-coordinated trade from the harbours to the markets and emphasises the significance of the island in the Aegean Sea. As for the organisation, Strabo gives another hint and describes the climate for merchants:

> for the importers changed their business to Delos because they were attracted both by the immunity which the temple enjoyed and by the convenient situation of the harbour: for it is happily situated

> for those who are sailing from Italy and Greece to Asia. (Strabo 10, 5, 4).

Additionally, this feature not only indicates a climate convenient for trade, but also a hotspot for multicultural exchange between different ethnic groups. In fact, the international trading site of Delos was dominated by a religious landscape and the security for traders was described by Pausanias: 'Delos was then a Greek market, and seemed to offer security to traders on account of the god...' (Pausanias. 3, 23, 3). Ionian Greeks had already settled on this island around 1000 BC and established sanctuaries for Artemis, Apollo and Leto (Philippson 1959: 112). Moreover, foreign gods were worshipped on the island as well. Therefore, a coexistence of different religions can be observed here (e.g. Trümper 2006; Scott 2013). This phenomenon has been described as a 'polytheistic network' by Michael Scott which has been intertwined with the religious, social, political and economic life of the island: 'Delos [...] became an increasingly cosmopolitan community over time, worshipping a combination of many local, Hellenic and foreign cults, assimilated and syncretized into an imaginative number of ways.' (Scott 2013: 45, 75–76). Furthermore, he observes a hierarchy of foreign and Greek cults on the island and points out that foreign cults were worshipped on a terrace, which lay on the way up to Mt Cynthos.[12] Alien cults were thus indeed worshipped on the mountain of the island, but Serapeion C, for example, was still in visual contact with the main sanctuary of Apollo (Scott 2013: 63–65, fig. 2.5). This means that local and foreign deities must have been worshipped in coexistence on Delos. Therefore, it has been stressed that merchants played a major role in designing and organising the island in order to allow the traders to worship the deities from their homeland (Scott 2013: 62–76).

Interestingly, no matter with which terms these types of multicultural societies have been described, their lowest common denominator was a certain need for trade that has been described by Daniels:

> trade was one of the primary motivating factors in bringing people together to form increasingly large and culturally heterogeneous communities, whether these were communities of foreigners settling in alien territory, the precedents of a future *polis*, or a port connected to a larger settlement. (Daniels 2015: 305).

Such settlements had important social functions for interacting groups of multicultural backgrounds and different religious orientations, e.g. mediating transactions between strangers. This situation in conjunction with a multi-religious basis has been described as pleasant for foreign traders in ports abroad (Daniels 2015: 313–17). This process of 'syncretism' has been recognized in this context as the natural by-product of larger migration movements caused by various social, economic and political factors. Finally, it has been stressed that the development of institutions can be understood as a factor in regulating uncertainties between cultural contacts, such as different languages or cultural differences. (Daniels 2015: 315–16). In connection with Gras's conclusion regarding the classification of ports and landing sites, this element constitutes an additional category when approaching harbours, especially *emporia*.

The case of Pithekoussai

In a discussion of landing and trading sites, Pithekoussai is the prime example of a place developing from a site where ships landed to a site that has been labelled as a 'maritime hotspot for trade' (Figure 3). Strabo described Pithekoussai as inhabited by Euboeans (Strabo 5, 9). Moreover, Livy pointed out that the Chalkidians were the local maritime power on this coast and they initially inhabited Pithekoussai before they settled on the mainland (Livy 8, 22).

A central concern here is the question that arose after the excavations conducted by Buchner and Ridgway as to whether Pithekoussai could have been an *emporion* as well. This has been discussed intensively among scholars (Ampolo 1994; Berard 1963; Coldstream 1994; d'Agostino 1994; de Caro 1994; Greco 1994; Malkin 1994; Mele 1979; Snodgrass 1994).[13]

The reason why Pithekoussai has been discussed as an *emporion* lies in the heterogeneous archaeological material of this settlement (Ridgway 1984: 122; Ridgway 1992: 108). And, for the first time, the question was asked whether a settlement could also have been an *emporion* even though no ancient source states this. Despite the controversy, the Pithekoussai debate played a decisive role in introducing the pivotal question of how to trace an *emporion* on the ground.

A vivid discussion followed the excavations of Buchner and Ridgway concerning the status of Pithekoussai as an *apoikia* or an *emporion* (Bresson 1993: 220–21, 223; Lévêque 1993: 230; cf. Castagna 2011: 50). The pros and cons were debated in the mid-nineties. The arguments for it being an *emporion* are basically the multicultural finds, for example in the ceramic record; the arguments for an *apoikia* are mainly the need for a highly developed organization in the form of a leading elite or administration and a vibrant trade and commodity exchange. According to researchers, an

[12] Egyptian gods were worshipped here from the 3rd century BC. The cult of Serapis is known on Delos since 220 BC with three sanctuaries (Scott 2013: 63-64).

[13] Castagna 2011, 50-52 summarises the whole debate.

Figure 3. Ancient settlements of Ischia. Pithekoussai in north-west corner (coastline after Google earth and QGIS, 2017; settlements after Coldstream 1994: fig. 4.1 (© Aylin Güngör)).

emporion, presumed to be a landing site, cannot fulfil these needs. This debate ended up in an important summary claiming Pithekoussai to be a special type of *apoikia* with elements of a *polis* that does not fulfil these criteria yet (d'Agostino 1994: 22; Greco 1994: 11–18; Malkin 1994: 1–9; cf. Ampolo 1994: 29–39). According to this theory, Pithekoussai was more or less a *polis* in the making.

Examining the archaeological finds from Pithekoussai, different degrees of cultural contacts and cultural exchange can be outlined. The archaeological material is vast and has been analysed from different perspectives. Therefore, only selected socio-cultural aspects will be highlighted here in order to cast further light on various different aspects of this case.

Boardman observes that Euboean and Ischian ceramics result from an eclectic mix of cultural contacts. Accordingly, archaeological finds from Pithekoussai show hybrid tendencies e.g. in terms of painting style and forms: some of the ceramics found at Pithekoussai imitate the Corinthian or Euboean style, and some even show influences from both styles at once. Moreover, he depicts locally produced ceramics with Aramaic and Phoenician inscriptions (Boardman 1981: 196–98, fig. 202). The most famous find from Pithekoussai, the so-called 'Nestor's Cup', also reflects this phenomenon, being of Rhodian production on the one hand with an inscription using the Euboean-Attic alphabet on the other (Buchner 1966: 8). Apparently, cultural contacts and cultural exchange not only took place here, they affected and impacted the interdependencies between societies and their material culture and moreover determined status and integration in this maritime community.

Important arguments concerning trading considerations are made by Buchner who describes Pithekoussai to be a maritime centre for commerce and 'the most advanced Greek port' (Buchner 1966: 9). Following his arguments, this is evident not only in the heterogeneous finds, but also in the iron slag found in the dump of the acropolis. This discovery is of central concern in the trade debate since Pithekoussai does not have any iron deposits itself. Therefore, Buchner linked these findings to trade with Tuscany and Elba that has the only metallurgical deposits in Italy, which were processed at Pithekoussai (Buchner 1966: 12). D'Agostino emphasizes Pithekoussai's role as a centre for craftsmanship that possessed the technological know-how to process metal and ceramics (d'Agostino 1994: 25). For that reason, Buchner questions the motives for 'colonisation'; these cannot only be explained agriculturally but can be understood commercially as well (Buchner 1996: 12). Furthermore, d'Agostino argued that Pithekoussai had to stay in contact with the mainland to secure access to food supplies (d'Agostino 1994: 24–26). This argument is also reflected in the recent analysis of Donnellan who concludes that Pithekoussai was part of a Tyrrhenian network (Donnellan 2016: 156–58, 162).

Surprisingly, no weapons or armours have been found during the excavations of Pithekoussai (Ridgway 1992: 77). This absence must also be considered in the context of a peaceful settlement or 'colonisation' and puts Pithekoussai directly in the 'fairway' of neutral trade that made it safe to do business there. This understanding does not contradict Ridgway's idea of an association of Euboeans entering an already established and supraregional trading system when they travelled westwards (Ridgway 1992: 29).

In addition, new research provides further information on cultural contacts and broadens the perspective of the scholarly debate. As one of the first colonies with cross-cultural exchange, Pithekoussai also provokes the question: 'to be or not to be an *emporion*'. In her research, Donellan concludes that there was not only a mingling of cultures at Pithekoussai, but also a local population that she describes as the founding fathers of this settlement. Donnellan stresses that the indigenous population of Pithekoussai was larger in scale than the Greek one. She emphasises that statistical evaluation of the archaeological material suggests that Pithekoussai was not an *apoikia* or *emporion*,[14] but that it was not even a Greek settlement (Donnellan 2016: 149, 166). She even says that Pithekoussai was dominated by an indigenous

[14] A description of her approach can be found in Donnellan 2016: 153-160.

population, not by a Greek one (Donnellan 2016: 149, 160). Moreover, her study shows that the percentage of the indigenous population was much higher than the Greek and she points out that in terms of Pithekoussai one can no longer talk of a 'Greek colony' in the traditional sense of the word (Donnellan 2016: 149). Furthermore, her studies showed that the earliest burials had Phoenician and Middle Eastern origins and not Greek ones (Donnellan 2016: 160). Following her arguments, it was a mingling of different groups from the Aegean, Levant and the indigenous population, which lastly questions the hellenocentric perspective. The research was focused on the painted ceramics, which portrayed the Greeks as the superior culture subjecting the indigenous population and the indigenous goods were rather neglected in comparison to the Greek ones. For the late geometric period she worked out an exclusively non-Greek origin, which subsequently led her to conclude that Pithekoussai must have been part of a Tyrrhenian network (Donnellan 2016: 162, 156–58).

Conclusions

New thoughts on emporia and their archaeological remains

The general aim of this article was to stress and provide new considerations when approaching the phenomenon of the *emporion*, which is still a matter of much uncertainty. As the scholarly debate has shown, the phenomenon of the *emporion* could not be solved adequately on a theoretical basis so far.

On the one hand, it has been shown that the diachronic written sources could not provide a clear conclusion on this subject. The approach through alleged prime examples highlighted that archaeological material often cannot provide sufficient evidence to offer certainty on these trading sites. Architecturally, the archaeological remains are ambiguous here as well. On the other hand, it has been stressed how fruitful further considerations of the architectural material could be. Moreover, this discourse revealed that cultural contacts and exchanges not only took place, but that their interdependencies impacted and reflected directly on the material culture of their society. On this basis, it is, therefore, appropriate to extend the question of how to identify an *emporion* and to look for indicators in a more comprehensive way. Therefore, it turned out that the question of how to trace an *emporion* can be asked on different levels and categories.

Rethinking the normative example of the *emporion* of Athens, the search for an *emporion* has delineated difficulties and uncertainties. The cause for the relocation of the harbours of Athens from the bay of Phaleron to the Piraeus cannot only be answered with socio-economic, but also with political, topographical and strategic reasons. Therefore, comprehensive and combined research contributes towards an understanding of the complex socio-economic and socio-spatial coherences and affiliations in the development of the ancient harbours of Athens, forming a maritime hotspot over time. It has been revealed that the prime example of an *emporion* has mediated towards an ideal conception of *emporia* in the ancient Mediterranean that requires further research of the archaeological record.

In search of a 'more or less sharply defined area' Delos has been revisited due to its significant status as a maritime hotspot for international trade. In conclusion, then, it is clear that the origin of this development cannot be derived from its agricultural or mineral wealth, but rather from beneficial political negotiations, a favourable location in the Mediterranean and liberal religious conditions. The latter have been discussed as an encouraging partner for international trade where merchants felt safe to do their business. Unsurprisingly, religious coexistence has been observed on Delos, which is a notable indicator of companionship in a maritime community. Finally, new approaches indicate that more areas can be connected to commerce than previously expected and recent underwater research will hopefully shed new light on the landing and trading sites of this island and the significance of Delos in the Mediterranean communication space.

The reason why early settlers stayed on the island of Pithekoussai can be revisited on several levels. The access to metal deposits is certainly an important argument for considering Pithekoussai as a hotspot in the overall context of a Tyrrhenian network due to its favourable position. Cultural contacts have been detected beyond the regional network of Pithekoussai in various regions in the Mediterranean up to the Levant and beyond Egypt. How this trade between the East and the West took place and whether intermediate stops and intermediaries must be rethought as well, is one aspect of this question. The others are different degrees of cultural exchange that must have taken place in direct and indirect ways. Additionally, the imitations shown in the ceramic record are an important reference point that links Pithekoussai to a multicultural Mediterranean, and ultimately leads to the question of how Greek this settlement actually was.

Traditional research has considered Pithekoussai to have been a Greek-established and Greek-shaped settlement whereas modern network studies indicated that Pithekoussai was a non-Greek settlement (Donnellan 2016: 162–63). In this context, it is noteworthy that migration movements are characterised by different varieties of cultural contacts such as mixing, coexistences, hybridisation and so on.

In terms of Pithekoussai and trade activities in the Mediterranean, one can determine cultural exchange, different degrees of cultural contacts that can be linked to a regional as well as to international trade networks, and the individual degrees of cultural contacts provide insights into socio-cultural aspects of this settlement. Finally, the scholarly debate on the example of Pithekoussai - 'to be or not to be an *emporion*' - can also be considered in other harbour cities in the ancient Mediterranean.

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The Limassol Carnayo:
Where Maritime and Intangible Cultural Heritage Converge

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Abstract

In pre-industrial societies, craftsmen possessed the necessary professional ability and experience to handle manual labour. This accumulated knowledge, from years of learning and practising their craft, is reflected in vernacular shipbuilding. It is ever evolving and thus does not present a uniform development as it is influenced by periods of prosperity alternating with periods of decline. Cyprus has a long shipbuilding tradition, serving the needs of a self-sufficient economy from the 18th century onwards.

The *carnayo*, Limassol's shipbuilding installations, has existed since the 19th century. Urban waterfront development led to the construction of the old and new ports, resulting in urban expansion and the *carnayo* being relocated twice. Its existence has undeniably influenced the maritime landscape and the locals' contact with the sea.

Vernacular shipbuilding exemplifies the convergence of Intangible and Maritime Cultural Heritage (IMCH). Maintaining the *carnayo* preserves exactly that; the area, people and oral testimonies constitute an integral part of Limassol's history. Despite the difficulties, revitalising the area is possible. The reuse of industrial buildings as a museum could emphasise its historical value and continuity, preserving the craft through shipbuilding tools, boats and archival photos. Ultimately, enabling the public to access IMCH results in it being appreciated and protected into the future.

Keywords

Vernacular shipbuilding, *carnayo*, heritage management, Cyprus

Introduction

Cultural Heritage is a complex concept, encompassing both natural and cultural heritage according to the 1972 Convention Concerning the Protection of the World Cultural and Natural Heritage. The 1972 Convention outlined a framework and two other important concepts, that of 'shared heritage' and its 'universal value' (Smith and Akagawa 2009: 1). As Cultural Heritage includes both tangible and intangible elements, both encompass various aspects of a community's life. Modern societies are characterised by plurality, the fluidity of the social nexus and mentalities, whereas events are contextualised according to the way they are linked to other events via socially recognised narratives (Tsiolis 2010: 34).

Heritage is further linked to issues of authenticity and integrity, which are expressed in terms of both Tangible and Intangible Cultural Heritage (ICH). The latter is a living heritage, transmitted over generations and connects community members with their past, present and future. The unique perspective articulated by way of recollections and local history makes this shared heritage intricate, intimate and important. According to the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage, traditional crafts are a manifestation of ICH, while the preservation of a dying craft of this sort requires continuous and often arduous efforts.

Vernacular shipbuilding can be regarded as a convergence of Intangible and Maritime Cultural Heritage (IMCH). On one hand, it falls under ICH as it is a traditional craft transmitted from one generation to another and yet it is maritime, as shipbuilding is directly connected to the sea and its people. The observed interaction between society and the sea is what defines maritime culture, and the relationship between the two is flexible and changing. The intangible resource, i.e. the shipbuilding craft, produces a tangible element, i.e. the boat. This cycle of transition, from intangible to tangible and ultimately maritime heritage, can be expanded to include the cultural landscape. This idea had already been expressed by Lipe (1984: 1–11) who further noted that cultural landscapes could qualify as cultural resources, as they have undergone anthropogenic alteration. In his exploration of the ways cultural materials can function as resources, he demonstrated that cultural resources play a central role in cultural continuity and perspective. This multi-layered complexity is attested in the maritime landscape of Limassol, including elements of the broader maritime community such as their activities, their language and recreation, and the tangible cultural elements involved in their daily work. All these elements, taken

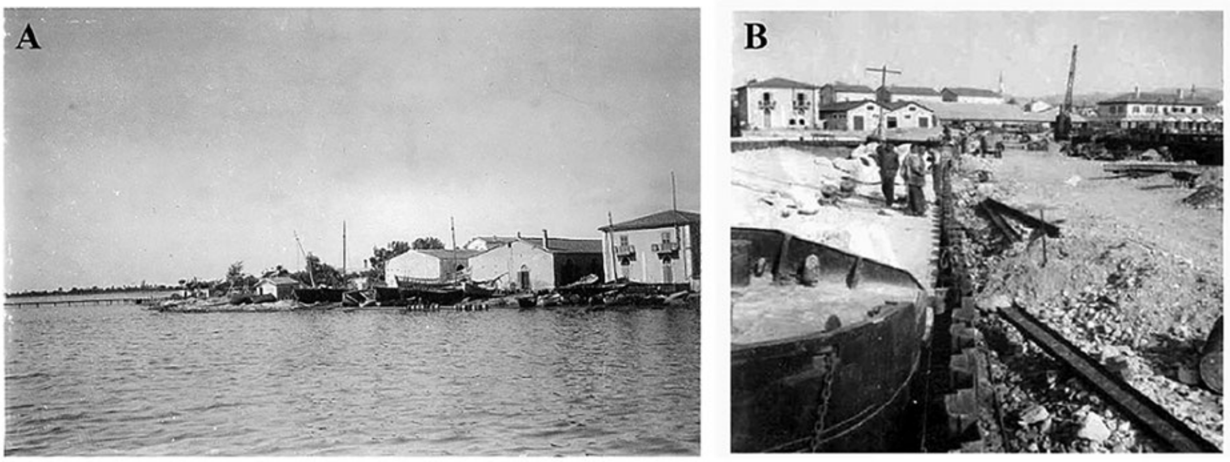

Figure 1a–b (L–R). North-west view of the *carnayo* installations in the 1950s and the east quay improvement works in 1955 (Pattichion Municipal Museum and Historical Archive of Limassol).

collectively or separately, produce a unique amalgam that defines the maritime community and constitutes its identity, with vernacular shipbuilding being only one aspect of it.

This paper explores the convergence of Intangible and Maritime Cultural Heritage, using the case of the Limassol vernacular shipwrights, the *karavomaragkoi*. It presents the craft through archival material and interviews with the shipwrights, and contextualises the available data within the maritime landscape of Limassol. The vernacular shipwrights of Limassol were selected as a case study for several reasons: the longevity of this local community, the complexity of their craft, and the ways in which they have affected the town's maritime landscape. The overall aim is to identify the problems and propose solutions to preserve the ICMH of Limassol.

Historical background

The maritime cultural heritage of Cyprus is well attested both in material culture and in written sources since antiquity. Cyprus's geographical importance is highlighted particularly in the Middle Ages when the island became a diplomatic and military base in the 12th century (Maier and Karageorghis 1984: 306), and pilgrims would often stop there *en route* to the Holy Lands (de Lusignan [1580] 2004). Portolans and nautical guides of the 13th and 14th centuries provide indirect information on trade in Cypriot harbours such as those of Limassol and Paphos (Jacoby 1995: 393), and notary documents reveal the associations between merchants and the maritime community (Jacoby 1995: 389–390). The integration of Cyprus in the *Stato da Mar* in 1489 consolidated its role both as a nautical base of the Venetian fleet and as a Venetian trade centre in the eastern Mediterranean (Arbel 1995: 487). Although we know that coastal towns, such as Famagusta, depended on maritime activity around their harbour, information on the Cypriot maritime community itself is rather scarce (Arbel 1995: 506).

The island's shipbuilding tradition takes a more concrete form in the Ottoman period. As Bekiaroglou-Exadaktylou (1994: 12, 76) comments, Cyprus was among the regions where the Ottomans maintained the existing Byzantine shipyards although these operated on the island only after the Treaty of Passarowitz in 1718. The favourable conditions of the treaty had allowed to continue flourishing in the Aegean: more vessel types had been created since the mid-17th century such as the *trehandiri* in Hydra (1657),, and shipbuilding design techniques evolved alongside the increased production (Bekiaroglou-Exadaktylou 1994: 115–117). One should note that the Ottomans valued Greek shipwrights immensely—they were commemorated in Ottoman sources and were transferred from other regions to man important shipyards such as the Imperial Shipyard (*Tersane-i-Amire*) of Constantinople (Beydiz 2017), which had a large cycle of production (Toraman, Güvemli and Bayramoğlu 2010: 192, 199–203). This constant flow of knowledge, skills, and expertise has been noted throughout the Aegean from the mid-16th century onwards (Bekiaroglou-Exadaktylou 1994: 138–144).

Despite the absence of detailed information, it is possible to trace vernacular shipbuilding at Limassol as early as the 17th century. At that time, the Ottomans had a fortified shipyard there similar to that of Constantinople (Sathas 1962: 157). Evidently, shipbuilding continued into the British Colonial Rule (1878–1960), although Cyprus had a profound lack of harbours at the time of this transition. There were only three safe anchorages at Limassol—Larnaca and Famagusta. Limassol had wooden docks along the coastline and ships had to unload their cargo by using lighters (Baker 1879: 257–258; Panayiotou 2013: 95; Panayiotou 2017: 35). This situation hindered seaborne trade, thus, the British commenced a series of harbour works across Cyprus using funds from the colony (Panayiotou 2013: 96–97; Panayiotou 2016; Panayiotou 2017: 33–34).

Cypriot anchorages were equipped with only wooden piers until the late 19th century and the majority of vessels docking there were fishing boats (Panayiotou 2016: 17–18). The British Consular Agent, Pietro Brunoni, wrote in his report to the new Consul at Larnaca in 1843 that the only harbour that was at all operational was situated at Famagusta and there were 36 silted anchorages across the island (Luke 1921: 179–180). These conditions permitted the use only of wooden vessels, as later attested in the Cyprus Blue Books. In 1887–88, ten years into the British Colonial Rule, the Blue Book records 327 Cypriot sailing vessels to have been engaged in such activities, with 9027 tons total capacity and a mean average of four crew members per vessel (Colonial Office 1888: 520). Fifteen boats were employed at Limassol district for fishing that year, which were apparently locally built (Colonial Office 1888: 553). The data available in the Blue Books (1880–1938) consistently show that Cypriots were solely operating wooden vessels and were often renting them out to the British. There is a small gap in the available data during World War II (1939–1945) but the 1946 Blue Book notes again, after their first appearance in 1923, four steam vessels under the Cypriot flag while they continued operating sailing vessels (Colonial Office 1948: 398–399). The historical data indicates that, as Cypriots had to carry out all seaborne transports, trading and fishing using wooden vessels, it is reasonable to suggest that shipwrights had been active from at least the early 19th century.

Limassol appears to have had a stronger relationship with the sea compared to other towns: 'Limassolians' owned merchant vessels travelling to Egypt and Syria. Local steam companies were founded in 1899 and 1905 and operated alongside agencies of foreign steam companies (Panayiotou 2016: 157-158). Moreover, the first shipyard began operating in 1922, run by the Fytos shipbuilding family (Pilavakis 1997: 171). We know of at least one more shipbuilding family tracing its roots to Limassol in the 1870s, the Parpour, who moved first to Lebanon and since 1958 operate at Paphos (Parpour 2018). The historical data, family lore and current craft practitioners all indicate that vernacular shipbuilding has a lifespan of more than 200 years at this southern coastal town.

The coastal landscape of Limassol began changing progressively during the British Colonial Rule. The construction of an iron pier and a customs office by the end of 1881 was followed by a series of improvement works in 1910 (Panayiotou 2016: 52–53, 72). The pier was extended in the late 1920s (Panayiotou 2016: 80) and the first shipyard began operating in 1922 at the old harbour area. The harbour works resulted in the first relocation of the *carnayo*, from the old harbour to the beach in front of the municipal zoo in the 1950s (Figure 1). This relocation is commemorated in the early 20th-century newspapers while the shipwrights themselves mention two relocations in total (Avgousti, C. 2016; Avgousti, G. 2016; Mpillis, L. 2016). The urban development of the 1960s resulted in a second and final relocation of the *carnayo* between the old and new harbours (Sophocleous n.d.: 2–3) (Figure 2).

In the post-1974 war era, Limassol expanded even further: the newly constructed port and the adjacent industrial zone gave the coastal strip its current characteristics (Ktori 2016: 115). The *carnayo* has influenced the coastal landscape between the two ports significantly, as the establishment of a shipyard is directly related to the local topography, taking advantage of inclined, sheltered areas to facilitate the daily repair works and pulling the vessels out of the water (Proikiou and Chatzipapadopoulou 1991: 15–16). The shipwrights had backfilled parts of the coast to meet those specific criteria (Avgousti, C. 2016; Avgousti, G. 2016; Mpillis, L. 2016), influencing the maritime landscape of the western edge of Limassol (Figure 3). Considering all of the above, the shipbuilding community had a central role in certain aspects of Limassol's development—early 20th-century seaborne trade would have faced difficulties without the local shipyard and its absence would have subsequently affected the financial growth of local traders who depended on it. Moreover, shipbuilding influenced the landscape itself particularly after the 1960s with the final relocation of the *carnayo*.

Although the craft has influenced local history in many ways, it remains neglected by Limassolians and academic researchers as well. Kanthos (1987) and Ionas (2001) studied traditional craftsmen, whereas Papademetriou (2003, 2010), Rizopoulou-Egoumenidou (2005) and Hadjiyasemi (2016) studied a number of traditional crafts. Strangely, vernacular shipbuilding has been marginalised by ethnographers, ethnoarchaeologists and maritime archaeologists, who focus on the study of shipwrecks (e.g. Demesticha 2011; Skarlatos, Demesticha and Kyparissi 2012). This paradox and the danger of losing a part of our heritage are the reasons the author pursued this project, which will hopefully fill a significant research gap.

Methodology and analysis

The documentation of vernacular shipbuilding in the broader context of IMCH was a multi-layered process. The methodology followed reflects the complexity of

Figure 2. Aerial view (north-east) of the current *carnayo* installations (Pattichion Municipal Museum and Historical Archive of Limassol).

the project itself, combining aspects of archaeology, ethnography and oral history, all within a maritime setting. The systematic recording of the craft and associated traditions functions as an analytical tool allowing the contextualisation of vessels within their historical and social background (McGrail *et al.* 2003).

a) Interviews with stakeholders

The author conducted interviews with all stakeholders: Cyprus National Commission for UNESCO,[1] Limassol municipality and shipwrights. These stakeholders are currently, or have been, actively involved in cultural heritage programmes related to vernacular shipbuilding. The interviews demonstrated the differences among them, leading to varied perspectives on the preservation and promotion of vernacular shipbuilding.

Limassol municipality referred the author to Dr Mimis Sophocleous, Director of the Pattichion Municipal Museum and Historical Archive of Limassol (PMMHAL). Dr Sophocleous was interviewed, and responded to two different, structured questionnaires. The first focused on the actions taken to preserve and promote local maritime heritage, and the second focused on the industrial heritage of Limassol including the possibility of using an industrial building as a maritime museum.

A series of semi-structured interviews was also conducted with the shipwrights; the interviewees were between 45 and 80 years old. The author recorded first the information regarding each shipyard (ownership, years of operation, location/relocation), and then progressed to the shipwright himself. The second part of the interview concerned the craftsmen and the learning process: their nationality and tutelage were key elements in understanding the chain of technology transfer, and at this point the craftsmen mentioned stories about old master-shipwrights. These references were often repeated during the third part of the interview, relating to the selection of appropriate wood, the design and the construction process of a vessel. The fourth part of the interview, regarding the shipbuilding tools, was sometimes enriched with a demonstration of the routine employed by old masters in using each tool.

b) Archival research

Pham (2015; 2016) highlighted the value and potential of archival research in her voluminous work on traditional boatbuilding in central Vietnam. Her approach on

[1] The Cyprus National Commission for UNESCO currently has no programmes or actions relating to the protection and promotion of vernacular shipbuilding, although this may change in the future.

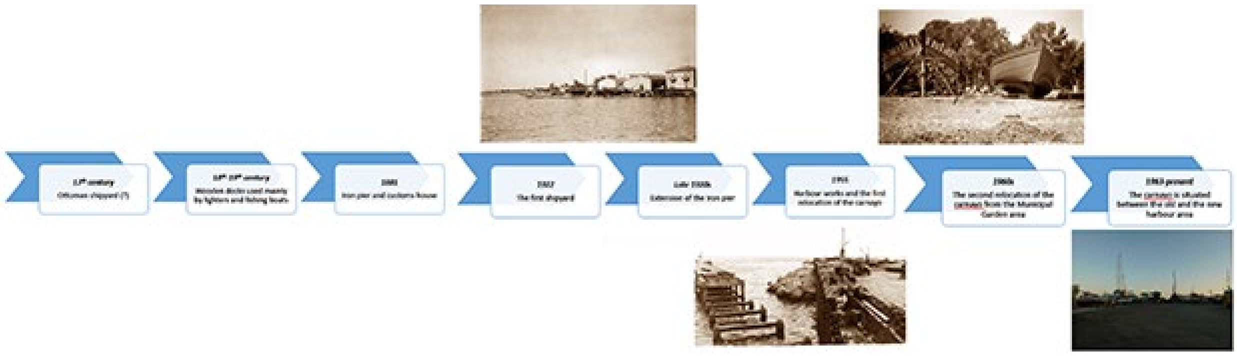

Figure 3. The *carnayo* relocations on a Google Earth interface (© author).

historical sources and the contextualisation of the retrieved data became a positive influence for this project as well. The archival research set the *carnayo* in its historical context, as the information provided background on the origins and development of vernacular shipbuilding during late Ottoman and British Colonial Rule (late 17th–mid-20th centuries). The Cyprus Blue Books were the main source of quantitative data for the years 1886–1946, illustrating that Cypriots had been consistently using wooden vessels. They also provided qualitative data: references to laws and regulations regarding boats, boatmen, wharf fees, and insight into the harbour works. The PMMHAL photograph collections illuminated the processes described in official, dry language or the press of the time. The photographs quickly became instrumental in understanding the landscape changes and how a shipbuilding crew worked.

c) Recording the vernacular shipbuilding tradition

The author benefited from Damianidis' (1998) and Dervenis' (1999) works on vernacular shipbuilding in Greece as well as Ionas' (2001) work on traditional crafts in Cyprus. A series of forms was created and used during fieldwork: 1) shipyard recording form, 2) shipwright's personal data form, 3) shipbuilding tools form (there are eight tool categories based on Damianidis approach), 4) vessel design and construction form. Apart from the forms, the author photographed the premises of each shipyard, vessel drawings and the tools. The amount of information dictated the creation of a relational database as described below.

d) The vernacular shipbuilding tradition database

The author designed and implemented a relational database using MS Access. The purpose was to digitise the collected data and use them more effectively for future research. The forms described above are connected with the use of common fields such as the shipyard or the shipwright's name. A new data card was introduced in order to record other maritime professions (e.g. sponge diving) mentioned in the interviews or documented during the archival research. The card contains the source of information, description of the source, accuracy level, personal data (if available), and has a section associated with personal or local lore. The author decided to include a final data card concerning the association of shipbuilding and other woodcrafts, as there were strong indications of such a relationship. Once the author completes recording shipwrights,[2] it will be possible to accurately portray the craft for all Cyprus. This process will be then repeated for other maritime professions (e.g. sponge diving) aiming to produce a succinct overview of IMCH in Cyprus.

e) Assessing this specific maritime landscape within the coastal urban nexus

The historical data offered insight on the establishment and relocations of the *carnayo* through time, which were further enhanced by the three generations of shipwrights who participated and recalled these events vividly (Avgousti, C. 2016; Avgousti, G. 2016; Mpillis, L. 2016). Fortunately, these events had been documented by various Limassolians with numerous photos, which give information on the coastal landscape evolution and aspects of the maritime community daily life and habits (e.g. shipbuilding, fishing, seaborne trade, festivals). The coastal landscape changes were further documented with photos taken in 2016. The author juxtaposed these with photos dated from the 1950s, 1960s and 1970s to establish the landscape changes at the former and current *carnayo* locations (Figure 2).

f) Identifying the problems to propose solutions

The shipwrights highlighted the problems and challenges they have been facing for more than two decades. The Limassol Municipality has an ongoing aim to revitalise previously neglected districts such

[2] The author has recorded all data concerning Greek and Greek Cypriot shipbuilders, and is currently working on the respective data for the Turkish Cypriots.

as the Actaeon Road area, where the current *carnayo* installations are situated (Fileleftheros 1991: 22; Fileleftheros 1998: 25; Iasonos 2002: 23–24; Iasonos 2004: 3; Iasonos 2006: 5). As previously mentioned, the shipwrights modified the *carnayo* beach to meet the requirements for their work. In discussing a possible fourth relocation, they emphasised the lack of another place along the coastline that meets all those requirements resulting in practical problems (Avgousti, C. 2016; Avgousti, G. 2016; Mpillis, L. 2016).

Results and interpretation

Human interaction with the environment results in the creation of representations relevant to the historical context under examination that influence culture and identity (Foucault 2002: 7–9; McHoul and Grace 1993: 4). According to Hall (2001: 50–52), in relation to maritime environments, such representations within the cultural and historical nexus of the community constitute 'aquatic culture', a viewpoint of the environment in the broader aquatic setting and an ongoing evolutionary process. The term 'aquatic culture', however, appears to be very specific, while one may argue that the landscape itself transcends such a restricted location (Head 2000: 14; Wagstaff 1987: 39). From the early 20th century onwards, archaeologists have tried to understand and interpret phenomena like urbanism and population changes using various methodological approaches. Bintliff (1999: 21–34) has argued that landscape archaeology provides the best approach for performing such analyses while Westerdahl (1992: 5) established the notion of the *maritime cultural landscape*. His seminal work was fundamental in the inception of this particular project, as it includes close-ranging and far-ranging activities, maritime history and ethnography (Westerdhal 2011: 736). The variability of elements ultimately extends maritime archaeology beyond vessels to include tangible and intangible heritage (Flatman 2011: 312–13; Ford 2011: 5–6). Westerdahl's theory has broadened maritime archaeologists' perspectives and influenced studies of traditional shipbuilding in becoming more interdisciplinary (Pham 2015; 2016: 38–39).

Agius *et al.* (2016) demonstrate how recollections form an integral part of the maritime cultural landscape and aid in the reconstruction of the shipbuilding community's identity. This approach provided the basis for recording the oral tradition, which is entwined with shipbuilding in Cyprus. The author noted that boats themselves do not hold any religious importance unlike the Patia fishing boats at Orissa (Blue *et al*. 1997: 201–05), yet Orthodox shipwrights diachronically venerate St Nicholas, the protector of all mariners, and wish him to grant their vessels durability and longevity (Avgousti, G. 2016; Mpillis, L. 2016). The memories of Limassol shipwrights focused rather on the migration of the *carnayo* from one area to another (collective memory) and the migration of a shipwright from one place to another due to work obligations (personal and family history). It is interesting to note that the personal and family history forms part of the collective memory, as all shipwrights face common struggles (Avgousti, C. 2016; Avgousti, G. 2016; Mpillis, L. 2016; Parpour 2018).

The collective memory of this community stretches back to the late 19th–early 20th century. Local shipwrights worked side-by-side with others from Symi and Asia Minor who chose Limassol as their new home: the Constantinou family came originally from Antalya, the Fytos family from Asia Minor, the Moraris and Mpillis families from Symi, the Avgousti family from Limassol, and the Parpour family moved from Limassol to Lebanon and then Paphos (Avgousti, C. 2016; Avgousti, G. 2016; Charalambous 2008: 31; Mpillis, L. 2016; Parpour 2018). This resulted in the transmission of shipbuilding techniques from Greece and Asia Minor to Cyprus. These were successfully integrated into local tradition (Avgousti, C. 2016; Mpillis, L. 2016). The integration positively improved shipbuilding techniques and, during the documentation of shipbuilding tools, it became apparent that the nomenclature used was a mix of Cypriot and Symian terms (Avgousti, C. 2016; Avgousti, G. 2016; Mpillis, L. 2016). The transmission of ideas, techniques, tool types and names was further corroborated by Damianidis (1998). The documentation of the shipbuilding process based on models, finished and unfinished vessels, drawings and videos of shipwrights at work enhanced our understanding of this creative exchange of ideas that has matured since the early 20th century (Figures 4–5). The chain of technology transfer comprises of intangible elements (technical knowledge, personal recollections about the shipwright's experience, lore regarding vessels), which are expressed and materialised in the wooden vessels.

When studying the available data previously described, it appears that Cypriot vernacular shipbuilding suffered much less than in other places, such as its counterpart in North Wales. McElvogue (2000: 7, 13) stresses the scarcity of historical sources and documentary records dating to before the 19th century, ultimately preventing him from gaining a coherent understanding of boatbuilding in North Wales. This led him to apply a different methodology, focusing on the construction technology of five vessels in the care of the University of Wales Bangor. The recording and reconstruction of the logboats provided comparative data which served as chronological indicators providing evidence on slate quarrying from the 16th to the 19th centuries and on shipping, and greatly contributing to local maritime history (McElvogue 2000: 13–14, 16, 80–82, 180–185, 251–262).

Figure 4. Shipbuilding in the 1960s (Pattichion Municipal Museum and Historical Archive of Limassol).

Figure 5. Shipbuilding in 2016, *Gregoris & Nikos Avgoustis Shipyard* (© author).

When comparing McElvogue's (2000) work to Damianidis' (1998), as they both studied construction technology in their respective works, it appears that the sheer volume of material prevented Damianidis from dedicating a bigger section of his book to the subject. The value of such a study is highlighted by Pham (2016: 59–110) who addressed the contribution of construction technology in the vernacular shipbuilding of Vietnam. She notes the influence of local geography on maritime routes and navigation, discussing how this affected boatbuilding and understanding the maritime cultural landscape (Pham 2016: 437–512, 515–19). Her approach would benefit the future study of coastal trade in Cyprus particularly when knowing that coastal trading had been practiced during the Ottoman period with 36 anchorages fulfilling that purpose at least since the 19th century (Luke 1921: 179–80). Nonetheless, it is clear that a future study of construction technology should form a standalone project.

Chivers (2017: xii–xiii) used construction technology to trace the lineage of Shetland boats and test the hypothesis that they were a unique Shetland product and not of Nordic descent. The combination of material evidence with linguistic evidence, oral testimonies, documentary and historic images (Chivers 2017: 31–34) resembles the approach followed in this paper and the future work planned. The boats selected as representative samples were compared to examples from western Norway and Faroe (Chivers 2017: 35–6). The comparison was chronologically extended using archaeological radiocarbon dated evidence to cal.850–960 CE (Chivers 2017: 53). It is interesting to note that similarly chronologically extended approaches have been employed by Selvakumar (2011) on Kerala, and Mishra (2000) on Orissa, both aiming to trace ancient boatbuilding through ethnographic study of traditional boatbuilding. The success of such an approach lies with the available data potentially leading to such a reconstruction. The present study has already produced sufficient results to pursue this aspect in the future, however, it is necessary first to create a corpus of: a) craftsmen who were active in Cyprus; b) the surviving vessels; c) conduct further research on the chain of technology transfer; and, d) compare the Cypriot vessels to potential counterparts (at this stage, Greek and Ottoman).

The *carnayo* is the only vernacular shipbuilding hub in Limassol preserving a unique element of IMCH. During the realisation of the project, several problems emerged: a) inadequate documentation and study of the craft; b) loss of oral history and culture, and, c) the difficult task of preserving a dying craft. All three problems create a vicious circle, starting from the fact that old shipwrights are dying out and no new ones are taking their place. All shipwrights stressed in their interviews the difficulties of learning the craft: one should start at a young age, it is a long learning process, it is an arduous craft, while nowadays the profits are significantly less when compared to the expenses of building a wooden vessel. The craft started suffering in the late 1980s when cheaper materials such as fiberglass were introduced, accompanied by cheaper labour available in other countries (Mpillis, N. 2016; Avgousti, N. 2016). This was translated into a smaller work cycle, less profits and lower salaries, which are all far from being incentives to take up the craft. One should further note that there are currently only three families of active shipwrights at Limassol, totalling just six craftsmen who can be considered 'masters', and can transmit such expert knowledge to young apprentices. Given the current fragile nature of vernacular shipbuilding in Limassol, the systematic documentation that has been carried out by the author halted any further loss of oral history and intangible maritime cultural elements. However, this cannot reverse the fact that there is no younger generation of shipwrights.

Discussion

The author was able to compile an initial list of shipwrights and specialised caulkers who had been active in Limassol from the late 19th century onwards. This was accomplished through personal interviews and archival research, and had not been attempted before the present study. Thirty-two shipbuilders and two caulkers were recorded, however, data from the Deputy Ministry of Shipping is expected to raise these figures once a review of the respective archival material is completed.

Shipwrights formed an integral part of the mariners' community as they provided them with the vessels to conduct their daily business and had relationships with fishermen, lighter captains, lighter owners and collaborated with mariners coming from different countries. Akif and Akif (2009: 106–107) illustrate such interactions wonderfully, noting that Turkish mariners left Crete in 1898 once it stopped being part of the Ottoman Empire, and moved to Limassol. Ahmet Çavuş, a seaman from Crete, played a key role in establishing lighter transport at Limassol harbour and owned three vessels. Akif and Akif (2009: 109) note that the collaboration between Greek Cypriot and Turkish Cypriot lighter owners led them to form a coalition just after the establishment of the Lighter Transport Company (LTC). These events demonstrate how the sea became their bond, transcending their livelihood as they fought for the common good.

One could say that local history and lore permeate the planks of each vessel built at Limassol, each one having its own background story and association with a shipwright. The vessel is the tangible element that carries with it two centuries of vernacular shipbuilding tradition. Vessels, the product of the craft, are realised through the shipwright, the human medium carrying that tradition and transmitting that immense wealth of knowledge both by building vessels and training future generations. The complexity of a vessel, an artefact to be more precise, reflects the high level of technical skill and conceptualisation needed to complete such a feat (Maarleveld 1995: 3–4). One can argue that this phenomenon is associated with the maritime community and the factors which have shaped it: geographic location, access to resources, easy access to the sea which facilitates the development of shipbuilding, economic cycles of growth and decline affecting the shipbuilding 'market', the manpower fuelling technological developments in the field, and the social and historical conditions creating a favourable environment. All these can be traced within the maritime cultural landscape, demonstrating how intuitive this relationship can be and how IMCH forms part of the landscape. The project results for Limassol were critical in understanding these often subtle processes, while simultaneously creating a solid basis for the planned study of Cypriot shipbuilding in its entirety.

Current trends promote the harmonious coexistence of humans and their environment, so as to preserve natural and cultural heritage, which shapes the character of an area especially for harbour zones where human interaction with the sea is a vital element (Vergi and Georgi 2013: 1957–58). The Limassol Municipality endorses the harmonious coexistence with the environment and has initiated a series of actions related to urban development, ensuring that sustainability is a principal element in such projects (Gerasimou and Georghoudis 2011: 109–16). Their endorsement is also expressed in the 2013 collaboration with Frederick University (Nicosia) to run the Sustainable Design in Coastal Areas (SUDESCO) intensive training programme. The programme focused on understanding the complexity of coastal landscapes and achieving sustainable urban development (environmental, economic and social). The *carnayo* area was the chosen field for investigation where the students had the opportunity to explore the regeneration options to enhance the coastal and industrial heritage of Limassol (Frederick University 2013: 1–2, 8–9).

Changes to the urban development and landscape, albeit sustainable, have affected the shipbuilding community significantly. The UNESCO 1989 Recommendation on the Safeguarding of Traditional Culture and Folklore and the 2003 Convention explicitly assert the fragility of such traditional crafts and the danger of permanent loss. The PMMHAL has noted the danger of losing cultural heritage elements and initiated several actions to curtail any additional loss (Sophocleous 2016). In 2008, the PMMHAL collaborated with Chios Prefectural Authority to promote maritime cultural heritage through an EU-funded project, the 'Interreg IIIA Greece-Cyprus 2000–2006'. The project presented aspects of vernacular shipbuilding in Chios and Limassol, in symposia and a website (Chios Prefectural Authority and Limassol Municipality 2008) dedicated to the subject. The Chios-Lemesos Maritime Heritage Site gives the public areas a concise overview of vernacular shipbuilding in both towns with short descriptions of shipbuilding techniques, the tools used, a section that explains shipbuilding terminology and archival photos. The project promoted the vernacular shipbuilding of two distinct areas to a wide audience in Greece and Cyprus, a significant step in heritage protection. It is important to note that the project was the starting point for the PMMHAL to create the necessary infrastructure that has allowed it since to become a key player in local heritage protection (Sophocleous 2016).

After this initial step, the PMMHAL expanded its actions further and became involved in the rescue of *Lambousa*, a traditional wooden fishing vessel, operating in Cypriot waters since the 1950s, and restored by the Mpillis family of shipwrights. *Lambousa* plays a key role in the PMMHAL educational lectures and programmes. This particular initiative focuses on Limassol's maritime character and the aspects of its relationship with the sea. The coastal landscape, docks and jetties, the carnayo, mariners, local history and oral traditions are only some of the topics covered by the PMMHAL staff at such events. The PMMHAL organises educational programmes for both children and adults and all lectures are open to the public (Sophocleous 2016). In both cases, the main focus is to develop the participants' affinity with the sea, offering an ideal setting for nurturing the budding local maritime consciousness.

Several countries have taken protective measures regarding their vernacular shipbuilding. These can be divided into two groups based on their overall aims: a) the preservation of surviving traditions; and b) the promotion of surviving traditions. One could argue that museums serve a dual purpose: the museum adapts and evolves to protect and promote cultural heritage, which reflects the current trends in museology. Maritime museums across the globe provide heritage management examples that range from the presentation of a shipwreck or vessel to the public, to educational programmes for all ages. Cyprus has only one maritime museum, the Agia Napa Municipal Museum Thalassa, with diverse collections and ship replicas such as the Kyrenia II and the papyrella. The absence of a national framework for safeguarding and promoting maritime heritage could be rectified with the creation of a second museum, in Limassol. Taking the present project results into consideration, the new museum could focus on IMCH and vernacular

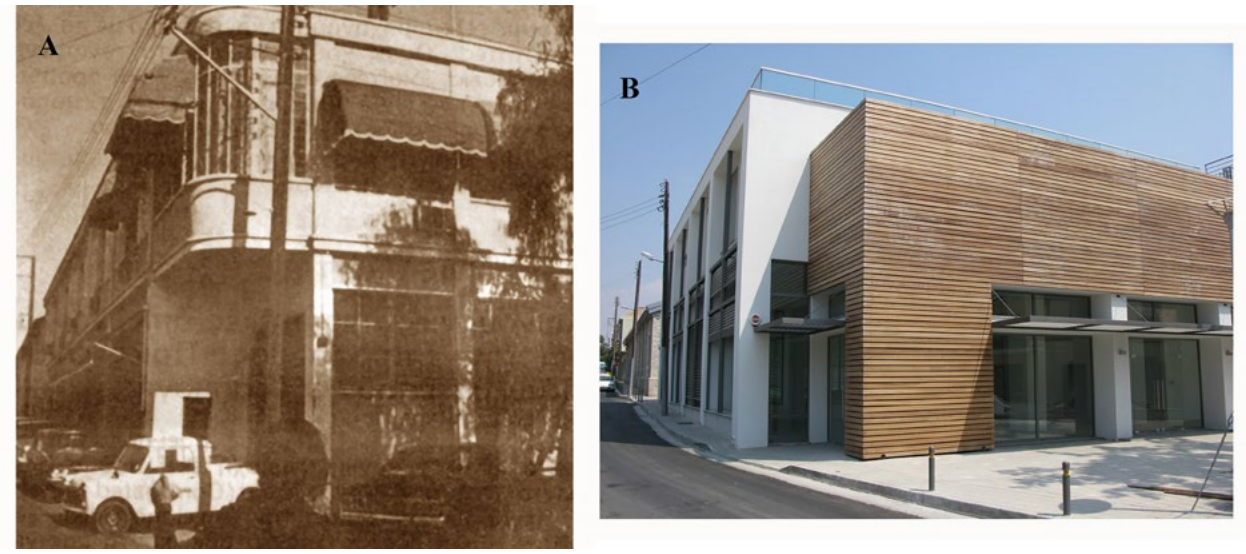

Figure 6a–b (L–R). The Kouvas Lithographers building turned into Limassol's Municipal Cultural Centre 'Panos Solomonides' (Pattichion Municipal Museum and Historical Archive of Limassol).

shipbuilding in particular. To further enhance this effort, the authorities could consider the option of hosting the museum in a preserved industrial building. Museology shares a strong connection with Industrial Heritage Management, as old industrial buildings have been reused as museums and Limassol has examples of industrial buildings being repurposed (Sophocleous 2016) (Figure 6a–b). In such cases, two approaches exist: either focus on the historical and archaeological value of the building, which carries culture into the future, or, the industrial buildings and landscapes can be reused and take up a new economical and socio-cultural role (Karavasili and Mikelakis 2001: 46–55). The reuse of an industrial building would help the public embrace local history and enhance the learning experience of any future educational activities. Depending on the building, an area could be dedicated to shipbuilding, and a shipbuilder could demonstrate the building process of a small vessel as part of a museum tour or an educational programme.

There is a long tradition of educational institutions that have included in their curricula actions related to the promotion of ICH especially for children. Pioneer educators embraced and introduced oral history in education after participating in community-oriented oral history programmes. It later became apparent that similar programmes for adults should be developed, as they had been cut off from their roots and there was a profound loss of knowledge that failed to be transferred to future generations. The 1972 Convention refers to the involvement with traditional activities that can lead adults to embrace and actively participate in their culture (Neuenschwander 1976: 8).

During the First International Conference on Adult Education in 1949, the influential role of adult education in the development of society was recognised. Twenty-five years later, the 1976 Nairobi Recommendation on the Development of Adult Education noted adult education as a central element of a country's educational system under the lifelong learning scheme. Adult learning has evolved significantly and it is acknowledged that it is pivotal in individual, communal or societal transformation. Despite the wide range of interpretation on the nature and character of adult education, it has clearly evolved from *education* into *learning*, a conceptual change in the field (UNESCO 2009: 12).

Cyprus established a lifelong learning scheme in 1952 called 'Educational Centres' (*Epimorfotika Kentra*). The Centres are coordinated by the Ministry of Education and Culture, and run annual programmes in urban and rural areas. They are the largest programme for general adult education (age 15+) via the lifelong learning scheme, aiming at the multifaceted personal development of individuals, and the socio-economic and cultural progress both of citizens and society (Ministry of Education and Culture 2012). Considering the above, and particularly the outreach of the Centres, the author reviewed their courses to ascertain whether any could be modified to include vernacular shipbuilding in their curricula.

One of the taught subjects is carpentry and woodcarving, a combined theoretical and practical class (Ministry of Education and Culture 2016). The participants attend lectures about the mechanical and chemical properties of wood, selection, cutting and carving methods, the tools used, which are complemented with information regarding woodcarving history in Cyprus. The aim is for the participants to produce their own woodcarving piece, as this is a craft-learning oriented course. It is taught in all major cities and the low cost (€55) facilitates the participation of people from all socio-economic backgrounds. Given the island-wide range of the scheme a new course on vernacular shipbuilding could be implemented with an integrated component on the various difficulties and threats to IMCH. Such a course could alleviate the stress on the craft, as shipbuilders would practice their craft across the island, creating bridges of communication between themselves and the public. The teaching language of the course should be considered too, as a course offered in English would give foreigners the opportunity to participate and embrace both the craft itself and the Cypriot IMCH. Once the public is engaged in such a process, it is easier to foster a culture of safeguarding, promoting, and preserving IMCH for the future.

The persisting problem of the diminishing numbers of vernacular shipwrights is more complex. A similar problem was observed in the case of Lefkara embroiderers, craftswomen of another dying art with roots reaching back to the Middle Ages, and a registered element in the Representative List of UNESCO since 2009 (Ktori 2017a: 79). The Ministry of Agriculture, Rural Development and Environment (MoARDE) collaborated with Lefkara Municipality and offered a Vocational Scheme dedicated to Lefkara embroidery. The programme ran in 2010–12 with beginner and advanced learning classes, and participants who were under 40 were entitled to a daily stipend of €18. The classes were taught by old craftswomen aiming to transfer their knowledge and create a new nucleus of embroiderers to preserve the craft. Despite the brief life of the scheme due to financial constraints, the stakeholders observed positive results and the craft was further promoted to the public (Xenophontos 2016). Ktori (2017a: 84) argues that had the programme continued and the new embroiderers further supported, it may have fulfilled its aim. Therefore, the possibility of establishing a vocational scheme for vernacular shipbuilding is certainly worth examining in the future.

Conclusion

Cypriot shipbuilding had been a *terra incognita* until this project got underway. It quickly became evident that the author needed to push the boundaries beyond a mere description of vernacular shipbuilding typology and repurpose this useful tool (Maarleveld 1995: 6). Typology became a stepping-stone to addressing and contextualising historical data about Cypriot shipbuilding during the Ottoman period (1570/1–1878), the British Administration Rule (1878–1959) and the Cyprus Republic period (1960–present).

The abundant data allowed targeted, in-depth research into shipbuilding at Limassol. The longevity of the craft is attested in a variety of sources and demonstrated its current fragility: the complexity and arduous process of learning, the low income when practising it, and unfavourable socio-economic factors, have all damaged shipbuilding to almost the same extent. The author opted to document the craft and use the data in structuring a potential way of preserving the craft while assessing available infrastructure and programmes previously conducted in Cyprus. It was clear that educational programmes and lectures are successful and should be additionally enhanced to reflect the character and value of IMCH. Both Limassol Municipality and the PMMHAL have been involved in the preservation and promotion of the local maritime heritage, and actively seek such opportunities on a national and European level. The idea of adult learning and vocational schemes through the Educational Centres and the MoARDE were also considered, as there are substantial data to confirm that such options should be explored and established.

The information that became available from this project should of course be shared with the public. Several ideas were considered before deciding on the creation of an interactive website dedicated to IMCH to be the chosen medium, to increase engagement between locals and their heritage (Ktori 2017b). The website provides information on local maritime history, vernacular shipbuilding in Cyprus from the late 19th century, and an overview of the shipbuilding process. These are complemented with archival material such as photos and newspaper articles. The public can also use the information form to submit any other data they have regarding IMCH. All the data are stored in a database to be used for further analysis.

The author has also acknowledged the importance of a full documentation of the craft and the opportunities this offers: compilation of a list of professionals involved in shipbuilding as well as mariners is near completion. This will be juxtaposed with the known anchorages of the last 200 years to assess emerging patterns and understand better the mechanisms behind the chain of technology transfer and the reason(s) shipbuilding developed in a certain area. The proposed actions mostly focus on the promotion of vernacular shipbuilding while some have a strong safeguarding element. However, the most pressing matter that should be resolved on a governmental level is that Cyprus clearly needs a new nucleus of vernacular shipwrights. It is hoped that firm steps will be taken in this direction towards preserving our living heritage.[3]

[3] As this paper went to production in 2019, the local authorities made the decision to relocate the Limassol *carnayo* to the village of Moni. Unfortunately, this effectively ends a 200-year-tradition at Limassol. It is hoped that transplanting the shipbuilding community will be successful, as the next few years will be crucial.

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Forty Years (and More) Since the Colston Symposium: An Archaeologist's View

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Abstract

In the 1960s–1970s archaeologists working on coastal sites became increasingly aware of the significance of the debate among geomorphologists about relative sea level change. For the author, the Colston Symposium of 1971 (published in 1973) was a key moment: he tried to evaluate the archaeological evidence for sea level change, during the Holocene. We realised that archaeologists could provide useful indicators of earlier sea levels for geomorphologists, and vice versa. Both sides also had to learn that unanimity of interpretation did not exist.

This paper discusses the various types of archaeological indicators, referring to a number of sites which the author has studied; it describes some lessons which he has learned, and mentions some points of caution. Finally, it looks at the great contribution which geoarchaeology is making to the study of ancient harbours, which had not been imagined, at least by archaeologists, at the time of the Colston Symposium.

Keywords

Sea level indicators, ancient harbours, slipways, geoarchaeology, catastrophism

In the 1960s we had realised that rise (or fall) in Relative Sea Level (RSL) was an important factor at harbour sites; but, also that it was not just a question of *sea-level* rise (or fall). Some relative submergence seemed to be due to subsidence (for example, the breakwater at Phaselis, Figure 1), and how could one explain the submergence of one of the harbour breakwaters at Knidos, and not the other? (Figure 2). By the time of the Colston Symposium (held in Bristol in April 1971)[1] we had studied some harbour sites with German colleagues Jörg Schäfer and Helmut Schläger and discussed the question with geologists such as Nic Flemming and Dietrich Hafemann (see e.g. 1965); and had corresponded with Air Force General Giulio Schmiedt (1964; 1972), who had moved from interpretation of aerial photographs to an interest in SL changes in recent historical times.

At the Symposium we discussed some types of archaeological feature, which can serve as indicators of RSL change, such as mooring-stones (e.g. at Teos [Figure 3] and Leptis Magna), which may be more reliable indicators than the surface of the quay itself: was it stepped? Did it slope? (For once we have the aid of an artistic representation—the famous Torlonia Relief,

Figure 1. Phaselis: west breakwater (© author).

Figure 4). The question also arose whether construction could have taken place underwater, for example with the use of hydraulic concrete (*pozzolana*). There was discussion also of slipways, fish-tanks and channels, which would only function with a precise water level, e.g. sluice-gates at Cosa and Sidon (Blackman 1973b). On the subject of slipways, further explanations are provided below.

Flemming discussed a number of sites in the Aegean with Sea Level Indicators (Flemming *et al.* 1973; see Blackman 2005a). We also learnt about 'deltaic

[1] Blackman 1973a: The Proceedings of the Twenty-third Symposium of the Colston Research Society. The name of Edward Colston, now very controversial because of his involvement in the slave trade, was chosen by a group of Bristol citizens when in 1899 they founded a society to support the young and struggling University College, ten years before the institution of the University of Bristol. Since 1948 it has promoted an annual symposium. Four participants in the Symposium were present in Fremantle at IKUWA6, 45 years later: Jeremy Green (who spoke on his underwater survey of Cape Andreas, Cyprus in 1969–70); Patrick Baker and Brian Richards, who had both been photographers in the Cape Andreas team; and David Blackman.

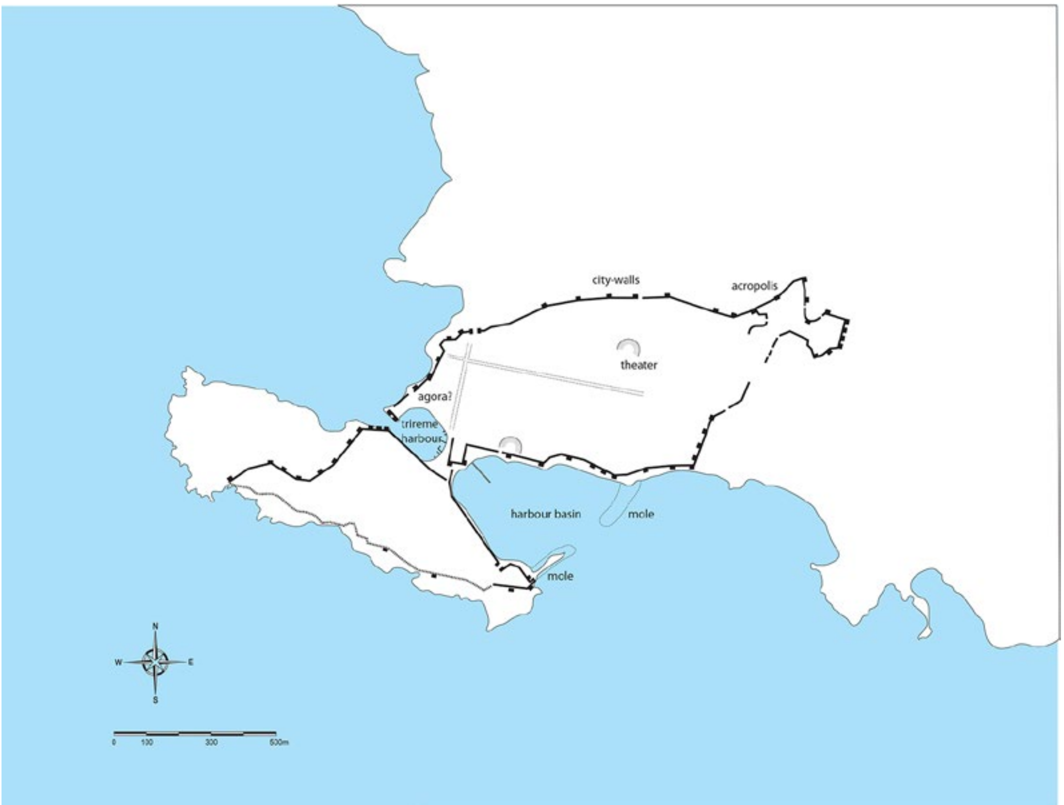

Figure 2. Cnidus: plan (Baika in Blackman, Rankov *et al.* 2013: fig. A11.4) (© author).

Figure 3. Teos: main quay with mooring-stones (© author).

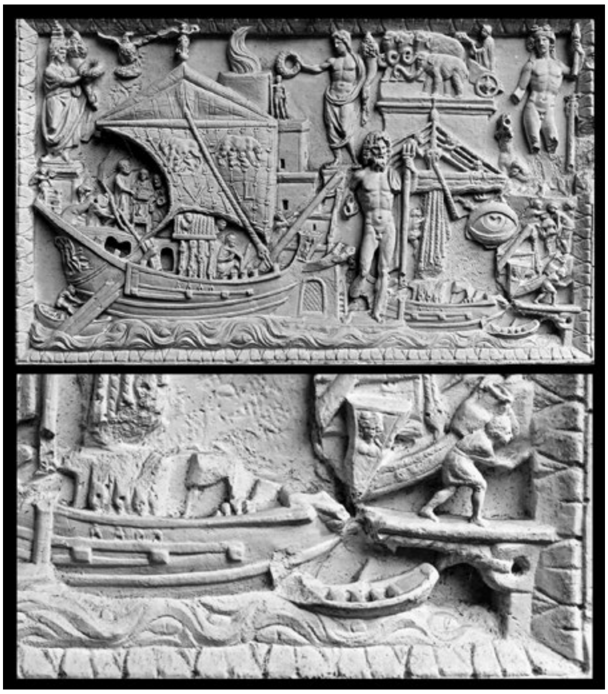

Figure 4. Torlonia Relief, with detail (Torlonia Museum, Gabinetto Fotografico Nazionale).

impaction' and 'isostatic recovery'; later about the 'reservoir effect' (Higham 1999). What is important to stress more than 40 years later is that in coastal sites we may have *datable* biological SLIs on archaeological features, which may themselves be *closely datable*. This can provide solid reassurance.

[On SLIs we look forward to the forthcoming book by Niki Evelpidou, Paolo Pirazzoli and Anna Karkani].

We realised then the value of co-operation between archaeologists and geologists, but also came to realise that perhaps we expected too much of each other (Blackman 2005a). Geologists have to realise the limitations of archaeological evidence, while archaeologists have to realise that the phenomena studied by geologists may be local and complicated! Also that there will be disagreements among geologists, as there are among archaeologists. A good example is Kition.[2]

A fine recent example of disagreement relates to the Sicilian Channel between Sicily and Tunisia, close to Pantelleria. Some banks, which now lie submerged, may just have emerged during and after the Last Glacial Maximum, around 19,000 years BP. On one of these banks, the Pantelleria Vecchia Bank, geologists have discovered ridges which they think were human-made, enclosing an embayment, and within this a 12m-long monolith (which they also claim to be human-made), now lying at a depth of 40m (Figure 5; Lodolo and Ben-Avraham 2015). They extrapolate a date from the local sea level curve; conclude inundation at 9350+/−200 years BP; and, argue that this proves significant human maritime activity in this region in the Mesolithic!

This is a dramatic conclusion, which is hotly contested by two other geologists and a prehistorian, who claim that the monolith is natural; that dating from sea level curves is dubious at this early period; that the Sicilian Channel is much less stable than areas to the north; and, that evidence for megalithic cultures belongs 5 millennia or more later. They reasonably comment that discussion with prehistorians before publication would have been sensible (Tusa *et al.* forthcoming).

You can read this battle for yourselves. Not a geologist, I incline to agree with the doubters.

The arguments on the tilting of the island of Crete go back to the mid-19th century, with Raulin and Spratt. The uplift of the western end of the island is clear—and most scholars attribute it to the 'Early Byzantine Tectonic Paroxysm'—but there is some argument about the date: most accept AD 365, but some want a somewhat later date.[3] The puzzle remains at a harbour midway along the south coast at Matala (Gerding in Blackman, Rankov *et al.* 2013: 389–92). Farther east at Lasaia, just east of Fair Havens, researchers in 1971 saw evidence of only a slight rise in RSL, but they had no permit for diving (Blackman and Branigan 1975: 28 and fig.7; plate 9.2–3); Theotokis Theodoulou sent to the author a Google map showing a submerged line off Trafos Island (Figure 6). Is it ancient? Theotokis will, I hope, investigate, and perhaps alter earlier conclusions. There has been modern construction in the Bay of Fair Havens, nearby, which would have had a lateral effect on the coastline. A cautionary conclusion: as was the case at Apollonia, remember that later visitors may see things that you didn't!

On the east coast of Crete, the picture is not yet clear about tilting. We need more study of the reported evidence of submergence from sites such as Palaikastro. We do have minimal evidence from a slipway site at Siteia (Trypiti) (Baika in Blackman, Rankov *et al.* 2013: 518–24); and even possible Minoan slipways[?] at Gournia in a very exposed position (Blackman 2011a).

Slipways were an important feature of ancient military harbours, and can be important SLIs, if properly studied and understood. For certain evaluations, one needs to know the original length of the slipway. (This includes an assumption about the submerged length at the foot; we had assumed *c.* 80cm minimum, but naval architects have said that it is not necessary at all!). For Naxos (Figure 7) two alternative explanations were given, since the lower part of the slips has been lost; this necessitated theoretical (if plausible) extrapolations; ancient sea level 2.05m above the present if the slipways were 42m long, and 1.84m if they were 44m long.[4]

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[2] Baika in Blackman, Rankov *et al.* 2013: fig. A11.9: 'Different hypothetical reconstructions of the ancient coastline and harbour basin based on recent geophysical surveys undertaken by various teams' (after Marriner and Morhange 2007: fig. 22 amended). As an archaeologist one cannot expect to follow geological debates in detail nor even to understand them all; but it is useful to know what the battlefields are. Recently, one was offered complimentary access to the latest thematic issue from *Geological Magazine* on 'Tectonic evolution and mechanics of basement-involved fold-and-thrust belts'. Thus one learns that there is a challenge to the assumption that deformation is entirely thin-skinned and decoupled from the basement.

[3] For the majority view: Pirazzoli 1986. See now Price *et al.* 2002 on the effect of recent changes in the calibration of radiocarbon (14C) dates on their assessment of the changes of RSL in Southern and Western Crete (see bibliography there). They prefer a date in the fifth or sixth century AD (c. 480–500), and argue that the tectonic uplift was not necessarily associated with a catastrophic earthquake. See also Flemming and Pirazzoli 1981; and Blackman's earlier discussion (2005a); but he now (2011a) accepts the Minoan shipsheds at Kommos.

[4] Geologists assume an uplift of the land of 130m in this area during the last 125,000 years—an average of 1.04m per 1000 years: Bordoni and Valensise 1998. See Blackman 2005a: 68; Lentini and Blackman with Pakkanen in Blackman and Rankov *et al.* 2013: 395–96 and references there.

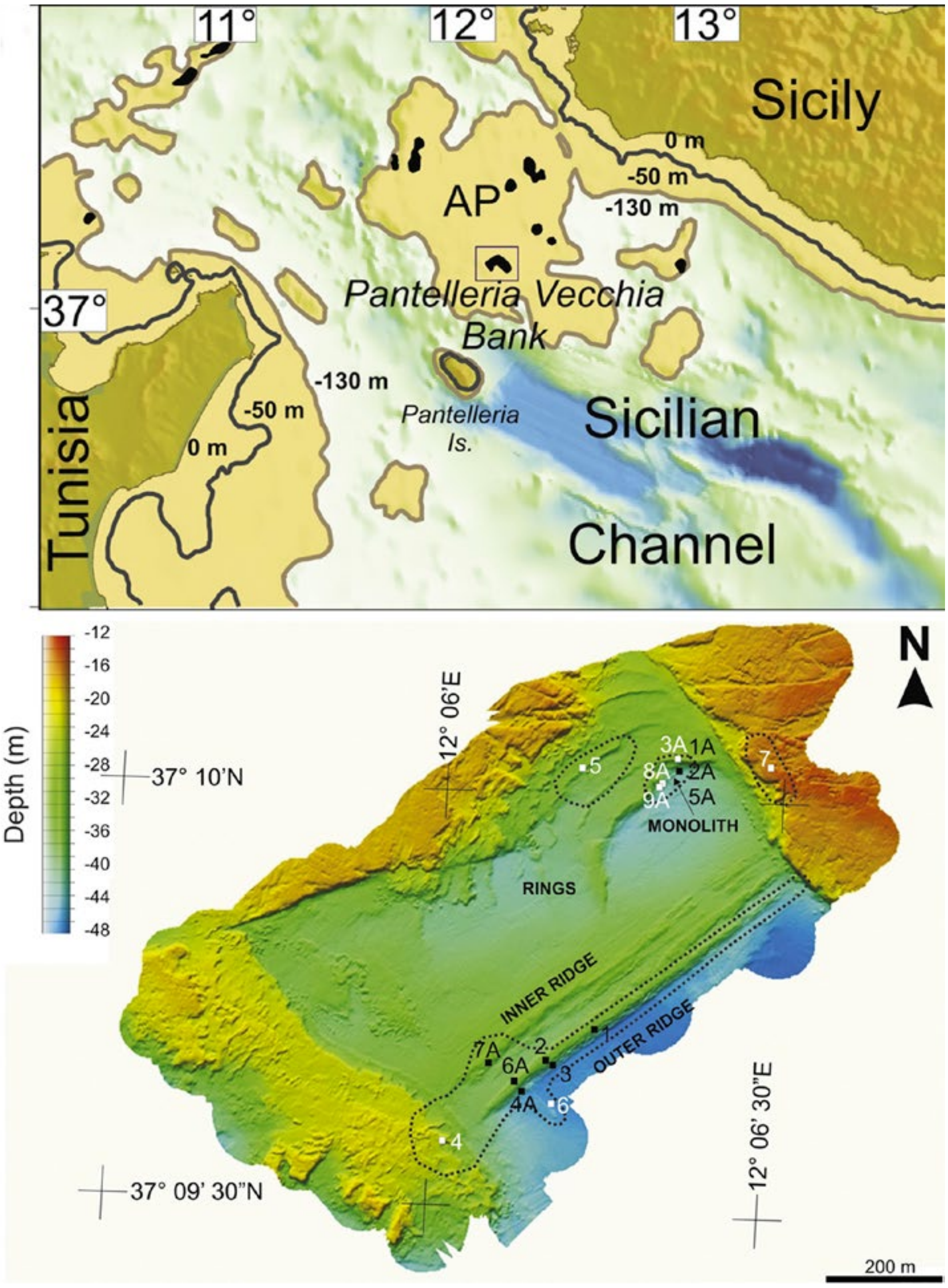

Figure 5. Sicilian Channel: map and underwater plan (Lodolo and Ben-Avraham 2015: figs 1b, 2).

At Rhodes even less material evidence was available—just the top end of a few slips—and the excavation records were lost in the last war.[5] The evidence for submergence was in fact the evidence of human reaction to change. Blocks were added to the surviving side walls of the ramps, so (after digging a small trial trench) it was concluded that there had been a human reaction to submergence of the shoreline as a result of the historically attested earthquake of 227/6 (which, as we know from Polybios, damaged the shipsheds); the reaction seems to post-date 150 BC, which is curious. Then a major uplift some 300 years later led to the abandonment of the military harbour, which by then had lost its purpose (Figure 8; Stiros and Blackman 2014). Where the lower end of the shipsheds probably *has* been defined is at Oiniadai. There the 'entrance' is clear. At Ca'n Picafort on Mallorca the situation is not absolutely clear; at Tersane Bay in Lycia we have only the (just submerged) *top* of the slips.[6] At Rhamnous we have not been able to test by excavation our hypothesis for the location of the slipways, for which our evidence

[5] Perhaps not totally: there is more to say on this.

[6] Blackman, Rankov *et al.* 2013: 410–19 (Gerding), 557–61 and 563–64 (Blackman); for Ca'n Picafort, see now Blackman and Cau 2016.

Figure 6. Lasaia and Trafos Island (Google map 22/07/2015).

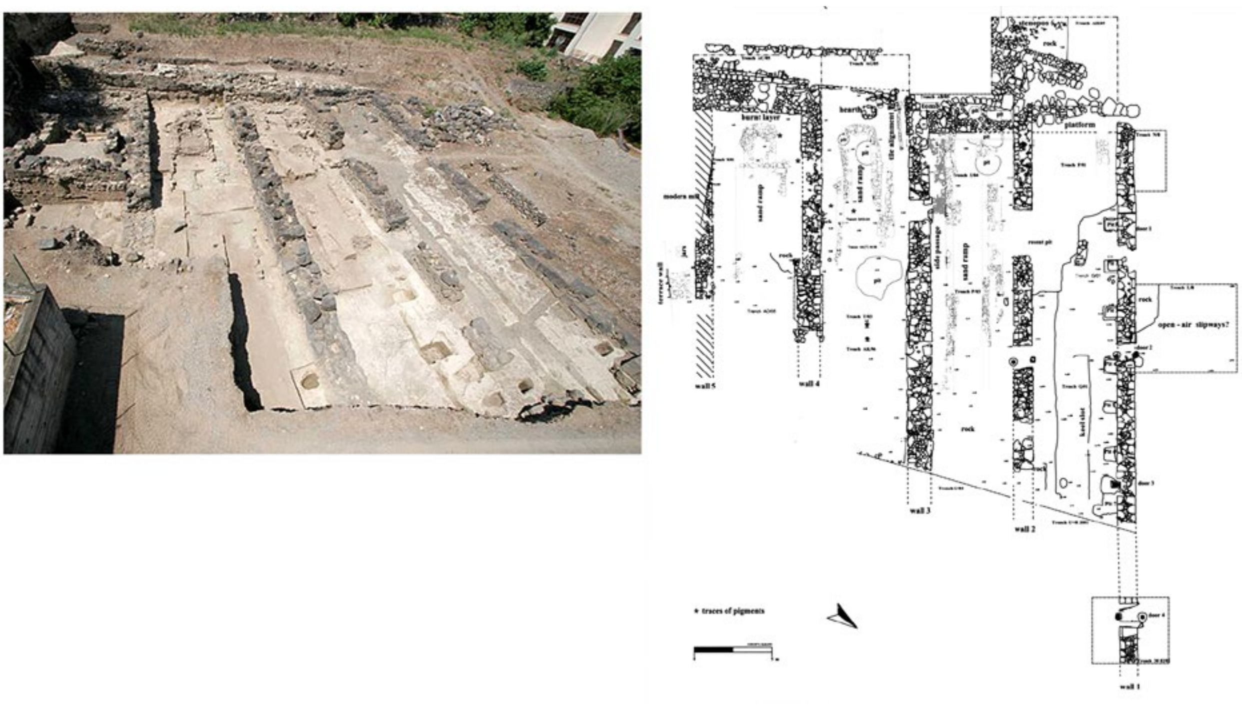

Figure 7. Naxos shipsheds: view and plan (© author).

is a clear reference to 'ship storage' in an inscription found on site.[7] We proposed a test trench at the foot of the slope in the west corner of the west harbour (Figure 9; Blackman 2005b: 1–2 and fig.1), above and on the line of the geological trench 'West 2'. This position, protected from the North wind, seemed to us the likeliest location for a small group of shipsheds.

This was one of our modest proposals for trial trenches to try to answer some questions raised by our survey. In the east harbour we proposed a test trench at the west end of geological trench E1, where the trench was

[7] The survey was carried out under the aegis of the Archaeological Society of Athens and the direction of Dr Vasileios Petrakos, excavator of the site. Preliminary reports by Blackman appeared in the *Praktika* of the Society from 2003 to 2011. Sadly, the financial situation after 2009 made it impossible to carry out the proposed test excavation. The final multi-authored reports will appear in the Society's journal, the *Archaiologiki Ephemeris* (on the historical evidence and the archaeological work on land), and will be submitted to the *IJNA* (on the underwater work, and the geological and maritime survey).

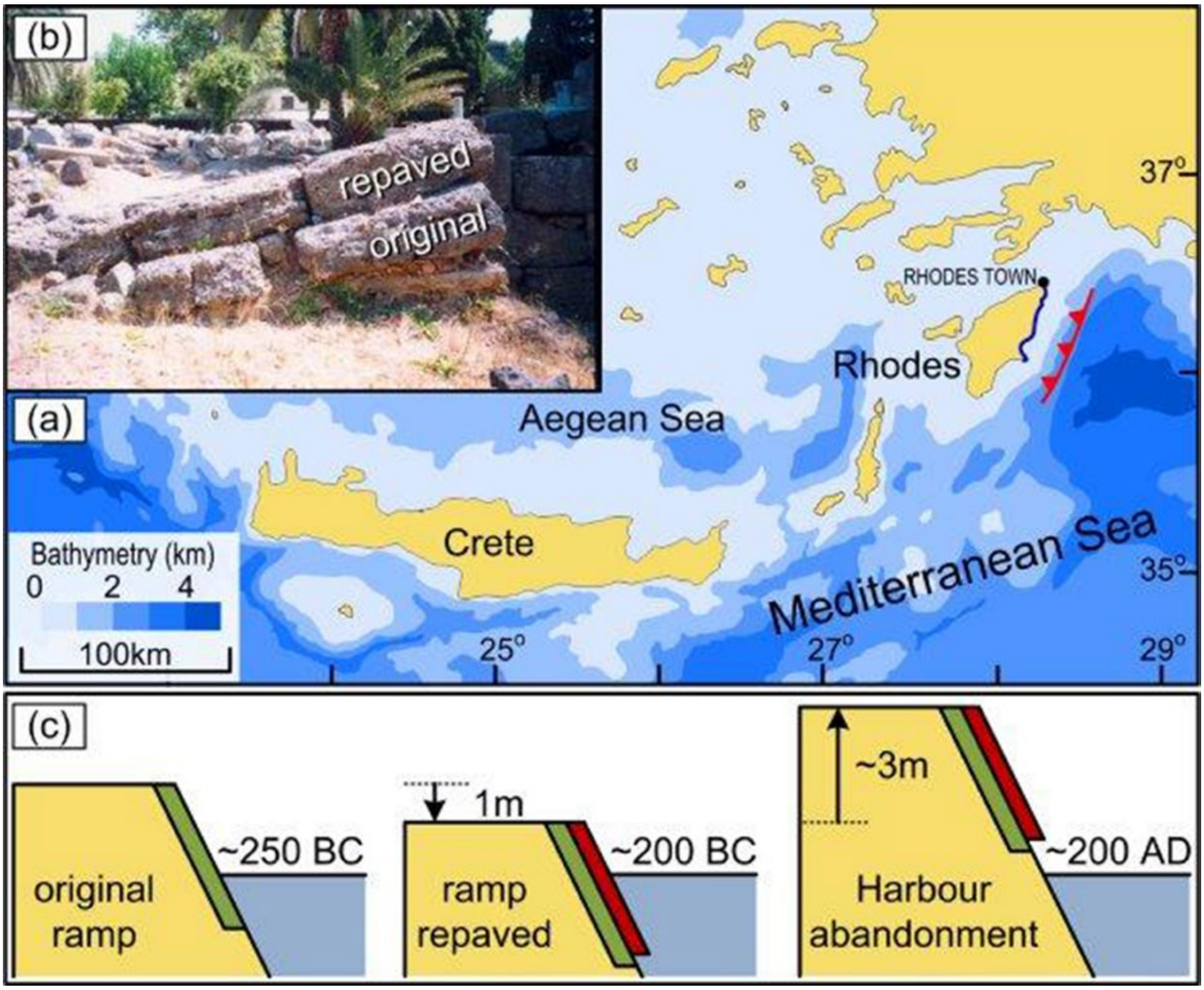

Figure 8. Rhodes shipsheds: Stiros and Blackman presentation (© authors).

stopped because of the appearance of archaeological stratigraphy. The purpose was to define the west edge of the harbour basin: a beach or a quay? (Figure 10; Blackman 2005b: 8 and fig.3). To the north of this we proposed a north/south trench across the line of the beach and the beach rock, in order to ascertain whether an east/west mole ran across to the tower and mole at the harbour entrance, to protect the harbour basin from the north wind and powerful seas, of which the team had considerable experience during its work at the site since 2003 (Blackman 2005b: 7–9 and fig.3). Beach rock is a tough problem, in every sense. We gather that it is also difficult to date: or see for example Fouache *et al.* 2005.

A final, cautionary tale from Rhamnous: samples from our 'geological trenches' in the west harbour produced very satisfactory results: 2521+/−24 BP (= 471 BC) for a shell sample from the ancient harbour floor; and 2218+/−25 BP (= 168 BC) for a shell sample from an upper level (not necessarily the latest), that would indicate use of the harbour from the Greek victory over the Persians to the Roman conquest of Greece (Blackman 2011b: 2). So it was necessary to cross-check with some samples from the east harbour but, here, most results were 'out of the frame' and only one result was at all satisfactory, with a date of 2183+/−24 BP (= *c.* 233 BC). However, we agree with the suggestion of Dr Petrakos, excavator of the site, that there may have been contamination by run-off from the spoil-heaps from his excavations in the fortress above. So here is another reason for caution. I can now add a further reason for caution: the possibility that Radiocarbon dates will be re-calibrated. The results given above, published in our 2011 report, must now be ignored; and we are now studying the re-calibrated results, which take into account the 'reservoir effect' (for samples that grew in the ocean).[8]

[8] The original results, received from the Oxford Laboratory for Archaeology and the History of Art, were published in Blackman 2011b: 1–2; the assessment of the re-calibrated results, also received

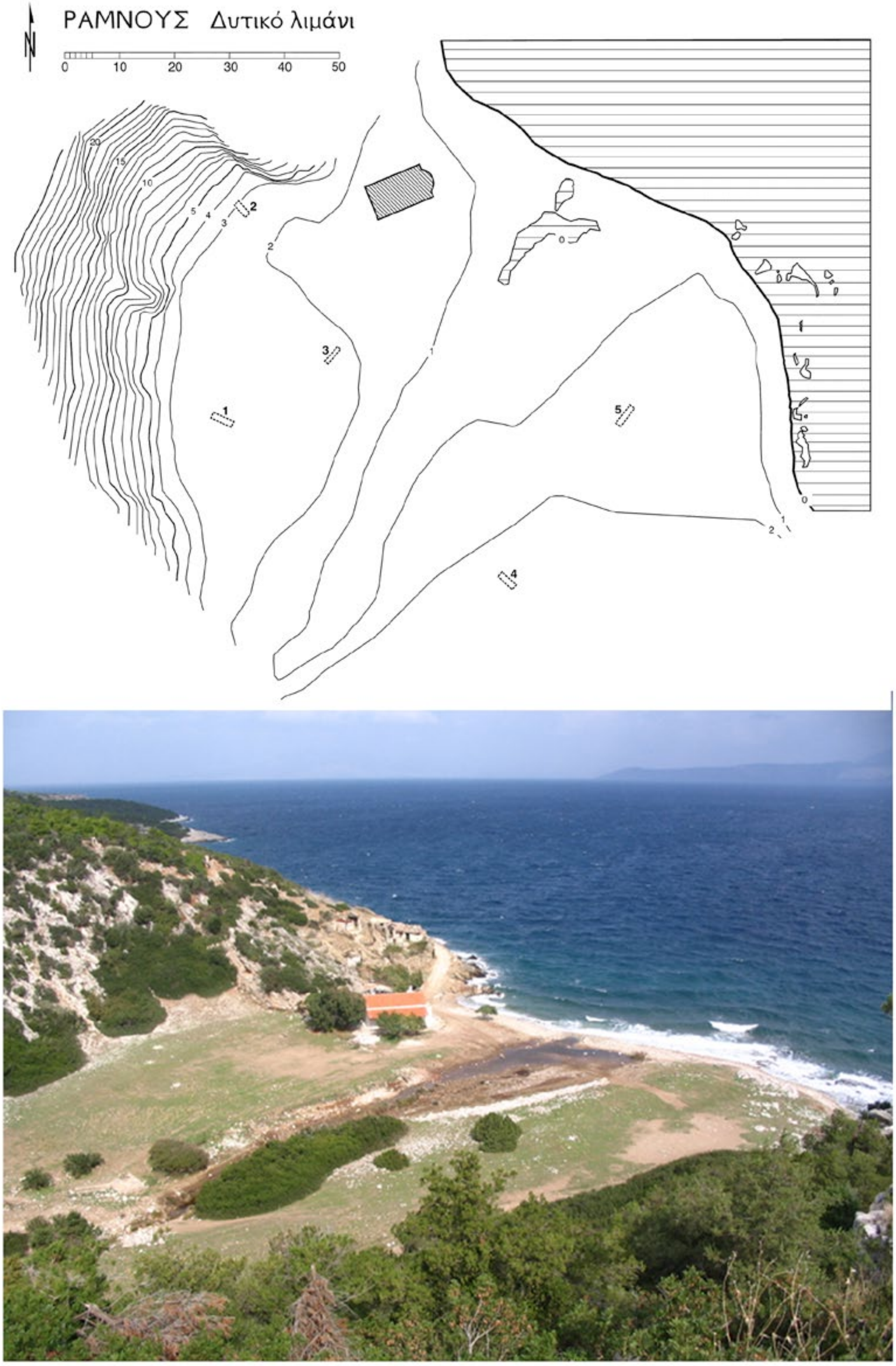

Figure 9. Rhamnous, west harbour: plan and view (© author).

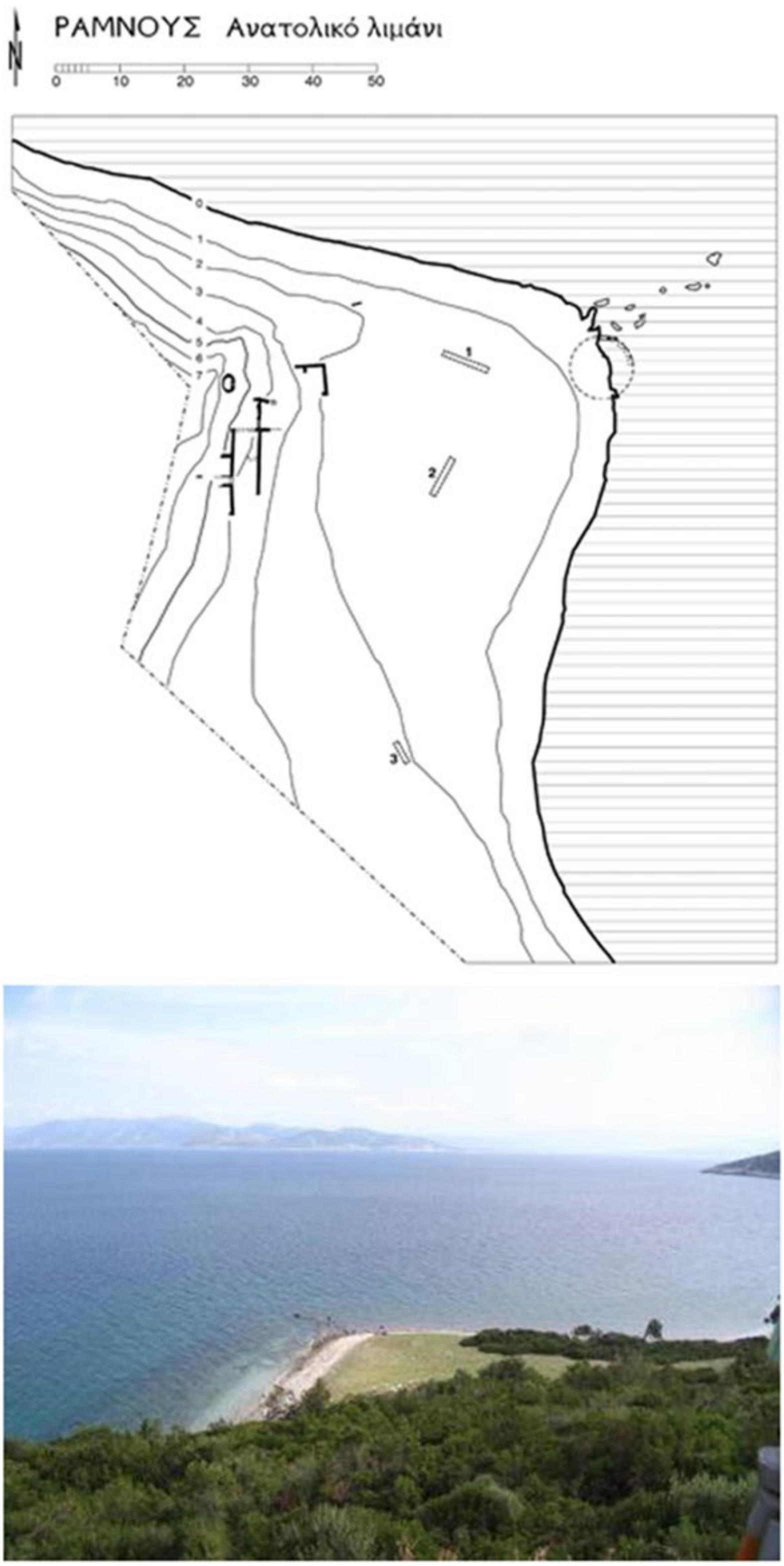

Figure 10. Rhamnous, east harbour: plan and view (© author).

The argument that one should not *over*-estimate RSL rise, and *under*-estimate the effect of compaction is an important one to keep in mind, including queries about the effect of dredging—'what would have been the effect of dredging in or near harbours, on the nearby shoreline?' This is an obvious point, which is not stated often enough. A wreck in a harbour basin defines the harbour floor at the time of sinking (allowing for it to have sunk into sediment).

It is clear from the studies of Morhange and Marriner (e.g. 2010) that dredging can affect conclusions from palaeoenvironmental studies exclusively based on biofacies chronostratigraphy. Furthermore, even if this can provide the physical context for an archaeological site, the archaeologists will still have to interpret it. What types of structures were used to protect the harbour basin? There is no substitute for real excavation (Morhange, Marriner *et al.* 2014: 711–12). This is the problem that we have with our unfinished work at Rhamnous.

Evidence for ancient dredging has been a highlight of the excavations on the shoreline of ancient Neapolis (modern Naples). Construction of the new underground *Metropolitana* with Line 1 along the coast, with shafts at the future stations and a major crossing of two lines under the Piazza Municipio beside the Castel Nuovo, has added much to our knowledge of the harbours of the Greek colony and the later city.

Earlier in the excavation, attention had centred on the northern part of the ancient harbour, with the remains of three shipwrecks and the timber piles of a mole of the late 1st, and another of the 2nd century AD (Giampaola and Carsana 2007; 2010). Now excavation under the Piazza Municipio has revealed further evidence of dredging, and other interesting features, which have not yet been published.[9]

Humans must have reacted to natural disasters in antiquity with horror, fear being aggravated by ignorance of the causes, though we can tell from Strabo, for example, that speculation was rife. He has a long discussion on the causes of changes in sea level and mentions a flood that he witnessed himself (1.3.4–20). The dramatic account by a late Roman historian Ammianus Marcellinus (26.10.16) of the earthquake and tsunami of 21 July AD 365 is a striking read. Most discussion of this passage by historians has concentrated on how other sources for this event (mostly Christian) interpreted it as a universal cataclysm, which was a divine response to contemporary political events (what is called 'providentialism'). Ammianus certainly *did* regard the event as an omen for the disastrous defeat of the Roman army at Adrianople in AD 378.[10] However, it remains a vivid description of a tsunami: he recounts the drawing back of the sea and its violent return—and he specifically mentions its effect at Alexandria and at Methone in Laconia. Whether it was the same event that caused the tectonic uplift in western Crete is still in debate.[11]

The natural effect of such catastrophes is clear, and it influences academic debate. Our French colleagues have addressed this recently in a reaction against the return of 'catastrophism' in studies of sites all over the Eastern Mediterranean—Helike, Santorini and Crete, the Nile Delta, Caesarea, and more. They warn that in the world after the tsunami caused by the Sumatra earthquake of 2004, or the Fukushima disaster of 2011, 'researchers are exploiting irrational social fears of natural and technological disasters underpinned by media sensationalism' and they speak of 'an intellectual dispute overshadowed by the battle for supremacy between academic disciplines and bibliometric competition.' (Morhange, Marriner *et al.* 2014: 715ff.).[12]

The important question for us is: what was the practical human reaction to catastrophic events in terms of repair and preventive measures? This is a matter of interest to us in the modern world. We have observed the proceedings of a working group on this subject at Ravello.[13]

Concluding on a more positive note, we now have the prospect of combining (fairly datable) archaeological evidence from coastal sites and increasingly precisely datable techniques such as lead isotope analysis. This,

from the Oxford Laboratory, will be published in the article to be submitted to IJNA. For the 'reservoir effect' see Higham 1999.

9 I have recently visited the excavation and discussed the results with the excavators. I suggested that there may have been a Hellenistic predecessor to the Roman breakwater which they have found and which protected the harbour from the south-east (but also probably caused the increased siltation and necessitated the dredging). Cores have been taken in the harbour area, but the archaeologists claim that their knowledge of the pottery sequences at this site provides more precise dating than Carbon 14! This will not always be the case. For the latest publication on the ancient harbour see Di Donato *et al.* 2018.

10 For Ammianus see Kelly 2004; the tsunami may well have been interpreted as a metaphor for the barbarian attacks of the period – or as an omen. The Roman Emperor Valens was defeated at Adrianople on 9 August 378, by an army of Goths and others; this defeat is considered to have led ultimately to the fall of the Western Roman Empire in the fifth century, though the Eastern Empire survived as the Byzantine Empire.

11 For a recent view see the discussion of radiocarbon dates from Sphakia and Western Crete, and the effect on human populations, by Simon Price and colleagues in Price *et al.* 2002: an excellent example of the value of inter-disciplinary co-operation. For the Atalanti region see Buck and Stewart 2000.

12 On the last point, and in a positive way, we remember the excitement among the publishers of the *International Journal of Nautical Archaeology* at the amazing bibliometrics of the article on the Oman shipwreck, a Portuguese ship from Vasco da Gama's second voyage to India! See Mearns *et al.* 2016.

13 At the European University Centre for the Cultural Heritage, within the framework of the 'Major Risks' programme. One learns to deal with jargon, for example 'seismic retro-fitting'.

from the study of sediment pollution can indicate human activities in the past, and also help us to define the development of ancient maritime sites, and activities in them. We could not imagine some of these techniques in 1971; but now we can exploit them to refine our study of human history—which is what archaeology is all about.

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Tallinn Harbour from the Middle Ages: Studies of the Former and Current Seabed

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Abstract

Today, Tallinn Old City Harbour is one of the most actively developed areas in Tallinn. New buildings are being built and, for that reason, extensive excavations are carried out to expand and increase the capacity of the harbour area to provide a service for an increasing number of cruise ships.

After the excavations of two medieval shipwrecks in Kadriorg in 2015, the authorities have started to set archaeology-related preconditions for excavations planned in the historical harbour area. One of the preconditions is carrying out a ground-penetrating radar survey. Studies of historical maps of the harbour, geological surveys and existing wreck finds are taken as the basis for setting the conditions. In this way, it is possible, to some extent, to prevent the removal of wrecks from their original location. Long-term preservation of excavated wrecks is problematic due to their size. The preservation of excavated wrecks is a great challenge, and the main solution should not be the documentation of archaeological excavations.

This article addresses the development of Tallinn Old City Harbour and its research challenges that are affected by the modern city landscape and a port with increasing ship traffic.

Keywords

Tallinn Old City Harbour, harbour archaeology, preserving shipwrecks *in situ*, ground-penetrating radar survey

Introduction

The Old City Harbour on the south coast of Tallinn Bay is Estonia's largest port, where significant development activities are carried out. These developments pose a great threat to the preservation of the cultural layer connected to the medieval and early modern harbour. Large areas are excavated down to the natural soil layers or even deeper, in order to lay foundations for buildings, to establish underground car parks, or for conducting piling works. Unfortunately, the historical harbour area is not under state protection as an archaeological monument, with the result that only a few archaeological excavations have taken place and these have not produced a lot of archaeological data. It is only in recent years that the excavation operations conducted in the harbour area have been set with archaeology-related preconditions according to the Heritage Conservation Act § 40 (5):

An immovable which, according to information held by the National Heritage Board of Estonia, may yield a hitherto unknown finding of cultural value shall be studied before the commencement of work. The study shall be conducted at the expense of the applicant for the permit.

At the same time it is not certain that all excavation operations on an area of interest will be brought to the attention of the relevant authorities for coordinating and setting of relevant conditions.

In order to add substance to the paragraph that requires surveys, the National Heritage Board ordered a programme of research work from the company, OÜ Agu EMS. The aim of the research was to connect a selection of the best-preserved historical maps reflecting the harbour's history in the course of the last four centuries, to present-day city maps. The original copies of the 12 maps from the period 1634–*c.* 1930 are located in Swedish, Estonian and Russian archives. The aim was to locate the most interesting areas from an archaeological point of view and the progression of the shoreline before possible future construction works (Nurk 2012: 88).

In addition, between 2012 and 2013, at the request of Estonian National Heritage Board, OÜ Agu EMS connected the geological boreholes of Old City Harbour to the present-day map. The aim was to reconstruct, on the basis of data from geotechnical boreholes, the natural topography and progression of the shoreline during various periods in the area where the Old City Harbour was located historically. Another aim was to select other archaeologically interesting information from geotechnical reports that could indicate a cultural layer which merited excavation, or wrecks or other harbour constructions that are buried in the soil.

Figure 1. Painting by Aivazovski, 1845, depicting a stormy sea at Tallinn. https://et.m.wikipedia.org/wiki/Fail:Aivazovsky_-_Reval_1845.jpg.

Conclusions on how the results of the works can be used can probably be made in the course of the next ten years on the basis of archaeological surveys.

In addition to the archaeological and geoarchaeological surveys, the issue of long-term preservation of excavated wrecks must also be addressed in the context of harbour archaeology. A historical harbour is usually not treated just as a facility, but rather as a broader functional system that also includes infrastructure on land (barns, pubs, etc.)—and presumably is also closely connected to the outskirts of the town. Nevertheless, remains of shipwrecks, the most significant features of archaeological cultural layer of harbours from different periods, are most commonly associated with harbour archaeology (see Lemée 2006; Milne 2006).

Tallinn Bay and port

Tallinn Bay is located on the southern coast of the Gulf of Finland. The bay covers an area of approximately 250m^2. It is well protected from winds, located between the peninsulas of Viimsi and Suurupi, and the islands of Naissaar and Aegna. Tallinn Bay is completely open to northern winds that usually generate higher waves in the bay. The speed of the strongest northern and NNW winds may reach 21–23 m/s once in 50 years. Strong and lasting eastern winds are also likely to occur (Keevallik 2003: 214; Soomere and Keevallik 2003: 87–89).

Tallinn Bay is one the deepest bays of Estonian coastal waters. The maximum depth is about 90m. At the same time there are many shoals that pose a threat to ships: Naissaar Shoal (depth in places 3–4m), Keskmadal Shoal (7.4m), Vahemadal Shoal (3.8m), Hülkari Shoal and Littegrund Shoal.

The first written notes about the construction of Tallinn Harbour are from the 14th century (Bunge 1855: 99) and since that time the harbour has most likely been located at approximately the same location, gradually moving further from the old town and covering new areas of the sea. Archaeologically, the most interesting areas are the harbour and areas located to the east of it.

Tallinn Old City Harbour and shipwrecks

The main archaeological finds in the harbour area have been shipwrecks. Throughout time approximately 30 shipwrecks have been found. There is very little information known about most of them, just a mention of a discovered wreck. Sometimes a short description or a conclusion about the ship's origin has been added (Rummel 1892: 77–78).

The known wrecks of Tallinn Old City Harbour are mostly located at the harbour aquatory, and an area to the east of the harbour. It is known from written sources that strong autumn storms washed ships to shore in that particular area (Figure 1). In September 1602, a storm (Müller 2008: 247) crushed not only the ships and boats that were sailing or tied up in the harbour, but also the harbour piers and coastal dwellings behind the city walls. The remains were most likely tossed towards the coast of Kadriorg.

Earlier excavated wrecks

There are many notifications of wrecks found in previous centuries, but only a few of them have been more thoroughly investigated. Pieces from the wreck, circumstances of discovery, finds, and the destination of the wreck have been more thoroughly researched on two occasions.

The first larger-scale excavations of wrecks in the Tallinn Old City Harbour were carried out in 1881, when the excavation works of the new harbour basin were taking place. A total of nine wrecks were unearthed from a depth of approximately 1m beneath the present ground level to a depth of 4m. One wreck was interpreted to be the Swedish warship *Draken* lost in a storm in 1609. The approximate length of the wreck was 26m, width 8m and height 4m. There were coins and other items found by the wreck that confirmed its identification (Amelung 1884: 73–79). In addition to the wreck of the frigate *Draken*, the remains of eight ships dated to the 18th century were excavated but, unfortunately, there are no detailed descriptions about those finds as they were considered to be uninteresting (Amelung 1884: 79–80).

The alleged wreck of *Draken* was recycled. For example, the wood from the wreck was used for floor parquet material and for building furniture. The items found from the wreck either disappeared, were sold for scrap metal or were distributed among the workers. Some items apparently reached collectors (Amelung 1884: 81). One of the finds was a cask containing Estonian butter that had been so well preserved that the workers ate it immediately (Amelung 1884: 79).

Secondly, in 1934, the wreck of an 18th-century Russian warship was excavated. The length of the wreck was 52m, width 9m and height 2.5m. The ship's bottom was lifted and since it was a rarity, it was put on display for a wider audience. The wreck was extremely popular and while it was on show people took pieces of it with them as souvenirs (Postimees 1934). Some of the pieces and items from the wreck were handed over to the Estonian Maritime Museum for preservation. The items included part of the keelson with frames, a piece of outer planking with a bronze cover, three copper fixing bolts, 11 cannon balls, incendiary and handgun ammunition, some copper coins, a brass cross pendant and three uniform buttons (Mei 1938: 61–63).

The wrecks of Tallinn Old City Harbour's aquatory

At the end of 2006 a shipwreck was found during the reconstruction of the 1st quay in the Tallinn Old City Harbour. This late 18th-century warship was lifted and documented in May 2007. Approximately 40 extremely fragmentary pieces of the shipwreck were salvaged. It was decided not to preserve the lifted wreck, and to give the pieces to the Information Centre for Sustainable Renovation, who tried to find solutions for recycling them.

During the documentation of the salvaged shipwreck it was determined that another wreck (registration number 30189) is situated at the same location. Since this shipwreck was lying deeper than 9m, and thereby did not hinder the reconstruction work of the quay, the National Heritage Board of Estonia decided to leave the wreck *in situ*, partially under the quay. The wreck is dated from the 2nd half of the 16th century to the 1st half of the 17th century (Tln 3278: figs 2 and 3). Due to increased traffic in Tallinn Port, more and more shipwrecks have been revealed both in the aquatory and in its immediate proximity.

The measurements and monitoring of the aquatory are conducted on a regular basis and, therefore, it came as a surprise when, during an inspection carried out by Tuukritööde OÜ in 2007, the remains of another wreck (registration number 30190 were located by the 3rd quay (Figure 2). The shipboards reach up 1.8–2m from the bottom. Thanks to the pile of limestone and granite in the centre of the wreck, the ship is securely attached to the bottom. The maximum measurements of the wreck are 23 x 9m and the wreck is most likely from the 19th century. It was decided to initially preserve the wreck *in situ* and conduct annual evaluations of the situation.

Kadriorg wrecks

The sea has been filled for a stretch of approximately 900m to the east of Tallinn Old City Harbour. The most recent larger-scale sea-filling operations took place in 1930s at Kadriorg. There were plans to establish a showground by the seaside in Kadriorg. According to an agreement between the Tallinn City Administration and the North Factory of Paper and Wooden Cardboard, the latter began to carry coal ash from the factory to the site, in order to fill the area. A modern newspaper described the area as being smelly and bog-like (Vaba Maa 1936: 9). Today, the ash, construction waste and household waste form a 4m-thick filling layer under which the two historical wrecks were revealed in 2015,

Figure 2. Map of Tallinn Old Harbour area (Estonian Land Board, Maili Roio).

when the construction of new apartment buildings was started (Figure 2).

Before the archaeological surveys, the ground was levelled off to the depth of the wrecks and then investigated using ground-penetrating radar to determine their measurements. The archaeological excavations of wrecks organised by the Estonian National Heritage Board took place in a relatively limited time-frame and with even more limited preparation time, in the course of salvage excavations. It was decided that both wrecks were to be preserved: wreck Viljo was placed under water in Tallinn Bay (Figure 4) and wreck Peeter is waiting to be conserved and exhibited at the Estonian Maritime Museum.

The construction of wreck Viljo took place soon after AD 1487 according to dendrochronological studies. As the tree-ring series of the wreck appeared most similar with Estonian pine chronology, we may assume that the pines for that ship were grown in the region of Estonia. The artefactual material from that wreck was too scarce to establish a possible time of wreckage (Roio *et al.* 2016: 141–42).

The wreck Peeter, preserved with more find material, was built after AD 1296 (Figure 5). Similarity between the tree-ring series and the East Pomeranian oak chronology gives us a basis for assuming that the oaks used to build this ship were grown in eastern Poland or even further east. It is difficult to establish when the ship went aground but the preliminary study of pottery suggests the second quarter of 14th century (Roio *et al.* 2016: 143–46).

Ground-penetrating radar surveys of the Old Harbour territory in 2016

By connecting the map of Tallinn Old City Harbour from 1825 to the present-day map, a shipwreck was located in the research area (registration number 30943). In 2016, ground-penetrating radar surveys were conducted in connection with harbour development activities, in order to determine the existence and exact position of the wreck. The geo-radar surveys confirmed the existence of the wreck and it turned out to be quite large, a 40m warship. The pieces of the wreck closest to the surface are at a depth of approximately 1.5m in moist soil. In addition, a small test trench was made at the spot where the signal was strongest. The aim was to get final confirmation about the existence of the wreck and the possibility of evaluating its condition.

With this case it was possible to change the planning conditions so that there will be no structures on top of or in close proximity to the wreck site. Also the water

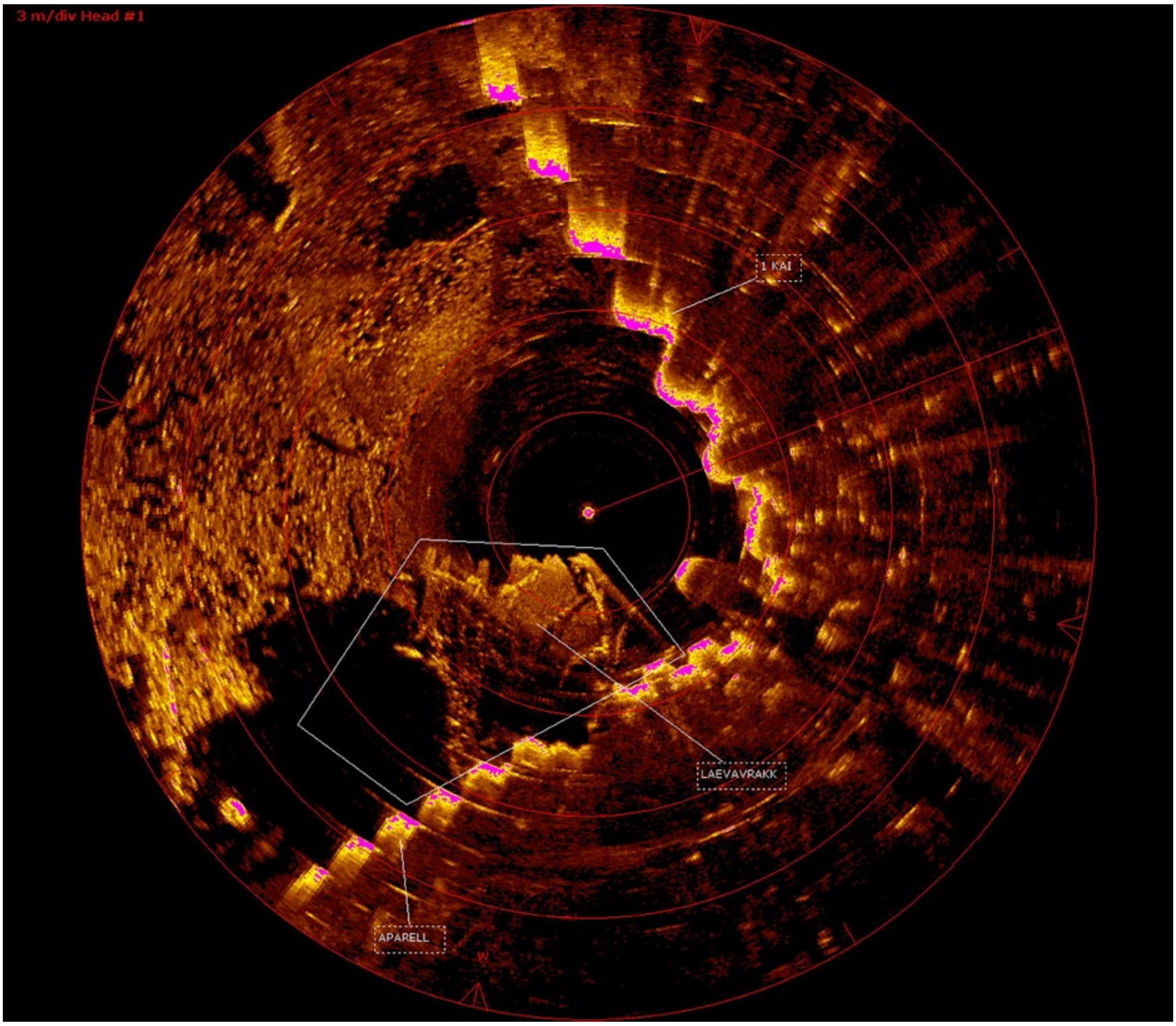

Figure 3. Sonar image of shipwreck, registration number 30189, within Tallinn Old City Harbour (Tuukritööde OÜ).

regime will not change and possibilities for further surveys remain because no new buildings are planned for the area. So the wreck has an opportunity to be preserved for a long time.

Conservation of shipwrecks in situ

According to the European Convention on the Protection of Archaeological Heritage, a State that has acceded to the Convention (in Estonia the Convention came into effect on 1 June 2002) must undertake to implement measures for the physical protection of the archaeological heritage, including for the conservation and maintenance of the archaeological heritage, preferably *in situ* (Article 4).

The wrecks discovered within historical harbour areas and on former seabeds have usually been situated in a favourable environment for hundreds of years. Every new activity planned in the harbour area may entail changes in the environmental conditions that may not be suitable for the long-term maintenance of shipwrecks. Conservation of shipwrecks *in situ* is the primary option, but if there are new buildings constructed at the wreck site, then long-term conservation and further research is very problematic. Therefore, it is very important to learn about the monitoring results of the Roman boat that was preserved at its original location under the new cancer centre of Guys Hospital in London. This is the first case of *in situ* conservation where a corridor was left below ground to the site of the supported wreck, in case it becomes necessary to access the boat for excavation. A monitoring system was installed for the boat (Sidell and Panter 2016: 267–72).

In addition to the wreck site that was confirmed at Tallinn Old City Harbour in 2016 (registration number 30943), there is another wreck that has remained at its

Figure 4. Sinking the wreck Viljo into Tallinn Bay (Maili Roio).

Figure 5. View of the pit of the wreck Peeter. In addition to the sheet pile wall, a well-point dewatering system was installed to enable archaeological excavations below sea level (Maili Roio).

original location near the harbour (registration number 30188). In November 2009, a shipwreck was found in the course of excavation operations at Lootsi Street. Parts of the shipwreck were destroyed. The majority of the wreck is located *in situ* at a depth of 3.3–4m in moist sand. The shipwreck is dated to AD 1210-1280 (Tln 3199). The wreck was found in connection with the establishment of a car park when a water tank was being installed. Sections of the wreck were revealed in the deep hole that had been excavated for the water tank. Unfortunately, the National Heritage Board was informed of the find after the hole had already been filled again, most of the parts of the wreck that were found had been removed and the water tank installed. Therefore, the site was not documented. Five pieces from the wreck have been preserved. They are located at the Estonian Maritime Museum and have been documented by the National Heritage Board.

Therefore, currently, there are four wrecks maintained at their original locations at the Tallinn Old City Harbour area. Two shipwrecks are located on land. The wreck with registration number 30943 is very sensitive to external influences at its location as it is covered only by 1.5m of soil and is in poor condition—the condition of the wreck was determined from a small test pit.

Taking into consideration the good condition of the wood that was lifted, and the depth of the location of the Lootsi Street wreck, we may assume that the environment conditions are favourable for long-term conservation, unless there are large developments that could change the water regime at the location.

The situation is most problematic with the wrecks that are located at the harbour aquatory and next to the piers. Wreck number 30189 is partly located under the pier and wreck number 30190 is located exactly next to the pier. It is likely impossible to consider those locations suitable for long-term preservation. So far, we have not found a solution for the physical protection of the wrecks that would also guarantee the necessary depth of the aquatory and would not jeopardise the ships coming in to dock. Maintaining the wrecks at their original locations without physical interference may call into question the safety of the service that the port is providing. In extreme conditions, pieces may separate from the wrecks and could damage, for example, the propellers of cruise ships.

Preserving excavated shipwrecks

Preserving excavated shipwrecks is problematic due to the size of the wrecks, which complicates their conservation process and identifying storage space suitable for them. Excavating, conserving and storing or exhibiting one shipwreck is much more complicated in comparison to the conservation and storage of other archaeological remains.

As a rule, harbour archaeology involves more than one wreck and, therefore, creating detailed documentation of the wrecks is one solution. After creating proper documentation, the wrecks are not preserved. In the years 1996–1997, eight Renaissance shipwrecks were thoroughly documented in Christianshavn harbour in Copenhagen using the total-station survey method. As no funds could be raised for conservation of the hull sections, most of the timbers were destroyed after 1:10 scale recordings (Lemee 2006: 82–95).

As we are dealing with non-renewable cultural assets, and shipwrecks and their parts are essentially archaeological finds, the State must ensure their conservation and maintenance after removing the finds from their original locations. Considering the volume of conservation work and the time pressure in the case of rescue operations, the aim with the Kadriorg wrecks was to excavate and to relocate the whole of both wrecks. Initially, it was planned that both wrecks would be relocated to the bottom of Tallinn Bay, but in the course of excavations, it was decided that the wreck Peeter would be conserved and exhibited.

The wreck Viljo was relocated to the bottom of Tallinn Bay and was partially covered with sandbags. The need for additional protection measures will be determined during annual monitoring. There are good prerequisites for maintaining wrecks in Tallinn Bay, due to the low salinity in the Gulf of Finland and good preservation conditions of the Baltic Sea. One of the initial tasks of the on-going maritime spatial planning process is to choose areas for preserving wrecks that could be used in the future for long-term maintenance of excavated wrecks.

Conclusion

The Old City Harbour area is one of the most rapidly developing areas in Tallinn. As a result of these operations, new archaeological data has been revealed about the history of Tallinn Old City Harbour. As the Old City Harbour area is not yet under state protection as an archaeological monument, many projects and construction plans are not brought to the attention of the heritage protection authorities.

The harbour area has so far not been studied in a complex manner within any scientific project. All surveys have been linked to single development projects and have been ordered by different companies. Shipwrecks are synonymous with harbour archaeology. There is very little information about the 20 wrecks that have been found in the Old City Harbour area over the centuries.

Only four of the wrecks have been preserved at their original location. Most of the information has reached us in fragments and therefore it is not always possible to be certain that the wrecks were actually removed from their original location.

In situ conservation is possible if surveys are conducted in the course of planning operations. We have started carrying out more ground-penetrating surveys at the Tallinn Old City Harbour area, which are then followed by archaeological pre-studies. At the same time, there may occur situations where it is necessary to conduct wreck excavations.

The conservation and storage of the wrecks after excavation is complicated due to the dimensions of the wrecks. Preserving the wrecks in the Baltic Sea and planning suitable areas for that in the maritime spatial planning process, could be considered as one solution.

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The Maritime Archaeology of Duplex Drive Tanks in the United Kingdom

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Abstract

The catastrophe at Dieppe in 1942, where unsupported infantry attempted to capture a fortified beachhead, showed the allied forces how difficult such a venture was. As part of the invasion plan for what became Operation NEPTUNE or the Normandy landings, the allied staff saw the need for armoured support for the first waves of troops ashore. This need evolved into the concept of 'swimming tanks' that would land a few minutes ahead of the first infantry waves. The development of such a weapon was undertaken in conditions of absolute secrecy in the UK from late 1942 onwards. This secrecy led to the destruction of much of the historical records that relate to these armoured vehicles, leaving a confused and largely unknown record of what was an important aspect of WWII.

This project sets out to record the known examples of such vehicles on the coast of the UK including a group lost as part of 'Exercise SMASH', the largest live ammunition exercise of the war, a full scale beach assault training exercise with all supporting arms including amphibious tanks. Though six tanks were lost during the exercise in conditions, which are not fully understood, the loss led to the changing of the operational plans for D-Day.

Using archaeological and historic data, this project offers an alternative interpretation for these loses and provides a better understanding of their subsequent impact on Operation NEPTUNE.

Keywords

World War II, D-Day, Duplex Drive Tanks, Exercise SMASH

Introduction

In late 1941, following the Japanese attacks on Pearl Harbour, Hitler and Mussolini declared war on the United States (Belcham 1981: 10: Doherty 2011); in response, under Prime Minister Churchill and President Roosevelt, the American and British forces formed an alliance. Although differences arose in their ideas, their defining decision was the large scaled assault of Europe to defeat Germany, launched from the British coast when the time was right (Belcham 1981: 10; Doherty 2011). The British Combined Services Committee (BCSC) was formed to study methods of gaining access to Europe, as by 1942 Nazi Germany had control over much of Europe. During the Nazi occupancy of France, Hitler had also ordered the construction of the 'Atlantic Wall'. This series of coastal defences running along the Channel coastline were constructed between 1942 and 1945, for the purpose of preventing amphibious invasions (Anderson 2010: 61–63). With France being a short distance across the Channel, the allied forces also needed to pre-empt an invasion of mainland Europe to meet the now advancing Soviet army to the east of Germany. Furthermore, Stalin was keen for the allied forces to create a western front, relieving some of the pressure Germany was putting on the Soviet armies.

In response, Churchill and Roosevelt devised the largest and most complex invasion ever to take place, Operation OVERLORD. The plan was to land forces on the northern French coasts, liberate France, then push towards Germany. The invasion, which was to take place on the Normandy beaches, was named Operation NEPTUNE and was described by Churchill as 'the most difficult and complicated operation that has ever taken place' (Winter 2014: 2).

During the planning of the landings on what became known as 'D-Day', the vast scale of the task at hand meant that invaluable cooperation was needed from all of the armed forces including resources and specialist equipment. Armoured units were needed to eliminate the German defences along the Normandy beaches, otherwise high casualties among the infantry would prove unacceptable. During the earlier landing at Dieppe in August 1942, a force of *c*. 6000 British, Canadian and US infantry was landed suffering heavy casualties (Thompson 2011: 38). There, the infantry was supposed to be supported by the Canadian 14th Army Tank Regiment with their new Churchill tanks; these were late arriving, leaving some of the infantry unsupported and exposed to German machine gun fire (Poolton 1998: 38). Driving the landing craft loaded with tanks up to the beach resulted in the Churchill tanks getting stuck in the shingle beach, with two landing craft reported to have sunk as a consequence of this. Those tanks that made it over the sea wall were prevented from progressing further due to a mass of anti-tank obstacles. The losses were very high, with 60% of infantry being either killed or captured (Thompson 2011).

The failed raid at Dieppe in 1942 led to the formation of the 79th Armoured Division, later known as the 'Hobart Funnies,' in October 1942 under the command of Major-General P.C.S. Hobart. At this time the Duplex Drive (DD) units consisted of the 27th armoured brigade, which itself consisted of the 13th/18th Hussars, 4th/7th Dragoon Guards and the East Riding Yeomanry, and the infantry of 285th brigade. In April 1943, Hobart's division was reformed as the only division in the British army made up of just specialised armoured units (Anon 1945: 9). A series of vehicles designed for specific roles during the invasion, including Bridge laying, minesweeping, flamethrowers and swimming tanks were all developed and extensively tested (Anderson 2010: 223; Anon 1945: 31). A key feature was the Duplex Drive system (DD) i.e. having a transfer box within the gears that switch power from the tracks to a single three blade propeller. The novel idea of these inventions was that they were armoured engineering machines, able to assist troops and other vehicles across and off the beaches as quickly as possible. To ensure their success the special vehicles had to be kept under extreme secrecy, for example the DD tank does not appear in the normal A.F.V. schedules (AVIA22/456). Additionally, the destruction of records was ordered in some cases, 'All papers concerning Exercise SMASH will be destroyed after the final conference' (WO199/2320). This high level of secrecy was maintained throughout the build-up to D-Day (Anon 1945).

Development

Nicholas Straussler was a boat builder specialising in floatation devices. He began working for Vickers-Armstrong designing tank accessories. The idea of amphibious tanks had been studied by several nations prior to the war (Fletcher 2006: 3). Many concepts were devised but Straussler eventually broached the idea of Duplex Drive swimming tank. The Duplex Drive tank works by having a transfer box within the gears that switch power from the tracks to a single three-blade propeller (two propellers on the later Sherman tanks) (Anderson 2010: 23). Flotation being provided by a canvas screen erected using compressed air filled tubes, given shape by a series of tubular supports running around the circumference of the tank (Doherty 2011: 51; WO185/66). Once the tank has 'swum' ashore after leaving its transport the Landing Craft Tank (LCT) at sea, the drive reverts to the tracks and the screen is lowered and propeller(s) raised (Fletcher 2006; WO185/66).

The British took on the idea of Duplex Drive (DD) tanks and Straussler was provided with an 8-ton Tetrarch Mk VII from the 1st Armoured Division in July 1940 to begin work on his prototype (WO185/66; AVIA22/1522). The Tetrarch prototype was fitted with an outboard motor for propulsion, technically making it not a DD tank. The resulting prototype was trialled around the Brent Reservoir in June 1941, and in September the Tank Board agreed Straussler's design would be applied to the Vickers-Armstrong Valentine and later the Sherman tank (Fletcher 2006: 6–7; WO185/66; AVIA22/1522).

On 6 July 1942, the first order for 450 sets of DD equipment was made prior to the seaworthiness trials due to the equipment being a 'matter of great urgency' (WO185/66). The DD tanks were all placed under the command of Hobart's division (Anon 1945: 9). Hobart began his career in 1904, a Royal Engineer throughout the First World War, his career continued through to the end of the Second World War. He was described as a determined leader who the war office received countless comments about as being 'impossible to work with' (Macksey 1967: 12). Nonetheless he was a devoted patriot with high expectations and a sense of urgency, an inspiration and irritation (Duncan 1972: 1). After transferring to the Royal Tank Corps in 1923 he was responsible for the training of some of the best known and most successful armoured divisions of the Second World War including the 7th Armoured Division, better known as the Desert Rats, the 11th Armoured Division, acknowledged as the best British armoured unit in Europe and the creation of one of the most important aspects of success on D-Day, the 79th Armoured Division (Macksey 1967).

While the DD tanks would not directly operate under the 79th Armoured Division, Hobart would be responsible for the training (Doherty 2011: 51). Most training in Britain took place using Valentine tanks and Hobart eventually trained ten regiments from Britain, Canada and the United States (Anon 1945: 9; Fletcher 1984: 23).

By the time D-Day was approaching the light Valentine tank had become out-dated compared to other allied and German tanks, both in terms of firepower and armour (Fletcher 1984: 23). The Sherman tank had become the main battle tank of the allied forces during 1943 and was the most obvious choice for conversion. While both vehicles could be made to float, the most notable difference was the additional propeller found of the Sherman DD thus increasing its power. The canvas screen on the Valentine was double thickness for support and to help prevent puncturing although once the DD equipment was adapted for the Sherman tank, the lower section was increased to triple thickness to help maintaining seaworthiness (Doherty 2011: 56). The forward position of the turret on the Valentine meant that the gun had to face the rear to raise the screen; the Sherman tank turret could remain facing forward while the screen was raised, allowing it to come into action much quicker.

Training

Extensive testing and training was conducted in the development of the equipment in the build-up to D-Day at sites around Great Britain, including Castle Toward and Moray Firth, Linney Head, Gosport, Westward Ho!, Bridlington, Slapton Sands, and Studland Bay. Freshwater training was also conducted including Fritton Lake in Norfolk (Doherty 2011; Fletcher 2006; Hills 2003). Trials involved launching and landing practice, live firing landings, seaworthiness, and exposure to small arms fire.

The first stage of DD tank training took place at Fritton Lake (also known as Decoy Lake) which was owned by an admiral who gave the army permission to turn it into the freshwater DD training school known as 'A' wing (Delaforce 1988: 66; WO166/10710). Tank parks and workshops were rapidly built—one of the earliest installations being dummy landing craft ramps to practice deployment from, swimming in offensive lines, along with the varying steepness of the lake's banks providing exiting practice (Macksey 1967: 250). The 79th Armoured Brigade started their freshwater training wing at Fritton Lake on 8 June 1943 upon the closing of Narford Lake where initial trials occurred (WO166/1096; WO166/10710).

The main saltwater training school was 'B' wing at Gosport. Upon the opening of 'B' wing on 1 November 1943, the 79th specialist saltwater training school for the use of DD tanks, under the command of Colonel Nigel Duncan was based here. Based at Stokes Bay, the Solent offered many different landing beaches within near reach, and there are several mentioned during training and exercise. There is evidence to suggest landings at Osborne Bay and Barton Head on the Isle of Wight, as well as further landing sites at Hayling Island, Bracklesham Bay and Littlehampton during Operation FABIUS. FABIUS was the final and largest rehearsal for D-Day, taking place over several days at the end of April and beginning of May 1944 (WO199/1396).

Hobart and his team of instructors successfully put ten Divisions through the saltwater school prior to the D-Day landings. The training was intense and covered all possible eventualities and is what made Hobart and his 79th division so well known. While at 'B' wing the tank crews would practice vehicle maintenance, launching and swimming practice at all times of day and night. During the operation of 'B' wing over 30,000 launches were conducted with the known loss of only one tank (Anon 1945: 15; Daniels 2003: 25; Delaforce 1998: 67; Doherty 2003: 57).

Full-scale exercises took place to prepare for the complex coordination required to make the D-Day landing a success. Rehearsal exercises were high risk in terms of German intelligence, the rehearsals involving the army infantry, navy bombardment and the air force. Exercises such as Operation FABIUS, SMASH and the American rehearsal Operation TIGER at Slapton Sands ended in huge loss of life after a German E-boat attack prior to the exercise (Manousos 2014; Zaloga 2012: 18).

Studland Bay

Studland Bay was used on occasion as opposed to the B wing training school further along the coast in the Solent. There the 4th/7th Dragoon Guards gave a full demonstration of LCT loading procedures on 11 and 12 December 1943 in front of Hobart upon completion of their training at B wing (WO166/11070). This was the first time that a complete unit of DD tanks was launched from LCT at once (WO205/750). During this trial the tanks were launched from 1500 yards (*c.* 1400m) instead of the planned 3,000 yards but it reads that all tanks landed with two minor mechanical breakdowns (WO205/750). The memo goes on to say that 'from a technical point of view this exercise proves conclusively that the DD tank is a very formidable new weapon' (WO205/750). The main lesson learnt here was that the most dangerous period for the DD tank is its launch from the LCT (WO205/750). Studland Bay also had several other functions in relation to the DD tanks. By 20 December 1943, three 'hards' (ramps used for the loading of LCT's and other landing craft types) had been constructed for the 3rd Canadian Division to carry out exercises (WO205/749). Further trials to take place at Studland included driving a DD Sherman through a simulated flame barrage attack known as Project FOUGASSE (Petroleum Warfare Material 1943) This involved setting fire to oil on the sea, then the DD drove through the flames unharmed using a device called a

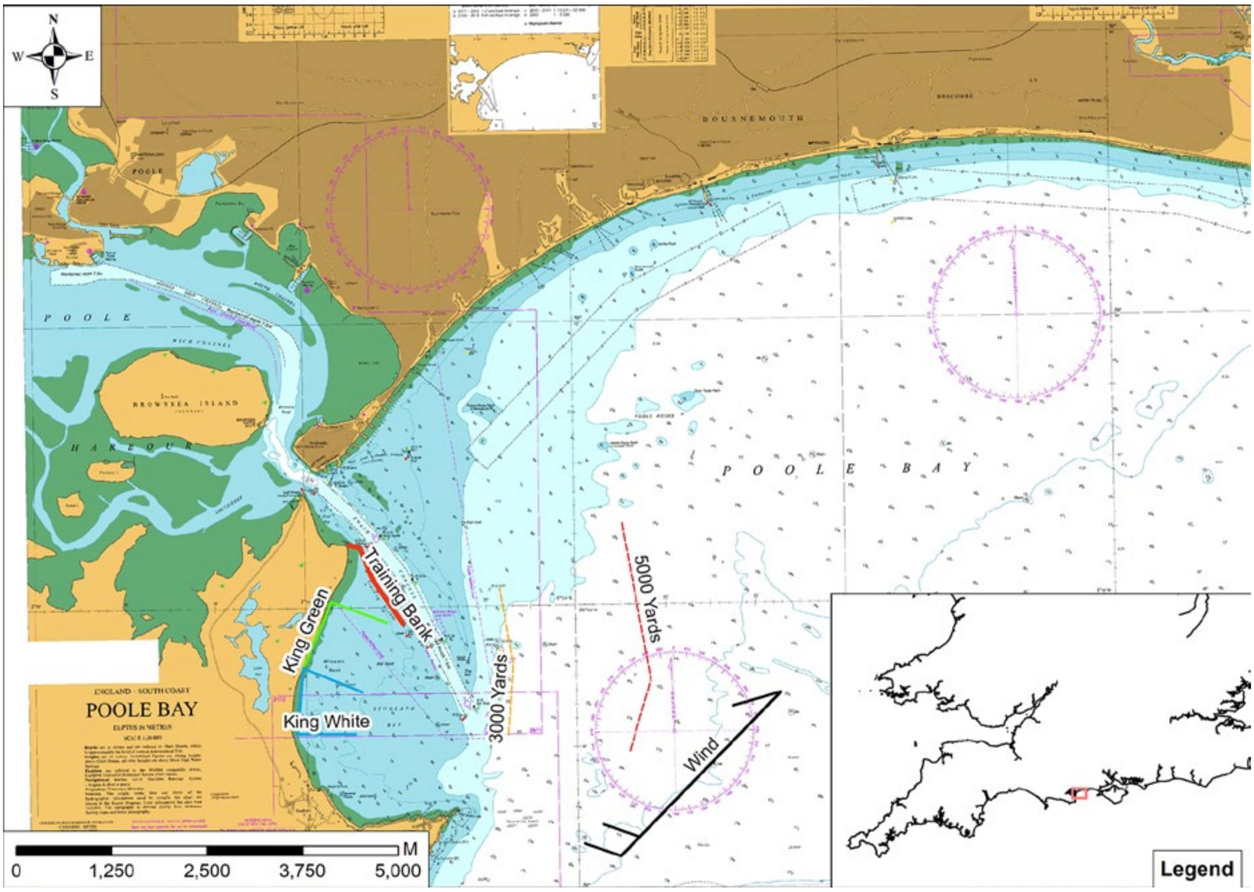

Figure 1. The positions and headings of the tanks in relation to the landing beaches of King White and Green (© Crown Copyright/SeaZone Solutions). All Rights Reserved. Licence No. 052006.001 31st July 2011. Not to be used for Navigation.

Belch that would suck up seawater and then squirt it over the canvas skirt (Doherty 2011: 54; Fletcher 2006: 24, 34; Fletcher 1984: 21). Studland Bay then became best known for exercise SMASH—one of the biggest live firing rehearsals of the Second World War.

Exercise SMASH I

Exercise SMASH was the code name given to a series of live fire beach assault training exercises taking place between 3 and 23 April 1944 in preparation for the Normandy landings on 6 June 1944. The first of these exercises was codenamed SMASH I.

Like D-Day itself 'SMASH I' was postponed by 24 hours due to the weather, eventually taking place at dawn on 4 April. The aim of 'SMASH I' was to assault the beaches of Studland and establish a beachhead, observed by a number of 'Class A' (VIPS such as senior officers, commanders and government officials) in Fort Henry, (WO199/2321) a purpose-built bunker overlooking the beach, which included King George VI, Winston Churchill and General Dwight D. Eisenhower. In addition, 400 'Class B' officers watched the exercises from Ballard Down. The assault was planned to take place on two sections of the beach designated 'King Green' and 'King White' but due the presence of the training bank, a human-made breakwater which covers at high water alongside the main shipping channel into Poole, the approach to 'King Green' would be restricted (WO199/2321) (Figure 1).

As part of this exercise two squadrons of DD tanks from the 4th/7th Royal Dragoon Guards were launched from ten LCT 3s, each with 5 Valentines to support the infantry landings of the 50th Northumbrian Division and securing a series of objectives on land. The official war diary states that the loss of the 'special craft' was due to 'the wind getting up with a strong sea' (Bovington Tank Museum 2014) and the deaths of 6 men: 'Lt. C.R. Gould, Sgt. Hartley, Cpl. Park 84, Tpr. Kirby and Tpr. Petty all of C Squadron, and Cpl. Townson of B Squadron'. In addition, a 7th DD ran aground, probably on the training bank. This DD maintained its buoyancy floating off in the next tide, drifting off more than 5km before being sunk by naval gun fire to prevent the vessel falling into the wrong hands (Stirling 1946: 43–44). After the exercise was concluded the relevant officers held a conference after which all documents concerning Exercise SMASH were destroyed. One outcome of the

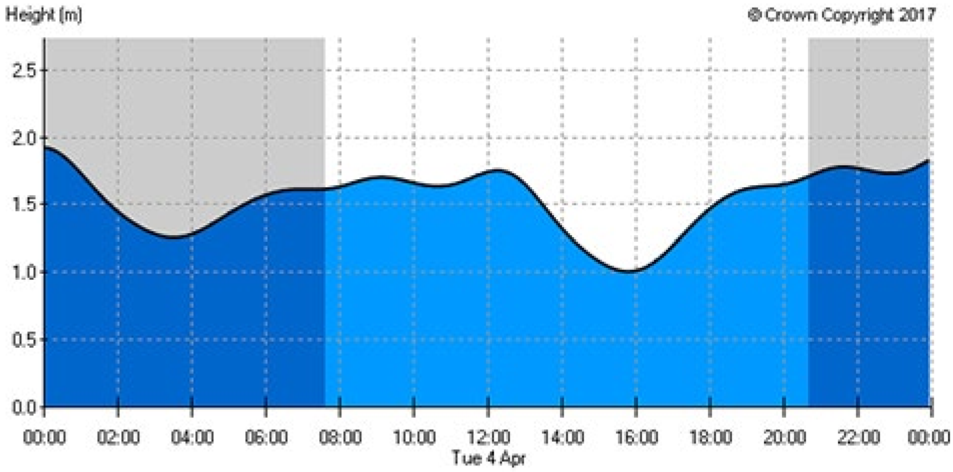

Figure 2. Tidal graph for the 4th April 1944 showing little tidal movement at the time of the exercise 07:40 after UKHO (2014) ' (© Crown Copyright and/or database rights). Reproduced by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office (www.GOV.uk/UKHO).'

losses was the appointment of a Regimental Officer as an advisor to Naval HQ on whether conditions were suitable to launch DD tanks (Doherty 2003: 54).

Circumstances of the losses

With the official records apparently destroyed details of the operation are based on eyewitness statements and the archaeological record. The official accounts give weather as the primary reason for the loss of six tanks. The weather report for Portland shows the wind on 4 April 1944 to be a steady force 4 from the south-west all day (Meteorological Office, 1944), and out in the bay waves of up to 1m could be expected. Further, the exercise took place over the high-water slacks with the tide at *c.* 1.6m above chart datum and at this state of the tide the training bank that usually sheltered the training exercises would be completely covered.

Lt (subsequently General Sir) Robert Ford later said of the incidents:

> ...We were on the surface of the water after coming off the landing craft and becoming increasingly apprehensive. The water was coming in very fast and although we had small pumps, they were just not effective. The weight of the water against the canvas was just too great. We knew we weren't going to make it. We were still floating and all four of us were standing on the top of the tank. Then a great wave crashed over the top and we sank to the bottom ... (*Bournemouth Daily Echo* 2005).

The suggestion that the tank sank almost immediately after coming off the landing craft is correlated by another trooper of the 4th/7th Royal Dragoon Guards, R.W. Mole (1993), who describes waves 'slopping in' as the tank exited the landing craft leading to it being front heavy and going straight down, with some others drifting off before sinking.

Major J.D.P Stirling states the DDs were 'launched in a very heavy swell but one which was adjudged to be fit for launching' (Stirling 1946: 43). He continues that shortly after launching the tanks the weather changed for the worse, 'the wind increased, the waves grew bigger, and the tanks began to get into difficulties' (Stirling 1946: 43). As the weather reports for the day showed no sign of changing it is likely that the DDs turned into the wind giving the impression of increased swell.

These eyewitness accounts attribute the heavy sea conditions as a cause for the loss but it is known from previous trials of DD tanks that they only had a freeboard of 12" (*c.* 35cm) in Force 1-3 winds with a calm sea state (ADM1/13246). This meant that even in moderate seas it could be expected that the tanks would take on water. Given the fact that the majority of the DD tanks launched at SMASH I reached the beach, other factors may have played a role in the loss of the six tanks.

While the DDs at SMASH I were launched from modified LCT 3s, prior to 1944 most launches were off LCT 4s and a letter (WO205/747: 9411) dated 24 December 1943 raises doubts that sufficient training and trials had taken place; and, whether under 'operational conditions' that DDs could be successfully launched from LCT 3s. In addition to this many of the DD training schools had not received the newly modified LCT 3s suggesting that the LCT 3 and DD crews had little experience in launching at sea especially if conditions were not ideal. This contrasts with the large amount of training in deploying from LCT 4s. Given the weight of a Valentine, *c*. 16 tonnes, each time the LCT unloaded a tank its displacement and distribution of weight would have changed—in combination with the bad weather this could have led to the tank sinking directly after leaving the landing craft.

The positions given for the remains of the seven Valentine tanks lost in Exercise SMASH varies greatly. In 2014, Bournemouth University undertook a study to accurately position the tanks and assess their rate of survival (Manosous 2014). This study successfully located all seven DDs using geophysical survey techniques and showed that the five tanks listed in the National Historic List for England (then the NMR) were over 100m out from the beach.

The plot of the DDs (Figure 1) revealed that Tanks 1 and 2 are close to the 5000 yard line (*c*. 4500m) from the beach on a westerly heading and within 100m of each other suggesting that these tanks are either from the same squadron launching close by or from the same LCT.

The other tanks present somewhat more of a mystery. These tanks appear to be running in two lines in a south-south-west direction heading far to the north of the landing beach. Given the slack state of the tide (0.3kts in an northerly direction) (Figure 2) (UKHO 2017) and their low freeboard, and therefore windage on the vessels, it is unlikely that they drifted any distance from their disembarkation point suggesting that they were launched parallel to the shore and had to head south into the wind to avoid running aground on the training bank as Tank 7 did, as this would expose the blunt bow of the vessel to the full force of the wind and tide possibly leading to their sinking.

Significance and lack of protection of the tanks

Their operational successes

The importance of the DD tanks and other specially developed vehicles aiding the infantry making progress off the beaches on D-Day is highlighted by Omaha beach. The beach head, codenamed Omaha, was the responsibility of the First US Army led by 1 US and followed up by 29 US divisions. The 741st Division consisted of 32 DD tanks, 29 of these were launched at 5000 yards into a choppy, tidal sea (Belcham 1981: 86; Fletcher 2006: 22). The result of this involved 27 of the tanks being swept off course and swamped. Two of the DDs made it onto the beach and a further three were not launched and landed straight onto the beach (Belcham 1981: 86; Fletcher 2006: 23). When this lack of armoured support is combined with the lack of other specialised equipment such as flails, the difficult terrain of a rising beach and Hitler's formidable Atlantic wall, casualties ran high. The clearance of beach defences was slowed by the requirement of infantry engineers, with infantry progressing only a few hundred yards by nightfall (Anon 1945: 53). Whereas on Sword Beach for example, the infantry was supported by a full complement of specialised armour and successful landings (33 tanks landing), made quick progress, advancing approximately a mile and a half by 0930 (Belcham 1981: 108). The combined British and Canadian casualties over the course of D-Day are estimated to be around 4200 across the three landing beaches. The American's casualties were about 6000 on two beaches with around half of these casualties being during the Omaha Beach assault (Anon 1945: 53; Belcham 1981: 118; Duncan 1972: 25; Fletcher 2006: 23).

The success of the specialised armour on D-Day is shown in their use during later operations. The crossing of the Rhine—Operation PLUNDER—was undertaken by the Staffordshire Yeomanry (Saunders 2006: 87) occurring under the cover of darkness on 23 March 1945. For the Rhine crossing, initial training took place on Fritton Lake with further training undertaken at Burton-on-Sather where the Staffordshire Yeomanry trained specifically in the crossing of rivers (Fletcher 2006: 36). Further training wings were opened on the River Mass and the Waal (Doherty 2011: 164; Fletcher 2006: 37). Prior to Operation PLUNDER, landings took place at Beveland, the river Elbe and the river Po (Doherty 2011; Fletcher 2006: 38). The US army utilised the DD tanks successfully for Operation DRAGOON, the amphibious invasion of southern France on 15 August 1944. Twenty DD tanks were launched from their LCTs, and 16 successfully made the beach (Zaloga 2012: 28). At least one Sherman DD was lost off Italy by the 753rd battalion during the training for Operation DRAGOON in July 1944 (Duncan 2017). DD Valentines also being shipped out to north Africa and the Middle East (WO32/10523). The memoir of John Leyin of the 25th Dragoons (Leyin 2003) recalls his training in India for the amphibious landings in Japanese occupied Malaya. The success of the DD tanks was clear. Clearly they are of considerable military significance.

The protection of the submerged DD tanks

Historic England recognise the significance of the exercise as seen in their listing of Fort Henry, the Bunker built for the VIPs to observe the exercise, as a Grade II Listed Building (List entry Number: 1411809). As one of the key parts of the exercise and D-Day itself the tanks played a vital role in the history of Europe with only a handful of DD Valentines known to have survived. Of the Poole Bay Tanks, all have been heavily salvaged with four of the six lost off Studland having been partially destroyed by the Navy in 1987 to prevent salvage of munitions by sports divers. Tank

2, which had the turret blown off, was salvaged by sports divers in 1989, the material recovered showed a remarkable level of preservation with material such as cardboard and personal items such as shaving kits and leather belts surviving (pers. comm. Nigel Bryant). With Tank 1 still intact the archaeological potential of the tank and, therefore, its significance is greatly increased; however, there is no desire from Historic England to protect the tanks under the *Protection of the Wrecks Act 1973* (Protection of Wreck Act 1973) as although they were travelling under their own power they are not recognised as 'wrecks'. Historic England has also changed their policy specifically so as to not designate the vessels under the *Ancient Monuments and Archaeological Areas Act 1979* (Ancient Monuments and Archaeological Areas Act 1979), which defines monument to include 'any vehicle, vessel, aircraft or other movable structure'. Even though they recognise the tanks as being of 'national importance' it is Historic England's policy not to use the 1979 Act to schedule below the Mean Low Water mark (Historic England 2015). It should be noted that Historic England has designated protection to at least one vessel, a WW2 Phoenix Caisson, which lies 660m beyond the low water mark in 2013 (List entry Number: 1415588), as well as several wrecks in the Intertidal Zone between high and low water marks. Historic Scotland and Cadw have also used the 1979 Act to protect shipwrecks below the low water mark such as the German High Seas Fleet at Scapa Flow.

Under the current UK legislation only the 1979 Act can be used to protect underwater cultural heritage (UCH), which cannot be identified as wreck. The failure to schedule these vehicles, despite their acknowledged national importance, especially when compared to the scheduling of surface monuments, would appear to show a 'sea blindness' on the part of the heritage authorities in dealing with UCH.

Conclusion

The intended use for the tanks was the Normandy Landings during D-Day, and much attention is drawn to Omaha Beach where the DD tanks failed to make the beaches due to bad weather. The units on the other beaches successfully deployed the tanks and experienced much lower casualties. The DD tanks therefore, played an important role in the Normandy Landings despite the high number of casualties on Omaha Beach. The success of the DD tank on D-Day lead to further successful amphibious landings, including Italy, providing vital support in multiple operations during the allied advance, such as Operation PLUNDER, the crossing of the Rhine (Fletcher 2006: 37). Without the DD tanks and the other specialised armour of the 79th Division the Normandy Invasion may not have gone as planned with many historians believing that the Soviets would have continued their push beyond Germany and could have even led to atomic war in Europe (BBC 2014).

Little work has gone into the investigation of the known DD tanks, beyond that being conducted by Bournemouth University (2014). The only known work to be carried out is on locating and recording of those lost during exercise SMASH and the one at Bracklesham Bay, with Manousos' (2014) concluding remarks on the tanks being that they are actively decaying and being actively salvaged, thus highlighting the importance of recording these vehicles while still possible. No other DD tanks are recognised to be within English waters; a Sherman DD lost in Exercise TIGER was raised in 1984 and is now on permanent display on Slapton Sands as a memorial to the lives lost during Exercise TIGER.

The extensive development of such a new idea shows the importance of the equipment, as authorities strived to maintain secrecy while developing and trialling at an extensive list of locations, combined with the struggle to produce the numbers needed for training and operational use. While the deliberately fragmented records and widespread coverage of the use of DD's makes this difficult, the significance and potential presence of these vehicles within the archaeological records is limited due to their secret nature.

The topic, therefore, should be studied to its fullest potential, such fragmented records being deliberately discrete over the nature of the equipment due to their success relying on secrecy. With very limited archaeological investigation being undertaken to locate, record and learn from those tanks within the archaeological records, further work must be undertaken to fully appreciate the role that these tanks played throughout the war. Many features of the war are well remembered, and deservedly so, with many protected structures, ships and aircraft within the archaeological records and the public eye. Many elements of D-Day have already received deserved recognition and protection, either through the Protection of *Military Remains Act*, as scheduled monuments or listed buildings. While features of the operation SMASH have already been listed (Fort Henry), the tanks have been noted for national importance but not offered any form of protection. The DD tanks were an important aspect of D-Day and one with such little archaeological presence should represent an ideal candidate for protection. The DD tanks are yet to receive the appreciation they deserved for their role in the Normandy landings, attention being drawn to their great losses at Omaha Beach. Little attention has previously been paid to the extensive investment that the War Office put into these tanks and their successful role in the penetrating of 'fortress Europe'.

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Missing Link—Evidence of the Military Evolution of a Global Empire

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Abstract

The establishment of a naval force was key to domination of sea routes and ultimately the expansion of the British Empire. This process began in the 16th century under King Henry VIII but did not develop until the time of Queen Elizabeth I. There had not been a single English wreck discovered in British waters from this pivotal time in England's military history until that of a late 16th-century wreck off the north-eastern coast of Alderney, Channel Islands, in 1977. This was excavated in increments throughout the 1990s, the results of which have been published, and early 2000s, the results of which have not. It has provided a collection, which now fills the gap of the transitional period from medieval to post-medieval England. The material found and recovered to date is mostly of military nature including the ship's ordnance (typically English), arquebuses, calivers and muskets and associated equipment, such as powder flasks, blades and plate armour. The ceramic collection indicates operation within the English Channel, with examples from Germany, the Low Countries, north-west France and England. There is no indication of this being a naval vessel. However, the arsenal on board indicates official military business. Recent assessment of the post-2000 material has shed new light on old theories. The Alderney wreck stands as an example of England's complete overhaul in the instruments and art of war and a demonstration of the role its naval force played in affirming the new, global power into which it was evolving.

Keywords

Alderney, 16th century, warship, naval warfare, military evolution

Introduction

Project Background

The wreck found in 1977 by local fisherman Bertie Cosheril, off the coast of Alderney (Davenport and Burns 1995), 900m north of Alderney lighthouse and 300m west by north of a reef called The Ledge in approximately 27–30m of water (tide dependent) (Alderney Maritime Trust 2010) (Figure 1), is thought by investigators to be what remains of a late 16th-century vessel, possibly of English origin, operating in the English Channel. It may have played a part in the religious wars of the time when the French Protestant king, Henry IV, backed by the English, fought against the Catholic League in France, backed by the Spanish, who were, at the time, seeking a port from where to launch a second armada across the Channel. These theories regarding the character and nature of the vessel were given shape and put forth by the researchers at the time through the analysis of a number of finds raised by local divers, along with artefacts which remain *in situ* and surveys from documented dives by the Alderney Elizabethan Wreck Project group in the 1990s and some historical research of the late 16th century, including:

- Two lead pan weights (Figure 2), which were among the most important finds—both stamped with the monogram 'EL' under a crown, to the right of which appears a sword signifying the city of London. This particular combination is apparently rare and was used late in the queen's reign, having been made standard by her proclamation of 1587—before this date a crowned 'E' was used instead. By 1603 there is evidence of a crowned 'I' on a lead weight held by the Museum of London, being King James I's monogram (Smith 1997).
- A letter from Sir John Norreys, commander of the English army in Brittany, to Lord Burghley, chief minister to Queen Elizabeth I, making direct reference to material that was sent to him but was lost on a ship wrecked off the coast of Alderney—the letter is dated 29 November 1592 (Parham 2001). No other vessel of this date has been found off Alderney thus far.
- A port cover (Figure 3) (on which dendrochronological analysis was carried out) identified as oak, with a ring sequence of AD 1437–1565 and at least ten sapwood rings missing, places the wood as having been felled after 1575 but cannot account for exactly how long after. The wood sample was difficult to work with due to its size and the fact that it was not frozen due to time constraints. The attained chronology best matches that of wood samples

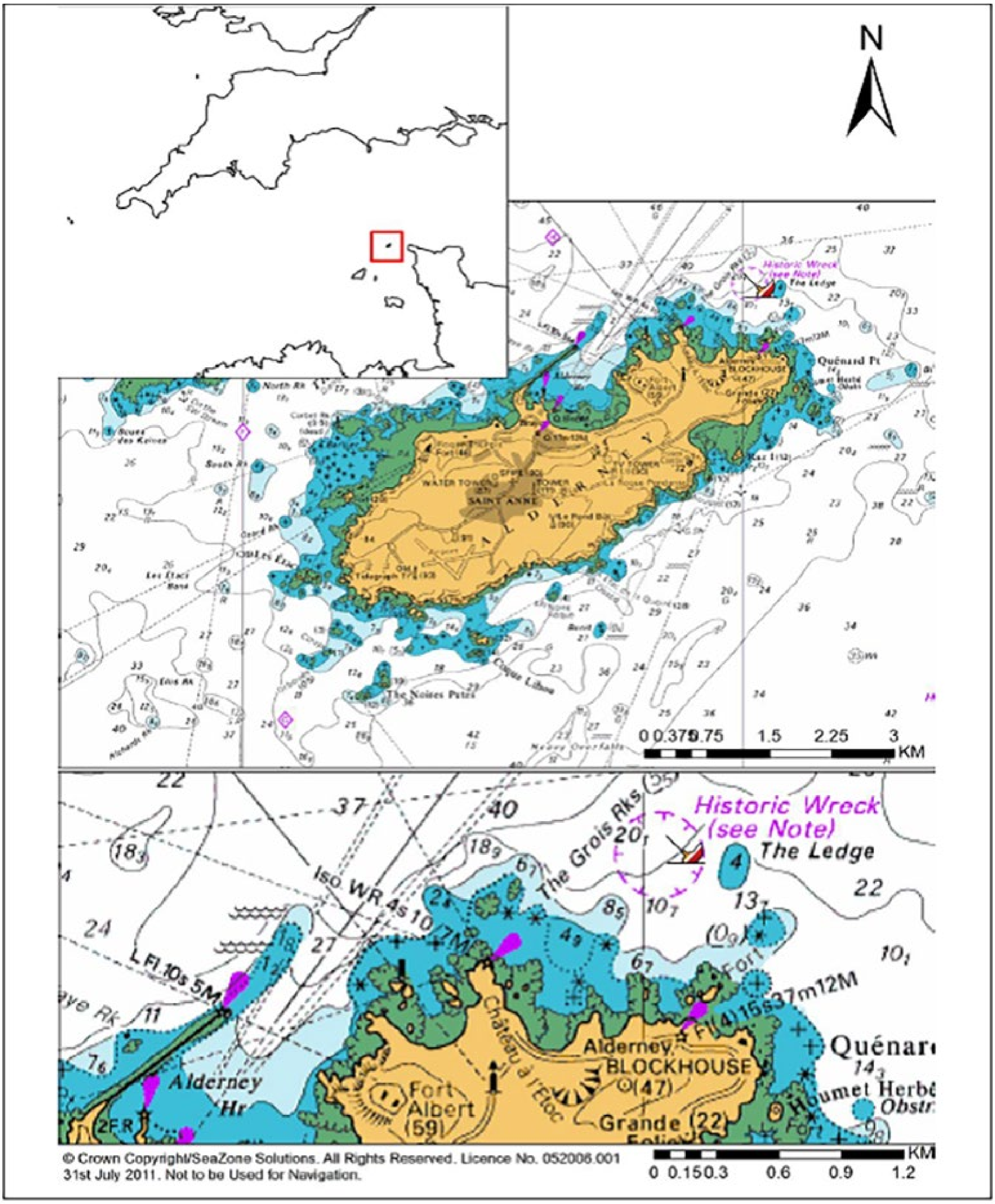

Figure 1. Tripartite map of the site location.

from southern England (Hillam and Groves 2001). Accounting for the time taken to season the wood and the working life of a ship at that time (which could be 20+ years) places the vessel between 1575 and not after the first few years of the 17th century (Alderney Maritime Trust 2010).

- Potsherds and some mostly intact ware are identified to originate in various regions of France, and the Low Countries (namely Belgium, the Netherlands and Luxembourg). They are almost all entirely of the same period and may be largely indicative of the ship's possible route

Figure 2. One of two lead pan weights found on the wreck; clearly bears Queen Elizabeth I monogram 'EL' under a crown and a sword which signified the Guildhall and hence the city of London (Alderney Museum).

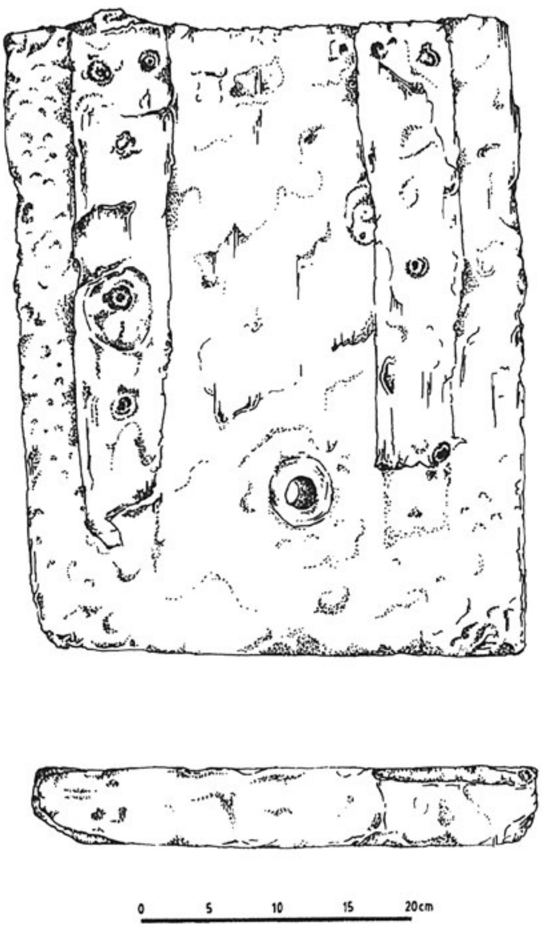

Figure 3. Port cover, 145, on which dendrochronological analysis was carried out (Monaghan and Bound 2001).

(Davenport and Burns 1995). This is explained in more detail below.

- Tobacco pipes, of which two have been found on the wreck so far—one clay and one pewter (Figure 4). Their presence is of great importance as tobacco smoking became popular in Europe during the late 16th century, at the end of which pipes were being produced commercially. The pewter pipe is of particular interest as its kind is rare—the closest other example being a pipe from the 1595 wreck of the *San Pedro*, in Bermuda, the comparable date and design of which indicate that the two pipes may share their point of origin. The clay pipe shares traits with examples from London and Southampton (David 1995).
- The vast majority of artefacts belong to the arms and armour group, which are typical of 16th-century styles—this is inclusive of: plate armour (breast, back, helmet), arms (arquebuses, muskets, calivers) and associated paraphernalia (musket balls, single gunpowder charge containers [apostles] and powder flasks) (Bound and Monaghan 2001).
- Heavy ordnance and associated shot (including round shot, star or spike shot, expanding shot and bar shot) are all typical of 16th-century English production. The shot are all of similar diameter, and cannon found to date—with three raised—are of almost identical bore size, which indicates a matching set of cannon (Bound and Monaghan 2001).

Within the collection, each piece strengthens the ground upon which current hypotheses about the wreck rest comfortably. However, further recent research was approached with caution as it can fall under heavy criticism in terms of the validity of future conclusions and the possibility that they are swayed by preconceived ideas regarding the origin and date of the wreck regardless of new, potentially opposing, facts. Perhaps the strongest point against the material, and inferences from it about the wreck, is the simple fact that there was very little, if any, archaeological control at the time of initial investigation, excavation and recovery of finds, placing the validity of any conclusions of that time on unsound ground.

In subsequent years, from 2000 to 2009, work was undertaken with more archaeological control. The material collected during that time is being kept in appropriate storage by Alderney Museum, Alderney Maritime Trust and Bournemouth University. In 2014/15 it was analysed, compared to the older collection, researched and interpreted from an objective point of view and with constant reference to standards and available literature, as well as consultation with

Figure 4. Pewter smoking pipe, one of two pipes found in total, the other made of clay (Alderney Museum).

professional specialists where needed. While the previous theories were kept in mind and considered throughout, they were also tested and challenged in order to ascertain if doubt was cast upon them when questioned in light of the post-2000 material.

Historical context

In order to provide a brief background to the snippet of the life and times that the Alderney Elizabethan wreck represents, an outline of relevant events is given below:

1558: Elizabeth I ascends the throne.

1585: Religious war in France (until 1589). Meanwhile England assists the Netherlands in a war against Spain attempting to reclaim lost territory—this event demarks a very clear moment in time when England is no longer 'neutral' in the affairs and politics of the Continent.

1588: Spain, under King Philip II, launch the first Armada across the Channel but are scattered primarily due to weather conditions and also by the assembled English navy.

1589: The religious war in France concludes and Henry of Navarre (Henry IV) ascends as Protestant king of France. He is opposed by the (French) Catholic League who is supported by Spain. Lord Willoughby is sent across with 4000 men to assist the French king.

1590: More assistance is sent from England—Sir Roger William lands in Normandy with 8,000 men while Sir John Norreys is sent to Brittany with 3000 troops.

1592: In October Sir Norreys returns to Brittany bringing a further 1400 men as well as warships and transport. In November they finally land in Granville via the Channel Islands after they were met with misadventure due to weather. Sir Norreys writes to the Privy Council regarding a ship 'cast away about Alderney'.

1593: Henry IV returns to the Catholic faith.

1596: In January, Sir Francis Drake dies shortly after his contemporary mentor, John Hawkins—the passing of these two great naval personalities (their 'misconducts' aside) marks an important point in England's naval history, as did their deeds in life. In October, the second Spanish Armada is launch but fails.

1597: The third Spanish Armada is launched but is also unsuccessful.

1598: France and Spain end hostilities with the Treaty of Vervins.

1601: The fourth Spanish Armada invades Ireland—and joins forces with the Irish against the English but is defeated at Kinsale.

1603: Queen Elizabeth I dies. James I ascends the throne.

1604: England and Spain sign a peace treaty.

Purpose of 2014/15 study

One of the main aims of the more recent enquiries into the collection was to compare pre- and post-2000 collections in order to ascertain if discoveries, subsequent to initial publication, support, refute or otherwise change the theories currently in place regarding the character, origin and purpose of the vessel.

- Acquire and compile physical and digital records of artefacts into a custom database;
- Amass existing site plans and spatial data information from other sources (e.g. dive logs) in order to position artefacts accurately on the site using a GIS program;
- Desk-based research of all previous publications in order to ascertain theories currently in place and accepted in regard to the wreck;
- Analyse the post-2000 collection in the individual finds groups i.e. ceramics, armaments etc., where number and/or nature of finds is significant; and
- Compare and contrast new analysis results with those of the pre-2000 collection.

The methodological approach for post-excavation assessment and analysis is that employed in other such investigations on sites including the Swash Channel (Parham 2010; 2012), Salcombe (Parham and Palmer 2007), Studland Bay and Oman wrecks (pers. comm. Dave Parham).

Assessment of finds was undertaken in the form of data collection and the subsequent division of finds into constituent groups e.g. ship material, material of domestic use, military collection etc. These were then assessed for:

- Quantity and/or quality of material in each group;
- Origin of material and likelihood of contamination;
- Presence of collection and sampling method bias; and
- Condition of material, including any influence on this condition by storage methods.

The archaeological potential of this data was evaluated from the results of the assessment based on the accuracy of collection and the capacity of the data to address the research question. Only by meeting these requirements did the material proceed for analysis. The assessment results of material not meeting the requirements appear in the appendices of this document.

Results

Some of the main points resulting from the 2014/15 study provide additional support to pre-existing theories regarding the character and nature of the vessel, confirm points previously put forward with some doubt and also refute some ideas.

Ceramics

The ceramic material forms a large part of the collection and is one of the main groups with diagnostic significance. The pre-2000 pottery collection, assessed and subsequently published, was found to be largely of one period and dominated by north-west European material which Davenport and Burns (1995) speculate may have been part of supplies from Protestant allies of England. This includes sherds representing four vessels and 29 incendiary grenade pots from northern France and over 25 domestic ware (coarse lead-glazed earthenware) cooking vessels (frying pans, tripod pipkins, cooking pots and jugs), well known from UK sites of the time on the east and south coasts, and 19 albarelli from the Low Countries (Bound and Monaghan 2001). Here, it must be noted that the abundance of albarelli (tin-glazed earthenware 'drug jars') is interpreted by Davenport and Burns (1995) as indicating the presence of a surgeon/physician on board the vessel and it is mentioned that there are parallels from Holland dating to about the same period i.e. late 16th century.

Other regions in this part of Europe are also represented by smaller samples including 7–9 bartmann (or 'bellarmine') vessels (salt glazed stoneware) from Cologne/Frechen, Germany, which are common of the period and a small piece from a handle of possibly Spanish origin. Other areas of France represented include Saintonge in south-west France by a single handle and Brittany by a single jug and possible body sherd (Bound and Monaghan 2001). Davenport and Burns (1995) note that the areas from which the pottery originates reflect the campaign routes of this time quite closely and highlight the fact that the Breton jug links the vessel to the area in which the campaign was focused and the ultimate destination of the ill-fated ship—this assumption is discussed below.

A most interesting and important observation is made by Bound and Monaghan (2001): that the ship was not only carrying munitions but also men—they base this theory on the sheer number of used cooking pots found on the wreck (30+), which is indeed much more than a crew of a ship would need, as the meals aboard a ship are usually prepared in communal vessels and rationed to crew members. They also point out that due to the coarse nature of the pottery it was obviously expected to have a short life span (presumably due to

Figure 5. Ceramic firepot, 1028 (left), found intact (Alderney Maritime Trust) and firepot, 1569 (right), found in cannon concretion and reconstructed by York Archaeological Trust.

the material's fragility and the rather robust lifestyle of a soldier). With its origin being in the Low Countries, they deduce that the men on board served in that region immediately prior to their journey.

The most unusual find in the ceramics collection is the substantial number of what have been identified as incendiary grenade pots and thought to be Beauvais ware—1028 is a complete example (Figure 5) with evidence of cloth cover held by string, with contents that were apparently grey/black thought to be gunpowder—which are rarely found or, as the authors point out, perhaps rarely recognised (Davenport and Burns 1995).

The 2014/15 analysis constitutes a preliminary study of the material following conventions within the highly specialised discipline of pottery analysis. Work was undertaken by following Orton and Hughes (2013) and denoted in the style of Brown (2002), as well as by consulting a number of other publications, used in the search for similarities in form and fabric. Some technique guidance and advice was kindly provided by Duncan Brown in the initial stages and later with provenancing where issues were met. The most significant result is as follows:

A number of sherds were found to be typical of English production especially in the red earthenware group. Sussex 'white painted blackware' was also identified on account of the dark grey exterior surface with evidence of white slip decoration (on said surface), a typical Sussex tradition (Barton 1979). Sherds that may be representative of North Devon courseware were also identified. It is a yellowish red-to-red fabric with a very dark grey core and dark green lead glaze inside with some dribbles and blotches on the outside. North Devon pottery is described as being pinkish red with a grey core, with lead glaze, which varies from honey coloured to dark green if not over a white slip (Longworth 2004). Alternatively, it may be from the south-east of England (pers. comm. Duncan Brown).

Surgical Instrument

For over ten years the albarelli sherds seemed to be the only 'conclusive' indication of the presence of a doctor on board. This is rather weak evidence upon which to base such an assumption, especially in light of the albarelli found on the Swash Channel wreck (Brown 2015) and the Salcombe Cannon site (pers. comm. Dave Parham) with no other medical equipment and the fact that the captain of the vessel would often distribute medicaments to the crew, in mind.

That is until the post-2000 field seasons. During that time, a curious concretion was raised and subsequently x-rayed to reveal the outline of what appeared to be a type of surgical instrument. Due to the unusual nature of the find it was immediately transported and attended to by conservators at York Archaeological Trust and was eventually cast in silicon (Figure 6).

Research conducted in 2014/15, points to the object being a double-bladed 'bistoury cache', roughly translated from French as 'hidden knife'. It is best to imagine a pair of scissors with outward facing blades and a sheath-like extension down the middle between the blades into which they are concealed when not open—the extent to which the blades open is screw controlled. It serves to cut into organs and open cavities and was most apparently used in lithotomy, the procedure of extraction of bladder and kidney

Figure 6. Double-balded bistoury cache, or lithotome found on the Alderney wreck and cast in silicone by York Archaeological Trust.

stones from the body—it is oftentimes referred to as a lithotome due to this use (Shelley 1958).

It would, however, seem that such an instrument had other uses also—Kirkup (2002; 2006) classifies these as wound enlarging instruments in use when the practitioner had need of widening the opening a wound to locate a foreign body lodged in the victim. The discovery of this instrument appears to confirm the presence of a surgeon on board the vessel, as initially speculated by Davenport and Burns (1995). Alternate theories for the presence of a practitioner are presented below in view of the larger picture surrounding the vessel.

Discussion

In light of the above analyses and research, the ship itself, its character and nature, have been reassessed. The ceramic assemblage has once again been of greatest value and contribution in the efforts towards uncovering more about this mysterious vessel and telling parts of its story.

The positive identification of earthenware typical of English production would shed some doubt on the suggestion made by Davenport and Burns (1995) that since most of the domestic ware originates in the Low Countries, it may have been the last location in which troops on board the vessel served, and introducing an alternate theory where troops and domestic pottery alike boarded in England. Indeed, Davenport and Burns (1995) claim that the collection is 'exclusively north-west European' which is taken to mean continental north-west European as Bound and Monaghan state that 'there are no vessels which are certainly English' (2001: 145) but there are a substantial number of English vessels represented in the post-2000 collection as detailed above.

Investigators in the past, who so avidly promoted an English origin for the vessel but highlighted that there was no English pottery on board completely failed to or perhaps avoided mentioning that this is simply impossible. The pre-2000 collection is a lot larger than the one analysed herein, although it is possible that English pottery had not been recovered to date, it is more likely that it was misidentified. The post-2000 ceramics collection, assessed and analysed independently of old theories and conclusions, using internationally accepted techniques and adhering to discipline specific national standards, has yielded results, which now add to and ultimately strengthen the said theories and conclusions. English pottery makes up a substantial portion of the collection studied in this project. While some of the material belongs to continental Europe but only in terms of manufacture, it is not unlikely that many of these were obtained in England, where they had been imported from the continent.

The large number of tin-glazed white earthenware sparked theories among investigators at the time as to the presence of a medical practitioner aboard the vessel. It must, however, be highlighted that their presence alone does not necessarily indicate the presence of a barber-surgeon. In most cases, especially on merchant ships and smaller warships, the ship's captain and/or officers undertook the duty of distributing the various medicaments and procedures seamen required with no more guidance than a procedural manual. However, in particular situations and mostly on the larger warships a surgeon was present: if part of a fleet the surgeon and his mates were under the supervision of a physician and at times normal crew members were assigned to assist under the surgeon and his mates. Certainly by the 18th century large ships of the line carried a surgeon and at least three mates (Friedenberg 2002). Only in light of a specialised surgical instrument, the double-bladed bistoury cache, or lithotome (discussed above), in combination with the albarelli, can the presence of a practitioner on board be assumed more securely.

The wreck has produced this mixture of material, certainly in different proportions but still regionally varied. Consequently there is no doubt that the vessel is likely to have visited different ports on either side of the Channel. A jumble of material is to be expected on a mobile unit such as a ship, which may have taken on crew members as required, who carried their own personal wares. Furthermore, the crew would have taken on supplies to replace items broken or lost during the voyage in the next port of call. Although it is likely that individual vessels came from a port in their country of origin, this is not always the case. To say for example that a single Iberian vessel was acquired at an Iberian port is too much of an assumption. To conclude on the basis of a single Iberian vessel that this is indicative of the ship's involvement in the war is a step too far.

On a par with this point is to state that there was a surgeon on board the vessel, based on the pottery assemblage alone, but is now more justified in light of the surgical instrument found, as indicated above. As such, several theories can be formed in regard to the presence of a doctor on board, for the ship itself and its nature. Surgeons were not always taken on board. In fact, the record points to their presence mostly on warships and merchant vessels of exploration (Keevil 1957; Westphalen 1999, 2002, 2003), for obvious reasons. In light of the military material on board and the lack (to date) of trade goods and stock and equipment that may point to a long haul journey, it would be logical to surmise that this vessel was engaged in a mission of military nature.

As the current historical research indicates that there were no English navy ships lost at this time at this location, it has been assumed that this was a queen's charter (Bound and Monaghan 2001). As such, a surgeon may have been provided to the ship, by agreement from the London Barber-Surgeons Company for example, as was the practice a few decades earlier (Westphalen 2002) at the time of the *Mary Rose*, in order to treat the men wounded in action among his other duties of maintaining the general wellbeing of the crew.

Conclusion

Work on the site and the collection is still underway but military involvement of this vessel is by now undoubted, especially in light of most of the heavy ordnance, arms and armour found on the wreck, described in great detail and compiled in the most comprehensive publication of the site to date (Bound and Monaghan 2001). From the first half of the 16th century the English relied on their superior handling of artillery during battle, as seen for example on the *Mary Rose*, which was rebuilt in 1535 to carry heavier cannon (Gardiner and Allen 2005). The intention was to avoid hand-to-hand combat and boarding techniques. The Alderney wreck, so far, appears to have been a relatively small vessel, outfitted with a set of a minimum, and perhaps a maximum, of eight guns of very similar size (Bound and Monaghan 2001). Even so, it appears to be carrying a relatively high number of the abovementioned firepots, indicating that perhaps an attack was anticipated. If so, it would only confirm the fact that the vessel was of some military importance and on an official mission.

The identification of English red domestic earthenware in this project has been a large step forward, as, taken in combination with other groups outlined in the introduction, it supports the theory of an English origin for the vessel as suggested back in the 1990s. While the combination of pottery from continental Europe indicates that the ship was indeed operating in the Channel, it had not visited every country of origin of the pottery.

In light of all the above, was this ship operating in the thick of a religious war with strong political undertones and on the English side, after all? It certainly appears to have been. There can be no alternate interpretation overall of the vessel and the larger picture surrounding it. Although the theory that it is the vessel mentioned in official communication remains under question, there are too many officially supplied or approved items and indications of genuine military involvement, even in the event that it was a hired vessel, to indicate otherwise. An English origin is strengthened by these items, as well as by the more everyday equipment, such as cooking vessels. The movement of the ship around the Channel is undeniable and the Low Countries are very well represented. This is no surprise, for this is a known ally of England and a station for English troops at the time.

As a time capsule of English military involvement in continental affairs of the late 16th century this wreck stands as the only known English vessel in UK waters from this pivotal time in British history. The beginnings of the century saw Henry VIII, traditional and very much in love with being king, clutching at the age-old sentiment of English rulers holding sovereignty over the seas. The construction of floating fortresses such as the *Mary Rose* bear testament to this, being a show of power—the power to lay claim to the waters surrounding the realm. Unfortunately, in the case of Henry, it was only a show. He drained the country financially to maintain the fleet, and when the coffers were empty he turned his attention to selling the wealth accumulated in monasteries (for more, see Wilson 2013). After his death in 1547, his young but sickly son inherited a bankrupt country and was very quickly succeeded in 1553 by Mary, a devout Catholic. The last Tudor, Elizabeth I, took the throne in 1558, and with it the burden of lifting an impoverished, backward and largely defenceless nation to a high enough standard to not only beat back the Continental threat but compete for power. Although Elizabeth resisted direct involvement in Continental politics while she reconstructed her bedraggled nation, for fear of not being able to withstand direct conflict with the more powerful nations of the time, such as Spain, she also came to realise the value of keeping allies on the continent. So she entered into alliance with the (Protestant) Dutch in their war with Philip II's Spain. With the treaty of Nonsuch in 1587 England finally became involved and this meant war with one of the largest powers in Europe (Adams 2004). Yet continued refusal to engage would have meant a Spanish takeover of the Netherlands, which was literally much too close to home.

The Alderney Elizabethan wreck bears testament to the movement of a small, backward country off the edge of Europe towards the global empire it was to become. It bears testament to the legacy of grand mariners and naval strategists of the time, such as John Hawkins and Francis Drake. The myth built upon the deeds of this time became a legend—a legend that captured the minds of the people and in the late 17th century and certainly in the 18th, placed the navy at the very heart of the nation. It was through this adoration by the people that the seaborne Britannia ventured far and wide to all corners of the globe. This was the transition from medieval to post-medieval England. Within 45 years from the time of the *Mary Rose* and its impressive arsenal of longbows, England changed not only its instruments of war, as is evidenced by the complete lack of bows on the Alderney wreck and the overwhelming number of firearms, but its attitude towards the art of war. Elizabeth's England was the beginning of a revolution that would ripple through the proceeding centuries and ultimately to the modern world.

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The Military Dockyards of the Greek World

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Abstract

This paper focuses on the birth and development of military dockyards in the Greek world between the 6th and 3rd centuries BC and considers related urban and typological issues. The improvement of dockyards—and related buildings—is strictly connected to the invention of the trireme. This warship, which spread over Greece during the 6th century, became the main vessel adopted by the Greek fleets during the Classical period. The trireme, like all the wooden ships, could not stay in the water for a long period, and the fleet needed to be launched in the easiest and quickest way possible. To accomplish this task, shipsheds were created, buildings set in front of the shoreline of the military harbour, which served to protect the ships. This paper aims to scrutinise both these structures—of which we have substantial evidence—including the facilities, fortifications and quays that formed military dockyards and to prove the importance of the development and the spread of this model around the Greek world. Within the *polis* these structures fulfilled both a practical and a representative function; noteworthy is the correlation among the growth of the city as a military power and development of the dockyards, which strongly influence the political and urban organisation of the *polis*.

Keywords

Military dockyard, warship, shipshed, Greek, urban organisation, sea power

Introduction

The purpose of my work is to study the origin and development of military dockyards for the safekeeping and protection of warships in the Greek world and to analyse the related urban and typology issues of these structures. This paper examines the correlation between the growth of the city as a military power and development of these kind of structures, which fulfilled both a practical and a representative function. The findings investigated here are dated from the 6th century BC to the late Hellenistic period.[1] The correct identification of these structures is difficult for two main reasons. The shipsheds were located inside the military harbours, along the shoreline, and because of the change in sea levels since antiquity, some of these structures are now underwater—like in the Zea harbour at Piraeus—or lie inland, like the case of Oiniadai. Secondly, since many of the shipsheds are set in harbours that nowadays are still in use, modern harbour installations have lead to the partial or complete destruction of the archaeological evidence, not to mention phenomena like siltation and dredging. Lastly, for a long time the Greek dockyards have had a marginal role in the history of studies and only in the last decades has their importance as a fundamental aspect of the history and structure of the *poleis* in the Classical period been understood.

Functional categories of 'arsenal'

The term 'arsenal' is very generic, and when we talk about the different facilities in the dockyards—each with a specific purpose—the risk of misunderstanding is very high. For this reason, inside the arsenal, there is the need to distinguish between three different functional categories. The shipbuilding yard is where the vessels were built and repaired; it was generally realised with perishable materials, scarce traces of which are preserved in the archaeological records. The only Greek shipbuilding yard identified with certainty is at Marseilles (Place Villeneuve-Bargemon and Place Jules Verne) where the anaerobic environment led to the preservation of the ships' beams (Hesnard *et al.* 1999: 36–7). Secondly, the *skeuothēkē* is the building for the storage of the ship equipment, like rigging gear and sails. These buildings are well known thanks to literary and epigraphic sources (*Inscriptiones Graecae* II² 1668 for Zea harbour and 9.I² 4.794 for Corcyra), whereas the only archaeological evidence that has been found is the famous *skeuothēkē* of Philon in the harbour of Zea in the Piraeus (Steinhauer 1991: 471–9). The shipshed is the building for the storage and protection of the warships where minor maintenance work was carried out; there is much archaeological evidence for these structures both in Greece and in the areas subjected to colonisation, like Sicily and Cyrenaica.

The shelter for the storage of warships is expressed in ancient Greek through the term *neosoikos*, which is

[1] Data updated to 2017

derived from the Greek word *naûs*, meaning 'ship', and the word *oîkos*, which signifies a 'house' or in this case a building. Therefore, the compound word created, 'ship-shed', expresses exactly the function of these buildings. In ancient Greek, the word *neoria*—singular *neorion*—was used. Although the term can also refer to shipsheds, it can also be used generically to describe the harbour installations in their totality.

The development of the *neosoikoi* is strictly connected to the invention of the trireme, the warship that—with its three levels of oars and tactical manoeuvering and ramming capabilities—revolutionised the sea-based warfare. This is the ship used by the majority of the fleets in the Classical period and on which Athens based its naval empire. The triremes were hauled from the sea to protect them from the *teredo navalis*—a shipworm that could destroy the hull in a matter of months—while the roof of the shipsheds protected the ships from rain and sun. There is no doubt that the *neoisoikoi* increased the triremes' lifespan. Shipsheds were built initially to facilitate this task and furthermore allowed the launch of the fleet in the easiest and quickest way possible.

The length and the internal width of the slipways inside the shipshed—when they can be reconstructed—are fundamental data for reconstructing the types of ship that were housed inside the shed. The shipsheds investigated by I.C. Dragatsis and W. Dörpfeld in 1885 at Zea harbour were used as a model for the reconstruction of the Atheniam trireme; in 1987, the survey and the measurements of the single sheds allowed the construction of a full-scale trireme—*the Olympias II*—which was 37m long and 5.5m wide (Blackman 1968: 181–2; Morrison *et al*. 2000: 4–5, 132–4, 192–5).

Archaeological evidence of shipsheds

The archaeological evidence here discussed concerns only the shipsheds which belong to the Greek world, i.e. the system of independent *poleis* in Greece proper and in the colonised area during the Classical period (Sicily, Magna Graecia etc.).

Shipshed remains have been discovered at 15 sites—in very different states of preservation—in some cases in more than one harbour: Abdera, Apollonia, Aigina, Corcyra (Corfu), Kition, Kos, Loryma (Turkey), Marseilles, Naxos (Sicily), Oiniadai, Piraeus with the harbours of Zea, Munychia and Kantharos, Rhodes, Syracuse, Cape Sounion and Thasos.

The slipways of Aigila (Antikythera, Palaiokastro), Cape Sounion II, Eulimna (Alimnia), Poiessa (Kea), because of their different nature and function, will be discussed further in a separate section. For now, it is important to bear in mind that the location of these structures is very important in understanding how the *poleis* employed their power at sea.

Structure of the shipsheds

As previously stated, the improvement of shipsheds is connected to the invention of the trireme and with the necessity to avoid the deterioration of the vessel. Those buildings were set immediately along the shoreline of the harbour basin. The shipsheds were organised in complexes that were made up of a considerable number of individual slipways placed next to each other in a continuous row. The only complete complexes have been found at the sites of Oiniadai and Naxos, consisting respectively of six and four sheds (Lentini and Balckman 2008: 3; Sears 1904: 228), while for the other sites the evidence only consists of one or two sheds, like in the case of Abdera and Kos (Blackman 2004: 77; Koukouli-Crysanthaky 1992: 162–3). As already stated, length and internal width are important considerations for understanding the type of ship stored in the shed. The average internal width of the shipsheds investigated is around 6–7.50m and would have housed a trireme without any problem. An interesting case is represented by the shipsheds of Rhodes, in the 'tetrapylon area', where the sheds have quite different internal dimensions based on the type of vessel stored (Figure 1; Blackman *et al*. 1996: 389–91). According to Blackman, the wider sheds housed triremes, quadriremes and quinqueremes; while the narrower sheds (4.40m) were used for smaller warships. For the latter, Rankov suggests *hemioliai* and *pentekontors*[2] (Blackman *et al.* 1996: 403–5). On the whole, the seaward side of the shipsheds is the part of the structures which was more subjected to damage; nevertheless the average length of the sheds investigated is attested around 37–38 m, and it is possible to estimate that all the sheds had a total leght of 43–45 m, like at Marseilles (Place Villeneuve-Bargemon) where the surviving lenght is c. 41-42 m (Blackman et al. 2014: 382, 385) - even for shipsheds that have been traced for a maximum length of 20m as at the sites of Kos and Corcyra (Blackman *et al*. 2014: 365, 324).

Inside the shipshed complex every slipway was separated from the others by dividing elements that could consist of columns, piers or walls (only at Naxos), generally realised in poros or limestone blocks. In many sites, only the foundation blocks were found—Syracuse (Via Diaz) is the most evident case of this—and it is not possible to determine with certainty which type of dividing element was used. The average distance between one dividing element and the next

[2] Different to Blackman, who thinks that the narrower sheds could possibly have housed *trihemioliai*; for Rankov the size of *trihemioliai* was closer to triremes and so they would have been housed in the wider sheds.

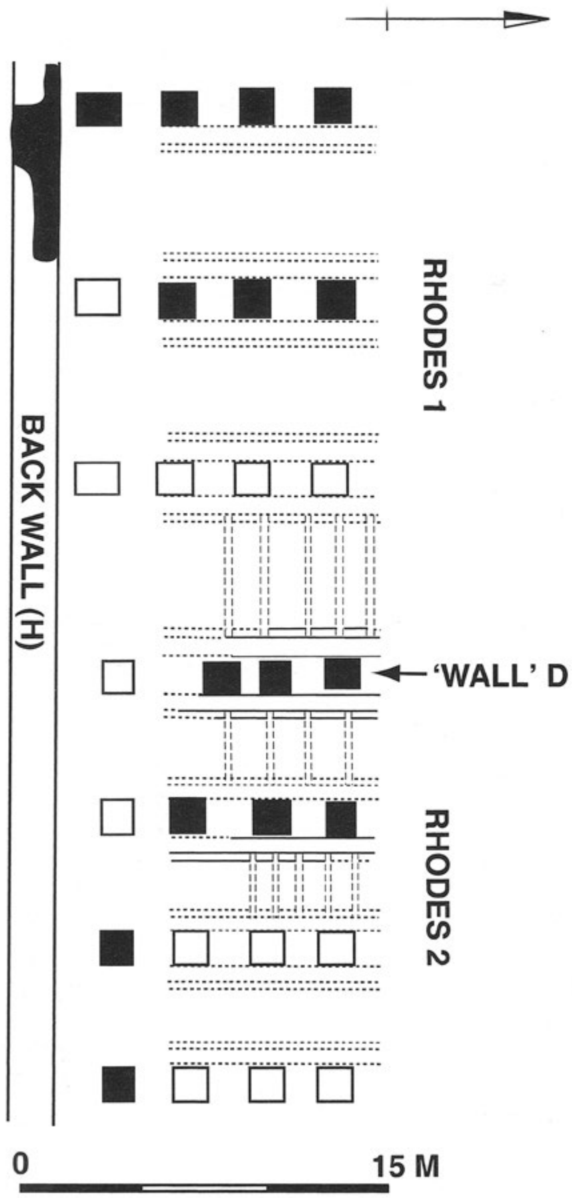

Figure 1. Rhodes: reconstructed plan of shipsheds in tetrapylon area; Phase 2 (Blackman *et al.* 2014: 512 fig. B20.2C).

(columns and piers) is attested to be around 2–3.50m. Also noticeable are the alternating rows of colonnades (respectively 3.38 and 2.16m—Lovén 2011: 88–103) in phase 3 of the Dragatsis/Dörpfeld shipsheds at Zea which, as at Oiniadai and Kition, present buttresses departing from the back wall that are in fact the first element of the colonnade (Figure 2). In cases like Sounion I (Double Shipshed Complex) and Thasos, the lack of dividing elements could be provisionally explained by the use of wooden posts (Blackman *et al.* 2014: 529; Lianos 1993: 263).

The centre of each slipway was occupied by a ramp, upon which rested the keel of the ship. Even though on many sites the ramps are badly damaged, if preserved at all, it is possible to reconstruct their structure. There are two types of ramp construction; they can be cut in the bedrock as at Oiniadai and Sounion I, or built with ashlar retaining walls as on most of the sites investigated, such as Zea, Kition, Kos, Rhodes, Corcyra. The ramps were generally filled with compact soil, cobblestones and gravel. An exception are the sand ramps discovered in the shipsheds of Naxos (Sicily) which for the moment represent a *unicum* in the Mediterranean (Figure 3); it is possible that this solution may have been applied at other sites (Blackman and Lentini 2003: 392). In some cases like Kition, Naxos and phases 2 and 3 of the Dragatsis/Dörpfeld shipsheds at Zea, the ramps curve towards the top end to accomodate the rake of the stern (Lentini *et al.* 2008: 314–7; Yon and Sourisseau 2010: 62–3). The presence of slots cut into the top surface of the ramps served to hold transverse timber sleeves, which supported the keel of the trireme while it was in the shipshed and eased the launching and slipping operations. This wooden groundway stretched some metres under the sea level outside the shed. All the ramps required a specific slope, to allow the storage of the warships inside the *neosoikoi*; the average slope of the ramps at the site examined is around 5–7°. An original solution is attested in the Zea shipsheds, where the slope is not provided by ramps but by the decreasing foundation blocks of the building (Blackman *et al.* 2014: 453).

The preservation of complete complexes is very rare, so evidence for shipshed entrances is very poor. Regarding the Piraeus, in the nort-west side of Munychia harbour, M. Petritaki investigated four sheds which had a back wall with a doorway leading to the street immediately behind (Lovén 2011: 48). The only two complete complexes discovered, at Oiniadai and Naxos, present two different arrangements. In the first case (Figure 2) an access was set along both the two side walls facing the seaside; while at Naxos, four accesses closed by doors (hinge traces) in the side wall leading to the first shed were found (Blackman *et al.* 2014: 413; Blackman and Lentini 2010: 37–9). These accesses were the only connection with the outside.

Inside the shipsheds, towards the back wall, there were passages to allow access to the single sheds. In Oiniadai and Zea (Dragatsis and Dörpfeld), this consisted of narrow spaces between the buttresses and slipways, while in Kition, towards the back wall, there were side passages (*c.* 1.7m wide) approached by three steps. In Naxos, because of the walls dividing the single sheds, openings in the side walls of each slipway were arranged (Blackman and Lentini 2003: 397; Yon 2000: 103).

Alongside the ramps, gangways were set to facilitate the movement of the crew during the slipping and launching. The average width of the gangways examined varies from 60 to 80cm; at Naxos, the good preservation

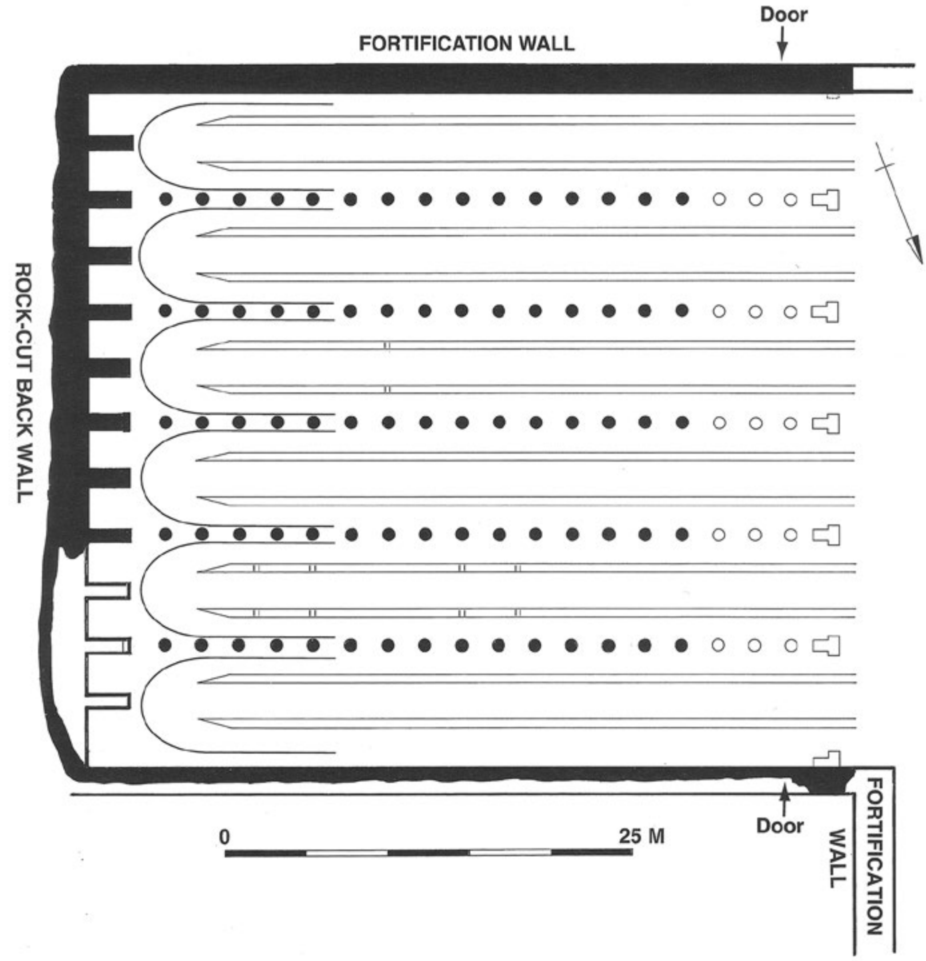

Figure 2. Oiniadai: reconstructed plan of shipshed complex (Blackman *et al.* 2014: 414 fig. B15.2).

of the site led the discovery of paved gangways, which have yet to be found anywhere else. Inside the shed minor maintenance work was also carried out, like the painting of the hull. This is proved by the discovery of pigments of hematite, a red paint, inside the ramps of Naxos (Blackman and Lentini 2010: 41–2).

In many of the sites, there was little or no evidence—consisting solely of a few tiles—of the roofing, but there is no doubt that all the slipways were covered. In general, every single slipway was covered by a tiled ridged roof. Because of the internal slope of the ramps, the roof was given a corresponding incline, either along a continuous line or in steps. In Oiniadai, the Doric capitals have a sloping abaci designed to support the slope of the roof. The shipsheds investigated in Zea harbour by Dragatsis and Dörpfeld present in the third construction phase a similar arrangement, though with the roof covering two slipways at the same time. (Blackman *et al.* 2014: 415, 470–1). At Naxos, the shipsheds were probably roofed in pairs by a series of three asymmetrically sloping ridge roofs (Blackman and Lentini 2003: 397).

An exceptional discovery in Naxos is the identification of the architectural decoration of the shipsheds, the only evidence of such a practice in the whole Mediterranean thus far. It was possible to distinguish two different roofing systems, which correspond to two chronological phases: the earlier roof—dated to the end of the 6th / beginning of the 5th century AD—is of Sicilian type with antefixes that show the unusual alternation of *gorgoneia* and silenus masks (Figure 4); the later roof is of mixed type with pentagonal cover-tiles of Corinthian type combined with semicircular pantiles (Lentini *et al.* 2008: 362, 323–49). This discovery is of immense importance, because it proves that the shipsheds where not only functional structures, but also representative places of the city wealth, worthy of being decorated like the other public buildings of the *poleis*.

The fortification of shipsheds

The shipsheds were placed inside the harbour basin, right on the water. In some cases they were included within the fortification system of the *poleis*; at Abdera

Figure 3. Naxos: Shipshed 3, ramp and back wall detail (Parco Naxos Taormina, Arsenale Navale o Neoria. Courtesy of Regione Sicilia, Assessorato Beni Culturali e I.S., Dipartimento Beni Culturali e I.S., Parco Archeologico di Naxos. <http://www.parconaxostaormina.it/it/naxos/arsenale-navale-o-neoria>.

and Naxos the shipsheds were located near the city walls, which enclosed them on the landward side (Blackman *et al.* 2014: 272, 395–6). In most cases, the shipsheds were located in the place the ancient sources called *kleistos limen*, namely the 'closed harbour' (military harbour) and, when arranged in several complexes next to each other, could surround the whole basin.

For protection, the harbour mouth was enclosed by moles and breakwaters projecting from the shore and ending with defensive towers on the seaside. Often the moles of the closed harbour were a prolongation of the city walls that enclosed the basin. This layout can be seen in many of the sites examined, the most famous and impressive example of which is Piraeus, with the fortification walls and moles protecting the three harbours of Kantharos, Munychia and Zea (Figure 5) (Lovèn 2007), followed by Aigina where the north complex is attached to a mole which acts as its back wall (Knoblauch 1972:75–80). Other examples can be seen at Corcyra, Rhodes, Thasos and Syracuse, even if for the latter the archaeological evidence is not conclusive (Basile 2002).

The shipsheds were protected not only on the seaside. An inner wall running along the coastline was built to divide the harbour area from the urban space. Therefore, is it possible to see how within the *polis* there was a clear separation between the city and the arsenals which housed the fleet. This wall had one or more entrances—for the Piraeus, B. Graser records traces of a '*Polygonalmauer*' running along the harbours of Munychia and Zea (Blackman *et al.* 2014: 437–40)—and enclosing the harbour facilities on the inland side, being connected to the city fortifications.

The topographical relationship between the *agora*, the polical centre, and the military dockyards is a fundamental aspect for understanding the importance—real and symbolic—that the *neoria* had within the Greek

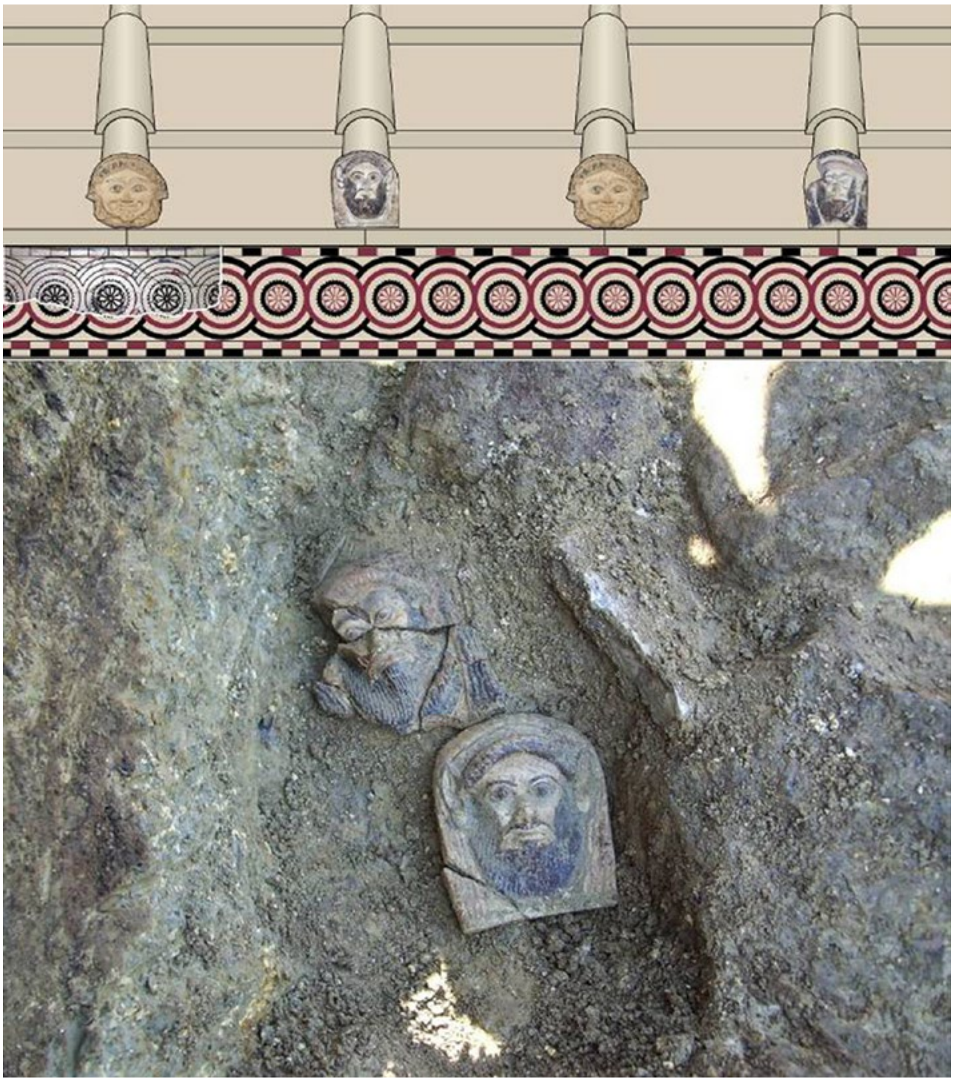

Figure 4. Naxos: silenus masks (type A) discovered inside shipshed 3; reconstruction of the earlier roof with alternation of *gorgoneia* and silenus masks antefixes (Parco Naxos Taormina, Arsenale Navale o Neoria. Courtesy of Regione Sicilia, Assessorato Beni Culturali e I.S., Dipartimento Beni Culturali e I.S., Parco Archeologico di Naxos. <http://www.parconaxostaormina.it/it/naxos/arsenale-navale-o-neoria>).

cities. The shipsheds of Corcyra (Alkinoos harbour; Kokotou site), constructed at the end of the Archaic period and the beginning the of the 5th century BC, were located in close proximity of the *agora*; more than one century later, in the 4th century BC, the shipsheds of Kos attested again this relation. In the cases of Thasos and Naxos, the proximity to the administrative centre is impressive; in the first site (Figure 6), the *agora* was directly adjacent to the military harbour, divided only by a stretch of the coastal fortification walls (Blackman *et al.* 2014: 193; 321). At Naxos, south of the shipsheds complex and on a higher level, was placed the open space of the *agora* (Lentini *et al.* 2008: 299–300). In addition to the clear representative function exercised by the proximity of the shipsheds to the *agora*, the latter would also have provided enough space to gather the rowers for the manning of the triremes (Blackman *et al.* 2014: 199).

The slipways

A slipway is a simple unroofed shed cut in the bedrock and often equipped with a wooden groundway to facilitate the slipping and launching operations. In most cases, the slipways investigated now lie below sea level for half or more of their length; unfortunately, slipways have rarely been investigated in their entirety because of the strong erosion that occurred over the centuries. The slipways investigated, already mentioned, are Aigila (Antikythera, Palaiokastro),

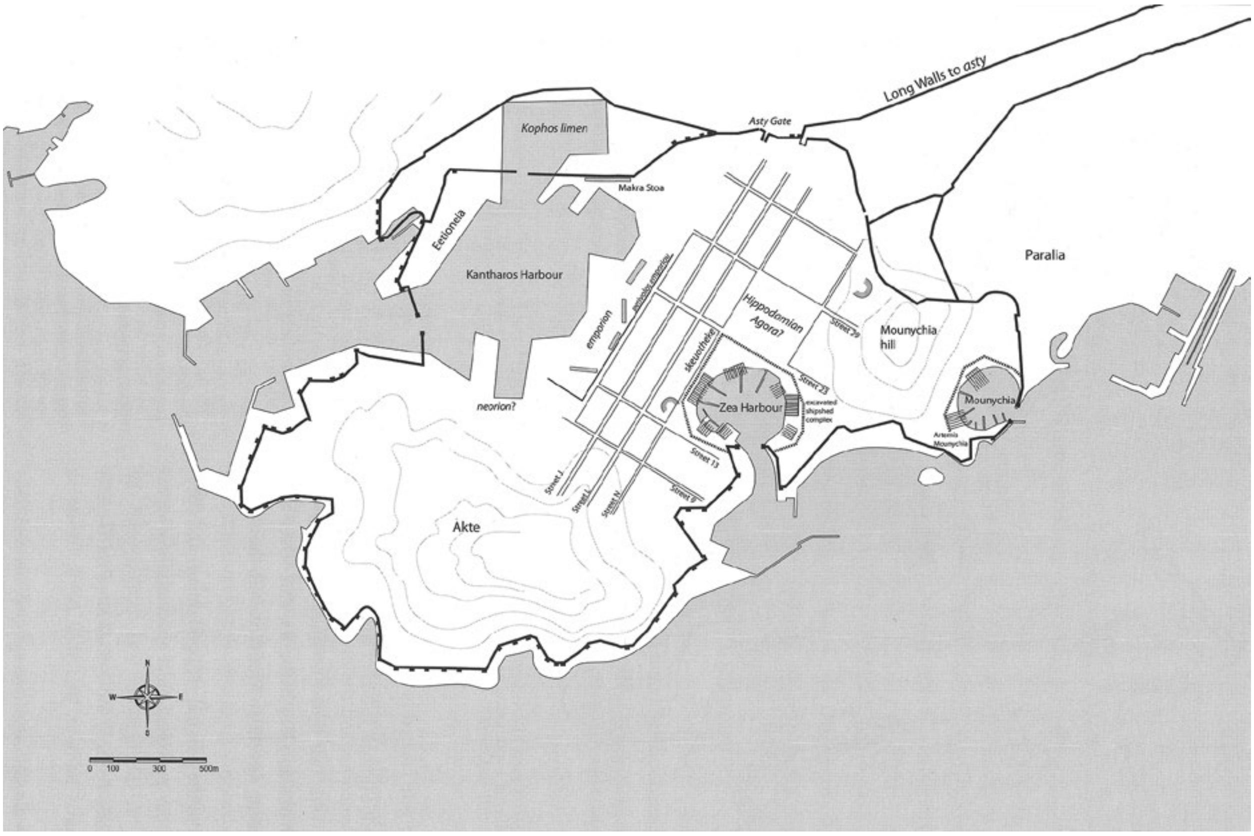

Figure 5. Piraeus: plan of the city with the three harbours of Kantharos, Zea and Munychia; wall circuit and main street grid (Blackman *et al.* 2014: 198, fig. A10.9).

Sounion II, Eulimna (Alimnia) and Poiessa (Kea island). The measurements of the length of the slipways vary from 18 and 27m. The widths are more regular at around 8–11m; only 'shipshed 1' at Emporeio Bay (Eulimna) is 18.5m wide and could have been a triple slipway. These slipways, which represent the basic structure for hauling, were all located in stategically important sites and in relation with harbour installations and fortifications. The slipway of Aigila was in proximity to the fortified acropolis of Kastro, while Sounion II was near the famous Athenian naval base of Cape Sounion. The slipway of Poiessa lies below the fortified hill of Phyra (Panagia Sotira), while near the two groups of slipways discovered at Eulimna (Emporeio Bay and Aghios Georgios Bay) were discovered traces related to fortifications and probably to harbour installations (Blackman *et al.* 2014: 277, 342, 530; Baika 2010: 69).

Conclusions

The archaeological evidence reflects only a small fraction of the shipsheds that existed in antiquity; *poleis* like Corinth and Megara, like many others, were with no doubt equipped with these structures that left no trace or have yet to come to light. At the sites investigated, complexes composed of several sheds have been discovered (like at Aigina, Oiniadai, Kition, Rhodes and Zea), as well as others consisting of only one or two sheds, like at Kos, Thasos and Syracuse. However, in each of these sites, the shipsheds were widely arranged along the shore of the military harbours, in some cases surrounding the whole basin, like in the harbours of Zea and Munychia. In this regard, the archeaological record needs to be considered very carefully, as the spread of the organisational system of shipsheds was much more widespread than appears from current evidence.

On the basis of the sites investigated, it is possible to observe how, starting from the 5th century BC, inside the *polis* a separation occurred between the commercial and the military harbour, planned to house and protect the city fleet. Precisely for their importance, the shipsheds needed to be protected both towards the seaside, due to enemies, and towards the landside, isolating them from the rest of the city as they were, essentially, a restricted military area.

The shipsheds are always included within a fortified system, whether the military fortified harbour or the city walls. The development of the dockyards and the growth of the city as military power strongly influenced the political and urban organisation of the *polis*.

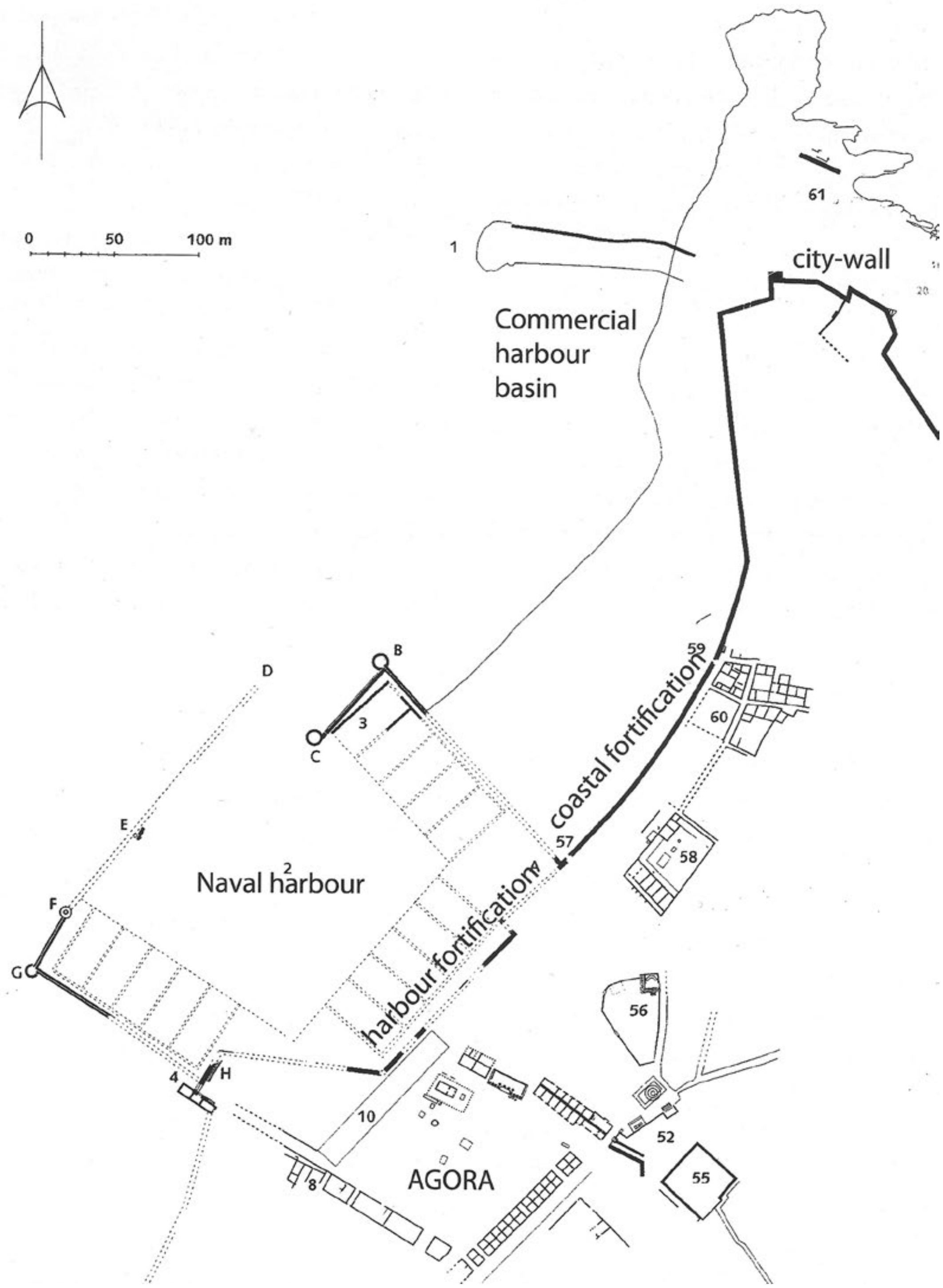

Figure 6. Thasos: military harbour basin, fortifications and relationship with the *agora* (Blackman *et al.* 2014: 190, fig. A10.3).

The planning and the distinct place in the city grid, together with the monumentalisation of the shipshed complexes show how they were recognised as founding places within the citizenry. They were the real and imaginary attestation of the military power (capability) of the *polis*. The fact that many of the military harbours were in proximity of the *agora* highlights even more the importance they had within the structure of the *polis*. There is no doubt that the shipsheds were public buildings, as proven by the roof-tiles found at Corcyra (Kokotou site) labelled with the letters ΔΑ[ΜΟΣΙΟΣ] (Blackman *et al.* 2014: 328).

An aspect that should not be underestimated is the visual effect that the dockyards would have had in antiquity. Although the Piraeus did not represent the average, its large number of shipsheds around the harbour basin can provide a good example. In the naval lists of Athens, dated to the second half of the 4th century BC (*Inscriptiones Graecae* II^2 1627.398–405 for 330–329 BC; 1628.552–9 for 326–325 BC and 1629.1030-6 for 325-324 BC), the same number of *neosoikoi* were reported: 82 at Munychia, 196 at Zea and 94 at Kantharos for a total of 372 shipsheds. Secondly, on the basis of the discovery of the architectural decoration at Naxos, it is possible to assume that maybe also some of the other shipsheds could have had decorations which have left no trace. Therefore, viewed all together, the shipshed complexes would have made a profound impression on the spectator.

More clear is the difference between the shipbuilding yards, where the construction and maintenace of ships was accomplished, and the shipsheds designated to house the warships, where at most minor maintenance work was carried out, like caulk and painting, as attested by the find of a red pigment, haematite, inside one of the ramps of the shipsheds of Naxos (Blackman and Lentini 2010: 41–2).

All the slipways investigated are located in militarily important places and always connected to harbour installations and fortifications that, considering the dimensions of the nearby settlements, when present, have been attributed to major naval powers. These installations were probably guard-stations for the facing sea and the nearby shores, or naval bases for assaults. Because of the difficulty of dating the slipways, it is only possible to make some general observations about the maritime powers controlling the sites. Sounion II was surely under the control of Athens, given its proximity to the naval base of Cape Sounion. Poiessa (Kea island)—located at the entrance of the Saronic Gulf—could have been controlled both by the Athenians or by the Rhodians, depending on the dating. The slipways of Eulimnia were probably arranged by the Rhodians, considering that the small island offers an excellent view of the east coast of Rhodes. The dating of Aigila is even more difficult; the fortification and construction of the slipway could have taken place both during the Peloponnesian War by the Athenians or during the Hellenistic period (Blackman *et al.* 2014: 279, 345, 491, 530).

It is possible to divide the sites where shipsheds were found into three different groups. The first category is composed of the great *poleis* expressing a military political awareness, having a strong extra-urban role. They are equipped with monumental shipshed complexes—with their related fortification systems. The sites with these features are the *poleis* of Athens, Corcyra, Rhodes and Syracuse (for the latter archeological remains are scarce, but we do have literary sources). The second group is composed of the mid-sized *poleis* that in the first chronological phases employed the shipsheds for a limited period of time and with smaller number of structures. Within this category are the cities of Abdera, Aigina, Apollonia, Kition, Kos, Marseilles, Naxos, Oiniadai and Thasos. The third group is composed of the slipways which—in conjunction with harbour installations and fortifications—worked as complementary ports, enhancing the coastal defenses and providing a naval base in strategically important locations. As mentioned above, these infastructures were probably established and controlled by the maritime powers belonging to the first group, like the *poleis* of Athens and Rhodes. Aigila, Eulimna, Sounion II and Poiessa (Kea island) are part of this group.

The shipsheds and slipways investigated here are dated from the 6th century BC to the late Hellenistic period; the first ones start being constructed between the end of the 6th and the beginning of the 5th century in the *poleis* of Syracuse, Naxos, Abdera and Thasos and expand in parallel with the growth of the *poleis* and the development of the fleets. The 5th century BC is the golden age of the military dockyards with the creation of the shipsheds of the Piraeus, Aigina, Corcyra, Kition and Sounion, followed by the installations of Kos and Oiniadai in the first half of the 4th century BC. Lastly, in the second half of the 3rd century BC, the Hellenistic shipsheds of Rhodes were constructed; while the shipsheds of Marseilles are dated by the 3rd and 2nd centuries B.C..

During the Hellenistic period and subsequent Roman period most of the shipsheds were abandoned and destroyed or employed for other purposes, for example as storehouses. The military harbour of Kition became a commercial port, just as at Rhodes (Yon 2000: 103); the shipsheds of Oiniadai and Corcyra were destroyed at the end of the 3rd century BC and in the 1st century BC respectively (Blackman *et al.* 2014: 329; 416). In the Roman period the majority of the shipsheds no longer exist or were used for different purposes.

Some explanation for this change is needed. During the Hellenistic period and later in the Roman period, the Greek *poleis* lost their political independence—initially under the Hellenistic kingdoms and then under Roman dominion, and consequently the right to possess their own fleets. From then on, military decisions were made in different places than those which had witnessed the rise of the fleets in the Greek world. Another important aspect is the invention and increasing use of polyremes in the fleets during the 4th century BC. The polyremes employed more than a single rower for each oar, resulting in an increase in their dimensions and stability. On the other hand, polyremes were unsuitable for tactical manoeuvering and ramming but had a clear advantage in more static engagements, like boarding, because of the large numbers of men and pieces of artillery and equipment that they could carry. The polyremes marked the first sign of the change in seawar styles and the decline of the classical naval battles performed mostly with the ram and tactical manoeuvering.

A proof of this phenomenon can be seen in the Athenian naval lists mentioned above which attest to the increased use of polyremes in the fleets during the 4th century BC. In the naval list of the year 330–329 BC, 18 quadriremes and 393 triremes were reported. In the list of 326–325 BC, the fleet was composed of the same number of warships, but only 360 were triremes, and the remaining were quadriremes. This could mean that maybe the triremes, once they were unusable, were replaced with this new type of warship that could be housed inside the same shipsheds. Exept for the quadriremes, which were not much larger than the triremes, polyremes could not fit inside the classical trireme shipsheds because they were too big and wide. Regarding the Greek world, the only sheds that might have housed quinqueremes are the wider sheds of the Rhodes complex. It is possible that most of the sheds designed for the quinqueremes still remain to be discovered. According to B. Rankov (Blackman *et al.* 2014: 99) is likely that sheds of even greater width, designed to house ships larger than the quinqueremes, did exist, though the only ones mentioned in the literature were created with the purpose of displaying ships as trophies.

At the conclusion of this study, it is possible to affirm that the military dockyards in the Greek world were a phenomenon of great urban and symbolic significance inside the *polis*, indicative of its military aptitude and seapower.

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Celebrating the theme 'Shared heritage', *IKUWA6* (the 6th International Congress for Underwater Archaeology), was the first such major conference to be held in the Asia-Pacific region, and the first IKUWA meeting hosted outside Europe since the organisation's inception in Germany in the 1990s. A primary objective of holding *IKUWA6* in Australia was to give greater voice to practitioners and emerging researchers across the Asia and Pacific regions who are often not well represented in northern hemisphere scientific gatherings of this scale; and, to focus on the areas of overlap in our mutual heritage, techniques and technology. Drawing together peer-reviewed presentations by delegates from across the world who converged in Fremantle in 2016 to participate, this volume covers a stimulating diversity of themes and niche topics of value to maritime archaeology practitioners, researchers, students, historians and museum professionals across the world.

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