A MARITIME RESEARCH PROJECT FUNDED BY THE EUROPEAN UNION CULTURE 2000 PROGRAMME

MACHU Report

Managing Cultural Heritage Underwater

Nr. 2 www.machuproject.eu

PHOTO FRONT COVER:
Björns Wreck, wooden 18th century wreck,
Stockholm archipelago, Sweden
Photo: Patrik Höglund, SMM

ISBN 978-90-76046-58-7
AMERSFOORT – JANUARY 2009

CONTENTS

MACHU (Managing Cultural Heritage Underwater) is a three year project between 7 countries (see above) sponsored by the Culture 2000 programme of the European Union.

The primary goal of the MACHU project is to find new and better ways for an effective management of our underwater cultural heritage and to make information about our common underwater cultural heritage accessible for academic purposes, policy makers and for the general public (see also Report Nr. 1). This is going to be achieved through the construction of a Web based GIS application (for management and research) and an interactive website that has to increase access of our underwater cultural heritage to the general public, the citizens of Europe. Through this, it aims to engender a greater public commitment to the protection of sites underwater. Further, by tackling the issues through a multi-country approach MACHU will inherently promote greater mobility of both data and researchers working in the field of common underwater cultural heritage. The project will therefore also contribute to a cultural dialogue between and mutual knowledge of the culture and history of the countries involved.

MACHU project will run from September 2006 until August 2009.

FOREWORD

MARTIJN MANDERS

Dear reader,

On behalf of the MACHU-project team I hereby present you the second MACHU report. In the previous one, which was presented in January 2008, the project and its goals and the partners involved have been presented. In this issue the project will be presented in more detail, focussing on the products we are producing and the use of those products in the European management of underwater cultural heritage (UCH).
For example, what can we do with the MACHU Geographic Information System (GIS)? What is de use of it for archaeologists? And for heritage management officers? The MACHU-GIS is an important product of MACHU, but certainly not the only one. The MACHU website is not just an assemblage of information on UCH. It has the purpose to specifically address several groups of stakeholders. Thé general public doesn't exist. To be able to address people well, we have to define them and to define their needs. In this issue the ways to address certain groups of stakeholders are being pointed out and explained.
MACHU is also investigating new ways to assess and monitor the UCH: Sedimentation Models are being developed and within MACHU the first attempts to date the seabed through Optical Stimulated Luminescence (OSL) are being executed.

The second MACHU report keeps you updated on what is going on in the MACHU project. But as you will notice, it is more than that. It contains information that is informative and can be of use for all involved in underwater cultural heritage. I sincerely hope you enjoy reading it.

THE TEST AREAS BURGZAND NOORD AND THE BANJAARD

WILL BROUWERS

The two MACHU test areas, the Burgzand Noord at the Texel Roads in the Wadden Sea (figure 1) and the Banjaard in Zeeland, were introduced in the first MACHU report. Assessments on wrecks and investigation on the two sites have continued in 2008.

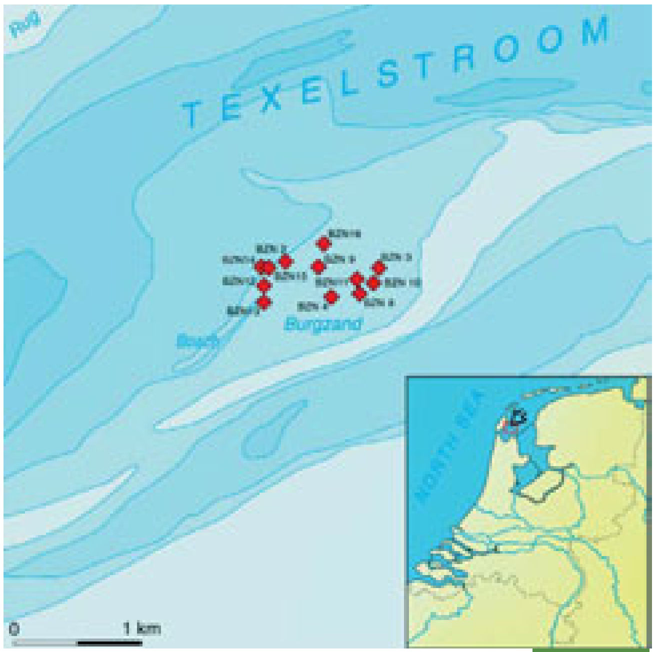


FIGURE 2

FIGURE 1

The National Service for Archaeology, Cultural Landscape and Built Heritage (RACM)
Rijksdienst voor Archeologie Cultuurlandschap en Monumenten

P.O. Box 1600, 3800 BP Amersfoort – THE NETHERLANDS
T +31 (0)33 42 17 421 **F** +31 (0)33 42 17 799 **E** info@racm.nl www.racm.nl

Representatives of the National Service for Archaeology, Cultural Landscape and Built Heritage involved in the MACHU project:
Martijn Manders, Will Brouwers, Paul Boekenoogen, Rob Oosting, Andrea Otte, Wendy van der Wens-Poulich, Aise van Dijk, Bertil van Os, Menne Kosian

CO-ORGANISOR **Directorate IJsselmeer Region Rijkswaterstaat (RWS) IJsselmeergebied**

Rijkswaterstaat IJsselmeergebied, Meet- en Informatiedienst, Zuiderwagenplein 2,
PO Box 600, 8200 AP Lelystad – THE NETHERLANDS
T +31 (0)320 29 89 98 / 320 29 76 63 **F** +31 (0)320 23 43 00 / 320 29 71 75
E wim.dijkman@rws.nl / herman.hootsen@rws.nl

Representatives of the Institute involved in the MACHU project:
Wim Dijkman, Herman Hootsen, Harry Koks

The test area in the Wadden Sea consisting of 4 wrecks (BZN 3, 8, 10 and 11) is actually a small part of a larger area that is called Burgzand Noord with 12 known sites *(figure 2)* of which five (BZN 2, BZN 3, BZN 4, BZN 8, BZN 10) are physically protected. The BZN 10 was subject to an optical stimulated luminescence (OSL) dating research programme: for the underwater archaeology a new method. The method and some preliminary results will be discussed in length elsewhere in this Report (see page 40).
The test area is being monitored each year – since 2002 – by means of Multibeam survey. Through this repeated survey we have built up a lot of know how on seabed change over the last 7 years, especially around the shipwrecks. It gives a good overview on the severe erosion of the seabed which is backed up with visual check ups by divers. The work has also shown the importance of ongoing monitoring and maintenance programmes on (protected) sites.

The Multibeam data is currently being incorporated in a sediment erosion model for the area around the BZN 10 which is going to be a detailed model complementary to the large scale sediment erosion model for the North Sea and beyond. This model is being developed for the MACHU project by the team of J. Dix of the National Oceanography Centre in Southampton (see page 40).
The RACM has also focussed on interpreting old historic maps.
Information on historic maps about coasts, currents, buoying and routing is of extreme importance for the MACHU project. This

FIGURE 2: The Battle of the Downs 1639 (painting by Reinier Nooms). The vessel shown is the Aemilia, Tromp's flagship.
Source: NMM London

FIGURE 3: The Texel Roads in 1725. Wall painting by Johan Reydon (1983). Can be viewed in the Maritime Museum in Oudeschild, Texel.

chart information can help to predict the disposition of (unknown) wrecks, the changing of coast and seabed during the centuries.
Dutch mapmakers were well known in the 16th and 17th century. One of the most significant marine cartographers was Lucas Waghenaer who in 1584 published The Spieghel der Zeevaert. His way of working was the standard for centuries (as a matter of fact a sea chart is still called a Wagonaer in English)
The first part of the Spieghel der Zeevaert – the chart of Holland and the Waddenzee – has been digitalized and projected in the MACHU GIS. From that same area, three other maps from different periods (1598, 1666 and 1773) are being digitalized as well, giving a good overview of changes of sea routes, gullies, sandbanks, etc. through time. More about the digitalisation of the sea maps can be found on page 26.

One of the sites in the Burgzand Test Area: BZN 3, was in 1988 the first shipwreck underwater ever being designated as an archaeological monument in the Netherlands. Around the wreck is a protected area with a diameter of 600 m was established, especially to avoid looting. In 2009 the protected area will be enlarged to a square zone of about 70 hectares. With this enlargement immediately twelve historic wrecks on the Burgzand will be protected by law.
In the other Dutch testarea – the Banjaard in Zeeland – the working strategy is different. It was from the start of the project a relatively unknown area. One thing we did know was the high dynamics of the seabed. Research on seabed changes are very interesting for the sediment erosion models of the Southern North Sea made for MACHU by the University of Southampton (see page). Thanks to the avocational diving community there are a lot of reported coordinates of wreck points inventoried. Several of these wreck locations have been validated and according to MACHU standards incorporated in the MACHU GIS. There are two avocational diving organisations who work closely with MACHU to validate more of these points in the near future (see also article avocational diving community and MACHU). In the summer of 2008 three locations have been surveyed with multibeam recordings which yield new information about the wrecks and the seabed around them. The multibeam recordings reveal two iron wrecks and one wooden vessel.

A particularly interesting case in which archaeologically skilled amateur divers from the Nehalennia Archeologisch Duikteam (NAD) contributed largely is the investigation to a well known wreck; The Rotterdam*. Divers from the NAD discovered wooden parts and ceramics (Beardman jugs) of another wreck underneath the Rotterdam. In other words: there were two wrecks lying on top of each other! Tree-ring analyses and ceramics found suggest a preliminary date somewhere within the 16th century.

**A steamer sunk 1888: see www.machuproject.eu: wrecks page*

History of BZN 3

It is not always possible to date or identify a wreck or say something about the history of a ship. However, the BZN 3 (www.machuproject.eu: wrecks page) was identified as the Dutch East Indiaman Rob that sank in 1640. The Rob is very well preserved with inventory, canons and even the ships galley (oven) still in place. The ship was approximately 35-40 meters long. We know quite a bit of her actual history. The Dutch Republic was still at war with Spain (80 years war: 1568-1648). In 1639 the Commander of the Dutch Admiralty Maarten Tromp was commissioned to prevent a large Spanish fleet (the Second Spanish Armada) from re-supplying the Spanish troops in Flanders. In the first encounter on 26th September Tromp deployed a new tactic: the line-of-battle in a leeward position. His flotilla of 17 ships destroyed or damage many ships from the Spanish fleet (in total 67 ships). The battered Armada was pinpointed at the Downs in English waters.
The commander summoned every armed merchant vessel in Dutch harbours to come and help destroy the Spanish fleet. And it is at this point we hear of The Rob being assigned to the flotilla of Admiral Maarten Harmsz. Tromp. We know it took part at the battle of the Downs in which on 31 October 1639 the entire Spanish armada was destroyed (figure 3). The Rob fought bravely serving in the squadron of Admiral Cornelis Jol - a famous buccaneer (nicknamed Pegleg) – and who was mentioned especially by Tromp. After the battle the Rob returned to Dutch waters were she sank while waiting at the Texel roads.

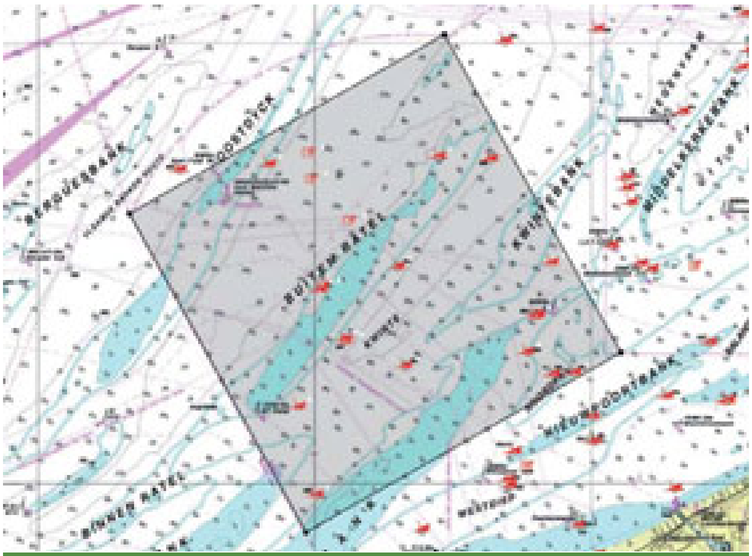


FIGURE 1: The Buiten Ratel area, 1 of the two 2 areas of the MACHU project, in which 21 wreck sites could be localised so far. © VIOE

ONGOING RESEARCH AT TWO TEST AREAS IN BELGIAN WATERS (FLANDERS)

INE DEMERRE & INGE ZEEBROEK

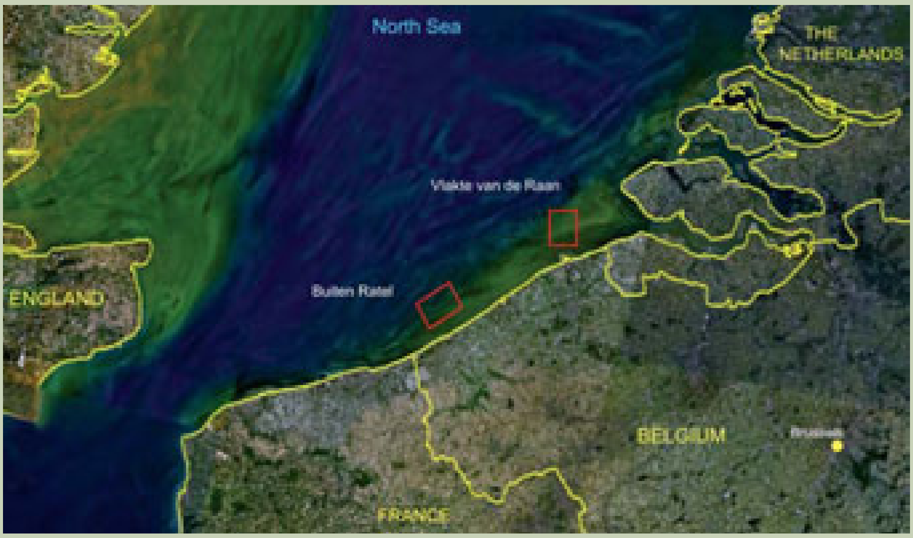
The first MACHU report included an introduction to the two MACHU project test areas in Belgian territorial waters, 'Buiten Ratel' and 'Vlakte van de Raan'. On the basis of the results of desk-based research the Flemish Heritage Institute (VIOE) has been organising the investigation of listed wreck positions from two private vessels, 'Ephyra' and 'Divestar', and the research vessel 'Zeeleeuw' (with the use of 'Vloot', the governmental shipowner) in cooperation with a team of voluntary divers (see article: *Cooperation with non-archaeological scientific institutes, organisations and individuals - Ine Demerre, page 30*).

This approach is designed to provide a fuller description of each wreck site and thereby to assist in identification and/or dating. The condition of each wreck is examined, with sedimentation, preservation, the extent and possible causes of damage, and potential threats all being considered. The seabed around each wreck site is also recorded as much as possible through observation and sediment sampling.

Of the 21 recorded wreck sites in the 'Buiten Ratel' area (*figure 1*), 11 have been investigated in this way. In two cases the reported wreck was not found. This may have been because of inaccuracy in the identification of the location – perhaps the result of some non-archaeological feature such as an anomaly in the seabed – or because the wreck has been buried by sediment. Nine shipwrecks were investigated successfully by divers.

The most thoroughly studied site is the 'Buiten Ratel wreck'. The 'vzw NATA' (a non-profit association called 'Noordzee Archeologisch Team Aquarius') has been engaged in underwater research at this site for 10 years, and now its records, including observations and artefacts, have for the first time been described and thoroughly analysed by the VIOE.

The Buiten Ratel wreck was a large wooden ship. Four of its large anchors are visible at the site. Only small sections of the wreck itself protrude above the seabed, but these include a large wooden beam and several parallel planks spread over an area of about 21 by 8 m. It is intended that the site should



The Flemish Heritage Institute (VIOE: Vlaams Instituut voor het Onroerend Erfgoed)
The Maritime Archaeology and Heritage Afloat Unit

Koning Albert II-laan 19, Bus 5,
B-1210 Brussels – BELGIUM
T +32 (0)2 553 16 50
F +32 (0)2 553 16 55
E instituutonroerenderfgoed@vlaanderen.be
www.vioe.be

Representatives of the Institute involved in the MACHU project:
Ine Demerre, Marnix Pieters, Inge Zeebroek

be recorded in greater detail. The Renard Centre for Marine Geology (Ghent University) *(see article: Cooperation with non-archaeological scientific institutes, organisations and individuals, page 30)* has made acoustic (seismic) recordings of the seabed and subsoil in this area, and these give an idea not only of the shape of the wreck, but also of the level of sedimentation. The amount of wood on the surface restricts measuring deeper parts of the wreck remains underneath, using this recording technique.

Many of the objects recovered from the wreck over the years have been linked with specific places situated in The Netherlands. Among these are a pocket watch from Amsterdam, clay pipes from Gouda, and the bottom of a tobacco box with Dutch inscriptions. Stylistic attributes and markings suggest a mid-eighteenth century date for many of the artefacts. Two wooden barrels were dendrochronologically dated to 1733 and 1735 respectively (Kristof Haneca, VIOE), dates which provide a terminus post quem for the sinking of the ship *(figure 2 & 3)*. The wreck has not yet been identified.
In the 'Vlakte van de Raan' area three sites were the subject of a successful preliminary investigation in 2008. All three were WWI or WWII submarines.

RESULTS

SEDIMENTATION

Most of the wrecks in the Buiten Ratel area are covered with a thick layer of sediment – this is especially true for two WWI destroyers, 'G-96' and 'Branlebas' *(figure 4)*. One site, B109/230, yielded only pieces of metal, wheels and wooden beams; perhaps the cargo of a 19th century ship carrying materials for railway construction *(figure 5 & 6)*.
There has also been significant sedimentation in the 'Vlakte van de Raan' area. Two identified wrecks – the 18th century *'t Vliegent Hart*, and the 20th century fishing vessel, Z.442 *Andre Jeannine* – could not be traced on the known positions through the use of 'multibeam' measurements and the wreck at site B126/306 could not be detected by depth sonar either.

The soil samples taken from most of the investigated sites, and from the area around each, ought to give an idea of sediment types and distribution on wreck sites as compared with the sediments of the Belgian Continental Shelf. The grain size of sediment taken from the wrecks seems to be different from that of the sediment of the surrounding area.

FIGURE 2: Drawing of one wooden barrel found on the Buiten Ralte wrecksite (inv.nr.BW 079). © VIOE, MARC VAN MEENEN

FIGURE 3: Cross section of barrel (inv. nr. BW 079) for dendrochronological dating. Tunnelling is visible of the Teredo navalis. © VIOE

Samples from the Buiten Ratel wreck (B114/230a), for example, had a median size of around 535 and 515 μm, while the median size of recorded sediment from the surrounding area was between 200 and 250 μm.

DAMAGE

Adorning each of the wrecks studied to date have been fishing nets – often complete, but snagged and entangled. While the snagging may cause damage, the nets sometimes cover and thereby protect parts of a wreck.
Poor visibility makes diving in the 'Raan' area difficult, but in spite of this complication at least as much evidence of looting has been detected at the 'Raan' sites as at sites in the more accessible 'Buiten Ratel' area. In each area items have been found which appear to have been lost in the course of efforts to recover parts and artefacts from the wreck sites. These include steel cables, dredges, and pieces of metal. Where shiny copper is visible, it is likely that the metal has recently been either cleaned or cut. At certain wreck sites the propeller and copper portholes have been removed.

In summary, the preliminary underwater investigations have yielded some important information about the wrecks in the MACHU test areas, notably in relation to the character of the different ships wrecked, and their condition. Damage to the ships is being recorded, whether caused inadvertently – through fishing, for example – or as a result of deliberate looting. Signs of looting have been identified on most of the wrecks studied. The visual record being compiled for the area around each site, together with sediment sampling, ought to provide data regarding sediment movement in the area of each wreck, and this in turn should assist with the development of conservation and protection measures. ■

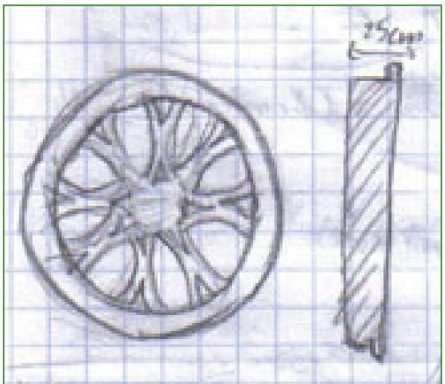


FIGURE 6: Sketch of one of the wheels of wrecksite B109/230 by divers. © VIOE BAS BOGAERT

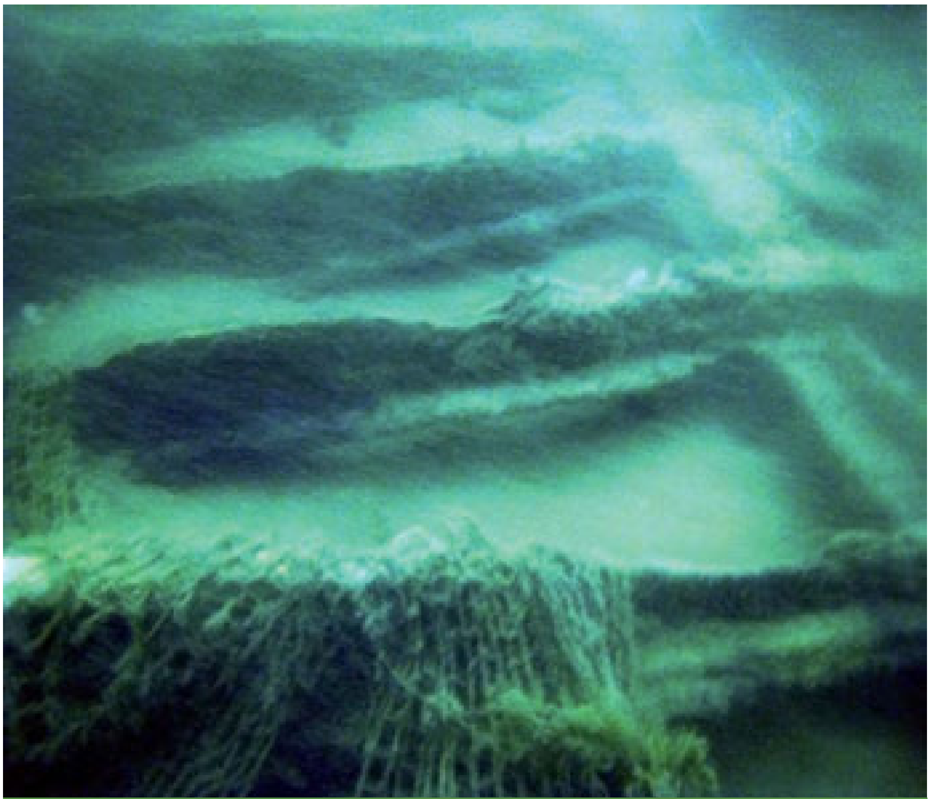


FIGURE 4: Photograph of a fragment on the wrecksite G-96 (B117/236a). The wreck is deeply covered in sediment. A large fishing net is visible. © VIOE

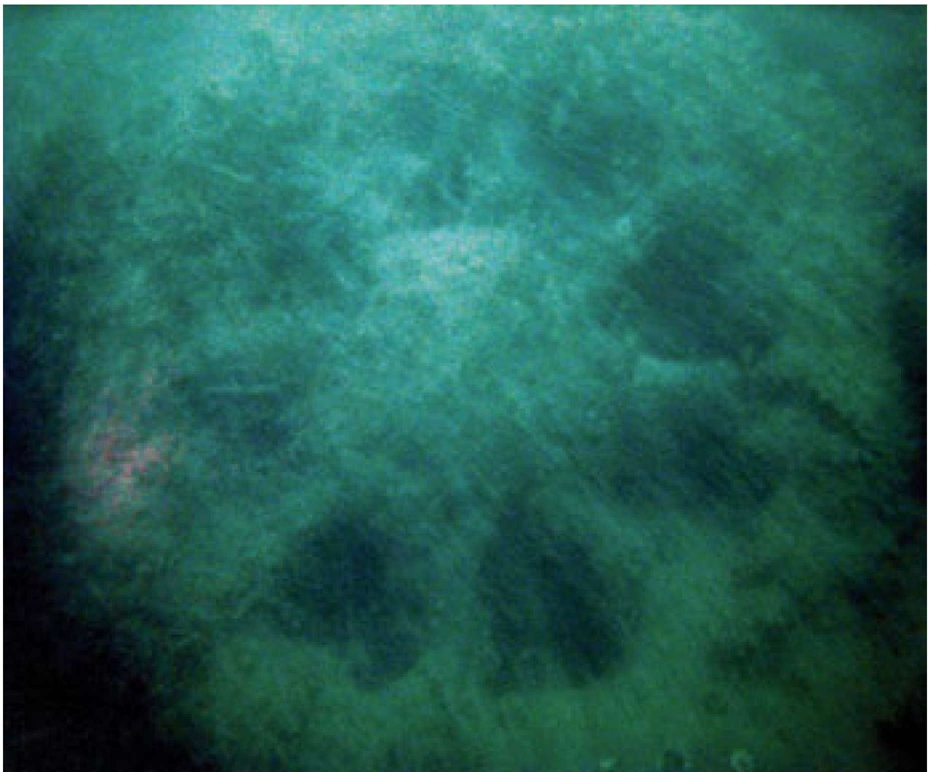


FIGURE 5: One of the five wheels detected on wrecksite B109/230, probably part of a train locomotive. ©VIOE

REFERENCES

■ Zeebroek I. et al. 2009-2010: *Een 18de-eeuws scheepswrak op de Buiten Ratel zandbank (Belgische territoriale wateren): onderzoek van de site en analyse van de vondsten (1)*, Relicta 6, (in preparation).

EXTREMELY RICH AND WELL PRESERVED UNDERWATER CULTURAL HERITAGE

THE TEST SITES WISMAR BAY AND RUEGEN

THE RGK PROJECT TEAM

Germany has selected two MACHU test areas on the Baltic Coast in the country of Mecklenburg-Vorpommern. The aim is to register all archaeological underwater sites in these areas. These are obviously wrecks but also maritime constructions, submerged Stone Age sites and more. Also detailed investigations about destructive processes on archaeological sites will be done. The two test areas are the Wismar Bay as a part of the Mecklenburgian Bay in the west and the coastal waters of Ruegen Island in the east of the country. In addition there is comprehensive new information available about these regions from the research that has been done in the same area by the SINCOS-II-Project *(www.sincos.org)*.

In 2008 the RGK has continued to investigate and register its abundant and still largely undiscovered underwater cultural heritage in Mecklenburg-Vorpommern. An important focus of work however has been the 18th century ship barrier near Greifswald in the Ruegen test area (see article page 32).
Besides the sites that have been described in the previous MACHU Report, the test area Ruegen also revealed three complete Stone Age log boats that were discovered during excavations for a storm water storage basin in Stralsund Harbour. One – from the younger Stone Age (4000-3500 BC) – is with 12 metres long the largest of its type on the south western Baltic Sea coast.

Other, extremely interesting maritime finds are discovered in Jasmund Bay. Here, near the 9th century trading place of Ralswiek, 4 early medieval (10th Century) shipwrecks were found and excavated. These clinker built boats are 10 to 14 metres long, 3.5 metres wide and 1 to 1.2 metres high. Their propulsion was by sailing and rowing.

From the other test area, the Wismar Bay, also early medieval ships were discovered. These were used as boat burials in the graveyard from the early medieval trading centre Gross Stromkendorf. No wood was preserved from these up to 14 m long boats, only rows of iron rivets marking the former plank lines. The application of iron rivets corresponds to the Scandinavian boat building tradition. ■

FIGURE 1: This logboat from Stralsund is broken into many pieces and pressed flat by the weight of the overlying sediments. PHOTO G. SCHINDLER & P. KAUTE LKD M-V.

FIGURE 2: Stoneage sites in the Wismar Bay. FIGURE MACHU

The Roman-Germanic Commission (RGK)
in cooperation with the Authority for Culture and Protection of Monuments in Mecklenburg-Vorpommern
Römisch-Germanische Kommission des Deutschen Archäologischen Instituts
Palmengartenstrasse 10-12, 60325 Frankfurt a. M
GERMANY
T +49 (0)69 97 58 180
F +49 (0)69 97 58 18 38
E info@rgk.dainst.de
www.dainst.de/abteilung.php?id=268

Representatives of the Institute involved in the MACHU project: Friedrich Lüth, Harald Lübke, Stefanie Klooss, Kathrin Staude

FIGURE 1: Rear of the Holland 5 submarine with its propeller. PHOTO: WESSEX ARCHAEOLOGY

PROTECTED WRECK SITE CASEWORK AND MANAGEMENT, SOUTH EAST ENGLAND

CHRIS PATER

English Heritage (EH) itself is not undertaking any fieldwork for MACHU. However all work is being undertaken by (sub-)contractors or licensees. The following overview of what has been undertaken on designated wreck sites that are situated in the MACHU Test areas is based on the reports handed over to EH. The summer of 2008 has been extremely bad for diving. Therefore not much work has been done on the sites.

The *Holland No. 5* was the last of 5 Holland Class submarines ordered from the Holland Torpedo Boat Company by the British Admiralty to see whether there was a future for submarines in the British Navy. The submarine was launched in 1902. In 1912 it sank off Beachy Head and became a designated site in 2005 (*figure 1*). This year the marker buoy was lost and the Contractor was tasked to:

1. confirm the position of marker buoy mooring block and
2. confirm position of rising chain.

The *Northumberland* and *Stirling Castle* are both lying on the Goodwin Sands. In 2007, the Licensee reported that the Northumberland, a 3rd rate 70 gun warship (1679) that wrecked in 1703, remains relatively stable with reduction in sediment to bow and stern areas. The Contractor was tasked to re-locate and accurately position any exposed archaeological material and commence intra-site survey.

The Stirling Castle also sank in 1703 during what is now called the Great Storm. Owing to the general trend for increased sedimen-

FIGURE 2: The site of the Dutch East Indiaman Amsterdam protected by a sheet piling. PHOTO: ENGLISH HERITAGE

tation being observed by the Licensee in 2007, Nigel Nayling from the University of Wales, was commissioned to undertake assessment for dendrochronological analysis and sampling.

In 2008 information panels of the Dutch East Indiaman *Amsterdam* (built in 1748) were placed at Bulverhythe, near Hastings where the ship foundered in 1749. At the presentation of these panels EH met with representatives of the Amsterdam Foundation, RACM and Hastings Shipwreck & Coastal Heritage Centre to discuss management of the Amsterdam *(figure 2)*. EH agreed to draft a Conservation Management Plan.

Another Dutch East Indiaman, the *Rooswijk* (built 1737) was found on the Goodwin Sand where it sank in 1740 and has been subject to commercial salvaging (see also MACHU Report 1). Following stakeholder consultation, the Conservation Management Plan for the Rooswijk has now been implemented and is available to download from the English Heritage website.

English Heritage, Maritime Archaeology Team

Fort Cumberland, Fort Cumberland Road,
Eastney, Portshmouth, PO4 9LD – ENGLAND
T +44 (0) 9285 6735
F +44(0) 23 9285 6701
E maritime@english-heritage.org.uk
www.english-heritage.org.uk/maritime

Representatives of the Institute involved in the MACHU project:
Ian Oxley, Chris Pater, Mark Dunkley

INVESTIGATIONS AT THE THREE MACHU TEST AREAS IN POLAND

IWONA POMIAN

FIGURE 1: The fossil soils horizons in one of dune ridges on the Vistula outlet cone area. PMM

USTKA TEST AREA

Based on the data recorded with multibeam echosounding, a bathymetric map (DTM) has been created for the area of a submerged forest (see also MACHU report 1). The geological characterization of this site was done with the results of side-scan sonar and seismo-acoustic profiling. The sediments from 5 vibrocores, each of ca 2 m long, have been described in a very detailed way.

The results of pollen analyses of two cores of sediments (117-1 and 117-3) show that the lower parts of the sediment were created during the Late Glacial and the Early Holocene time (ca 10500 – 8500 years BP) but that the upper part of sand settled down during the Subboreal period (ca 3500 – 3000 years BP). So, with the help of geological and palaeo-botanical sciences a whole sub-merged landscape has been created and dated.

PUCK TEST AREA

Also for the Puck medieval harbor a bathy-metric map (DTM), based this time on single-beam echosounding data and a side-scan sonar mosaic, has been created.

Because the sediments in this test area are disturbed due to many (infrastructural) underwater works done in the past, four additional corings on land have been done for the purpose of reconstruction of the ancient shoreline and possible palaeo-environmental changes. From these sediments samples for radiocarbon datings and pollen analyses have been taken which are under investigation now. These results will be published as data layers in the MACHU GIS and in the final scientific publication of MACHU.

The Polish Maritime Museum in Gdańsk

Centralne Muzeum Morskie, Olowianka 9-13
80-751 Gdańsk – POLAND
T +48 (0)58 301 86 11 *Main office*
+48 (0)58 320 33 58 *Secretariat*
F +48 (0)58 301 84 5
E info@cmm.pl
www.cmm.pl

The Polish Geological Institute Subcontractor to the Polish Maritime Museum

Polish Geological Institute, Rakowiecka 4 Str.
00-975 Warszawa – POLAND
T +48 (0)22 849 53 51
F +48 (0)22 849 53 42
E sekretariat@pgi.gov.pl
http://pgi.gov.pl/pgi_en/

Representatives of the Institute involved in the MACHU project:
Iwona Pomian, Thomas Bednarz, Waldemar Ossowski, Szymon Uscinowicz, Grazyna Miotk-Szpiganowicz

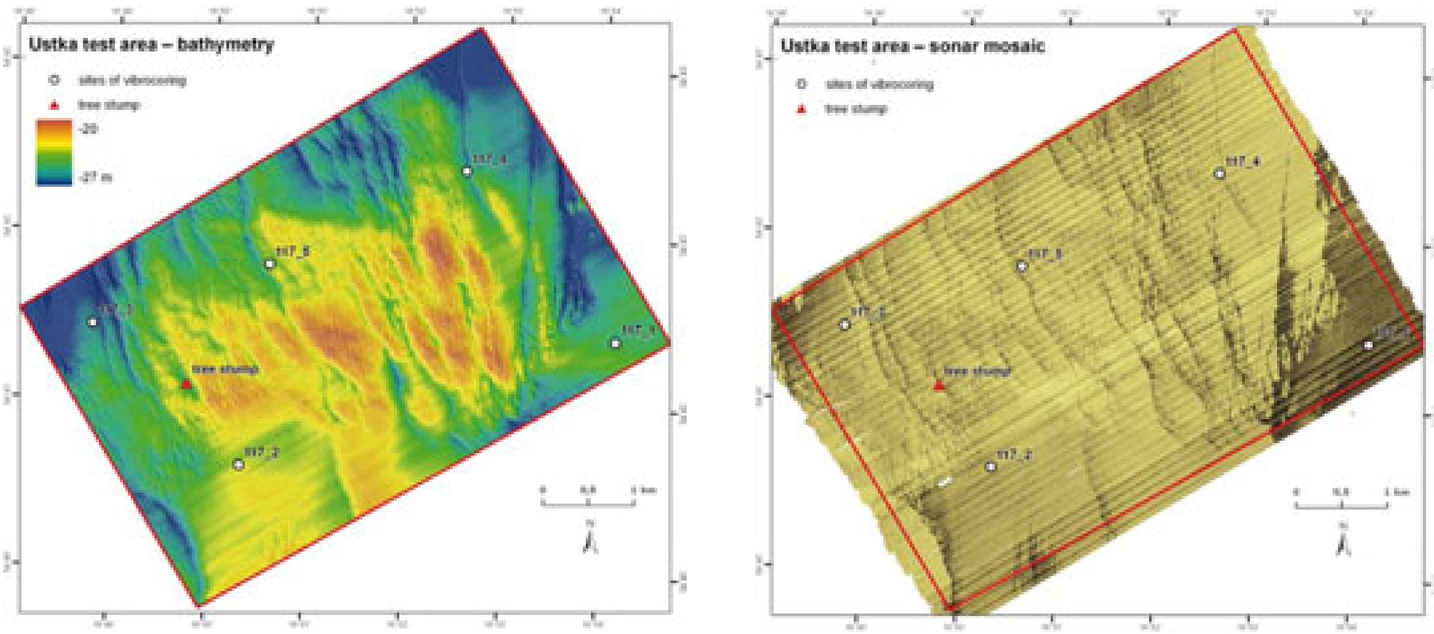


FIGURE 2

GDAŃSK TEST AREA

A bathymetric map (DTM) of the old harbor of Gdańsk based on single as well as multi-beam echosounding data and side-scan sonar mosaics, allows us to choose the locations for vibrocoring. Up till now, 5 vibrocores. All sediments were described in a detailed way and two cores have been investigated palynologicaly. The results of these analyses show that the lower parts of clay and sand in the core 117-1S are of the Late Glacial period origin, while the development of peat took place during the Early Atlantic (ca 7000 – 6500 years BP). The gap of sedimentation covers more then 2500 years. The lower part of the sediment of vibrocore 117-3S was created at the end of Atlantic period and the upper part consisting of silty-clay sediments – during the Subatlantic (ca 2000 years BP and later). The gap of information connected with the sand sedimentation covers about 2000 years.
Based on the DTM and by comparison of the old maps from 1613-1997 years (1613, 1674, 1701, 1761, 1814, 1997 year) using ArcGIS, the preliminary reconstruction of Vistula outlet development and shoreline migration has been done.

To precise the information about the development of the Vistula outlet, 13 samples of sand from dune ridges on land for Optical Stimulated Luminiscence (OSL) dating and samples of fossil soils for pollen analyses have been taken. These are all under investigation now and will be published in a later stage.
To enable better explanation of the present state of the archaeological sites in this area a detailed photo, video and drawing documentation of five wrecks has been elaborated to present on the MACHU website.
Not less then 70 historic maps showing entrance to Gdansk harbour from the 17th and 18th century have been collected and digitalized. In the coming months a selection of them will be added in the MACHU GIS. ■

FIGURE 3:
The map from 1674 year with nowadays coastal line.
Source: APG 300, MP-1128

Assessment on the Arade 23 wreck site 2007-2008

FRANCISCO ALVES & PAULO MONTEIRO

FIGURE 1: PHOTO: DANS

The so called Arade 23 site was located in 2005 by CNANS (now DANS) during a magnetometer and side-scan sonar survey of the Arade river estuary, one of the two Portuguese MACHU project elected areas. In 2006, survey dives on the site identified it as being a tumulus of ballast stones, from under which poked some fragments of wood with copper nails. This gives us a preliminary dating starting from the late 18th century onwards.

Portuguese Centre for Underwater and Nautical Archaeology

Instituto Portugues de Arqueologia
Avenida da India 136
1300 300 Lisbon
PORTUGAL
T +21 36 16 546
E cnans@ipa.min-cultura.pt
www.ipa.min-cultura.pt/cnans

Representatives of the Institute involved in the MACHU project:
Francisco José Soares Alves
João Gachet Alves
José Antonio Bettencourt
Patricia Carvalho
Helder Hermosilha
Vanessa Loureiro
Paolo Monteiro

In 2007, a field season was executed to assess the site. Its first phase was to surround the wreck with six referential stakes and to fully record whatever was exposed without disturbing the site. Several wooden dead-eyes, one pewter spoon with an engraved mark ('J:V'), and some timbers were then recorded. In order to complete the basic assessment of the site done the previous year, a second field season was organized in 2008. Its objectives were:

- to locate the keel, if present, as well as both ends of the ship extremities (stern post and stem post. ;
- to excavate a trench across the hull to discover the layout and record the dimensions of the scantlings;
- to recover any potentially diagnostic artefacts as well as any loose piece of the wreck for preservation purposes and;
- to physically protect the wreck site.

For this purpose, the already implanted positioning scheme of 2007 was also used and all measurements were again done by using the

Site Recorder 4 for accuracy checks. The overburden of sand and silt accumulated during the course of a year was removed with the aid of a water dredge and a test trench was dug between P5 and P3 - a line that effectively intersected at 90° the wreck at its most extant surviving section.

Test pits were also dug at both extremities, near P4 and P1. Unfortunately, not only the extreme ends of the vessel could not be located, but the keel was also absent as was any sign for the turn of the bilge.
The trench that crossed the wreck section transversally was done by the manual removing of ballast rocks as well as by clearing any sand overburden intermingled with them. Few and scant artefacts were recovered: mainly some fragments of ceramic, some shards of glass and the bottom of a dark tinted glass bottle. Near P5, a large folded sheet of copper hull sheathing studded with copper tacks was also discovered.

The scantlings revealed by this test excavation were not uniform, with the timber assemblage beneath the ballast mound showing a wide collection of widths and timber orientation. Also, the wood used for some of the timbers was clearly different from the one used on other structural elements.
Considerable effort was spent trying to understand this exposed section. It was concluded that the construction that has been investigated is part of a board side, somewhere above the turn of the bilge.

At the end of the project, 30 bags of sand were used to weight down two large pieces of Geotextile on top of the wreck (already applied successfully in the 2002 Arade I field season). These physical measures should protect the site against looting, anchoring or other damaging activities. The canvas, the trench and both test pits were back-filled with sand from around the site. For that purpose, the end of the water dredge was used. This allowed us also to investigate the outside perimeter of the wreck dispersion area. No further wood elements or artefacts were found except in the area to the southwest of the wreck, where several ballast stones were located . We are confident that had any other large parts of the wreck been buried under the sand in the immediate vicinity, these would have been detected.
At this moment, due to the nature of the samples and the artefacts but also the limited intrusive work executed, the site can only be dated roughly in the 18th century. The site has not been identified. ■

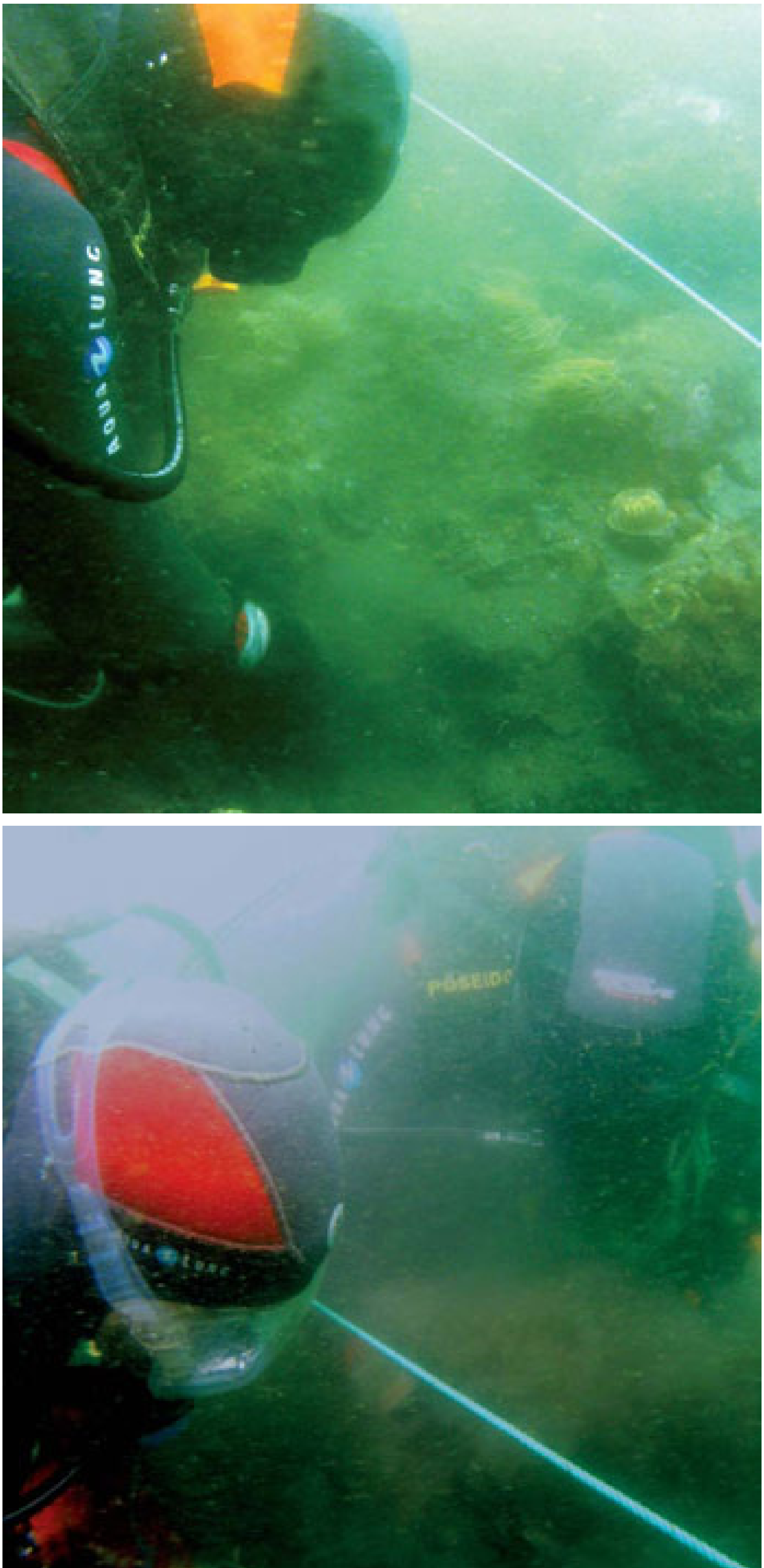


FIGURE 2/3: Divers working at the Arade 23 wreck site. PHOTOS DANS

THE SECOND YEAR: FOCUS ON DATA

NINA EKLÖF & JIM HANSSON

During the second year of the Swedish MACHU project there has been a focus on collecting data regarding the diving frequency on wrecks in the Stockholm archipelago. Information has been collected through a webpage, where divers were invited to answer a web based questionnaire. The project has also focused on gathering information regarding the effect and the impact on the wrecks caused by high diving frequency. To record and document these effects, fieldwork was performed in fall 2008 on five chosen wrecks. These wrecks were chosen on the basis of the results from the questionnaire.

FIGURE 1: The 9 wrecks chosen for the fieldwork.

DATA COLLECTING; QUESTIONNAIRE

A web based questionnaire was published during spring 2008 on the Swedish Maritime Museums webpage and during 2 months answers were submitted from over 300 divers. In the questionnaire the divers were asked to provide answers regarding behaviour, knowledge, diving frequency and reach ability. They were asked to specify how many dives they had done on 30 selected wrecks. A result seen in the answers is that many divers dive very deep and on wrecks that are difficult to access and reach. Open water and 45-60 meters of depth are not a hindrance, on the contrary it seems that many divers search for wrecks with these parameters. This is also confirmed by the fact that 63% of the divers have taken a Nitrox course. 65 percent of the divers in the Stockholm area have dived deeper than 40 meters and 5 percent answers in the questionnaire that they have been diving deeper than 90 meters. The average depth for a dive is between 20-40 meters.

Another conclusion from the answers is that the area has a high diving frequency in total the 30 selected wrecks had 8400 dives. A few conclusions regarding diving frequency and reach ability show that variables that do influence upon the diving frequency on a wreck are if the site is easy to reach from land and if it is an intact wreck.

The diver's answers show that reasons for starting diving are interest for adventure, nature and/or wrecks. For most divers the driving force behind the diving are the same as when they started but their interest for wrecks has increased.

Main factor that make a wreck interesting for divers to visit are if the hull of the wreck is intact. Known history and a wrecks name and origin are variables that make a wreck attractive for divers. Also diving depth and exposed items are answered to be important aspects that make the diver choose a wreck for diving.

DATA COLLECTING; FIELDWORK

Amongst the 30 wrecks in the questionnaire 9 wrecks have been chosen for fieldwork, this year 5 wrecks were documented *(figure 1)*. The aim of the fieldwork is to see changes due to both natural damage and damages from diving. The wrecks are chosen from the criteria to find two similar wrecks in different environments and with different diving frequency. Through the documentation of theses wrecks and combining this with earlier recovered information about the status of the wrecks, the GIS modelling will be able to tell changes or

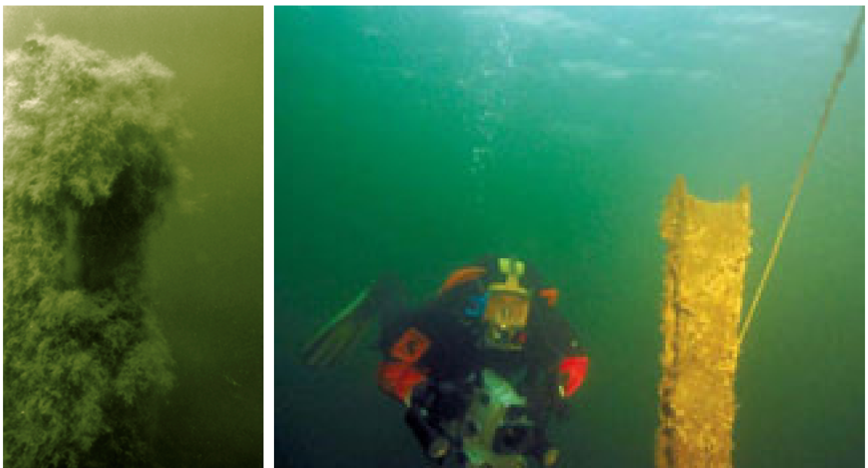


FIGURE 2: Björns wreck. A intact tiller hole documented during the 1970ties. The MACHU fieldwork could state that it is now broken. PHOTOS: JIM HANSSON, SMM

The National Maritime Museums

P.O. Box 27131, 102 52 Stockholm
SWEDEN
T +46 8 519 549 00 **F** +46 8 519 548 94
E registrator@maritima.se **www.maritima.se**

Vasa Museum, Maritime Museum in Stockholm and the Naval Museum in Karlskrona

Representatives in the MACHU project:
Björn Varenius, Andreas Olsson, Nina Eklöf, Mirja Arnshav, Anette Färjare, Göran Ekberg

influence that can or have damaged the remains. The methods used during the fieldwork were video documentation, photo documentation and control measuring of measurements that are documented since before. With some wrecks it will be possible to compare earlier documentation, to see what has happened during time with the remains.

RESULT

■ *Käppalavraket* is an unknown wreck, both in historical background and regarding its construction. The wreck has a very high diving frequency and is easy to access. The site is exposed and near the major route to Stockholm. The wreck is poorly documented so the only noticeable influence from diving was that a shoe is missing and a frame is broken. The wreck has high diving frequency during the winter period and will be documented again during next year fieldwork.

■ *Sappemeer* is a big intact steel wreck situated far out in the archipelago. The wreck has a high diving frequency though it is difficult to access. The wreck is documented since before in videos and photos and also has a known history. The fieldwork documentations showed that there has been happening a lot with the wreck. Here fragile rails are broken due to what belived is incautious divers. During the fieldwork natural detoriation also were documented.

■ *Björns vrak* is a very well preserved wreck that is difficult to access and with a low diving frequency. There is earlier documentation available in form of photos, videos and also a very careful documentation measuring. The fieldwork showed that both anchoring and diving have caused damages to the wreck. The bilge pump is broken, the hole for the tiller were also broken, possible due to a buoy line causing the tiller hole to brake. The bilge pump has possible been broken by incautious divers, but it can also be due to anchoring since the bay is an extremely well sheltered and popular anchoring place for boats during the summer season.

■ *Riksäpplet* is a well known wreck and has a dramatic history and background. The wreck is easy to access and have a diving frequency. The earlier documentation that is available was studied before the fieldwork. At this site is was possible to see several changes that definitely are caused by divers, mostly it is loose finds that has been moved around on the wreck or finds that now are missing. An elevation wedge belonging to the canons that has been lying on the well preserved anchor rope is now missing. *(figure 8)*. A block wheel that earlier was buried in the sediment has been dug out and are now placed on top of visible planking.

■ *Kungshamnsvraket* is a medieval wreck with a relatively high diving frequency and earlier documentation about the wreck is available. As this wreck is located close to Stockholms harbour's north route and in the narrow Skurusundet, the site is influenced by currents. During the fieldwork two stoneware urns, observed in earlier documentation, were not possible to locate, possibly diving or currents has influenced upon their position. The wreck will be in next years fieldwork.

During the following year the project will try to find out which variables control the scuba diving in the purpose to find an indicator for a GIS analyse regarding scuba diving and its impact on wrecks, in the purpose to apply the indicator on all the 500 registered wrecks in Stockholm archipelago. ■

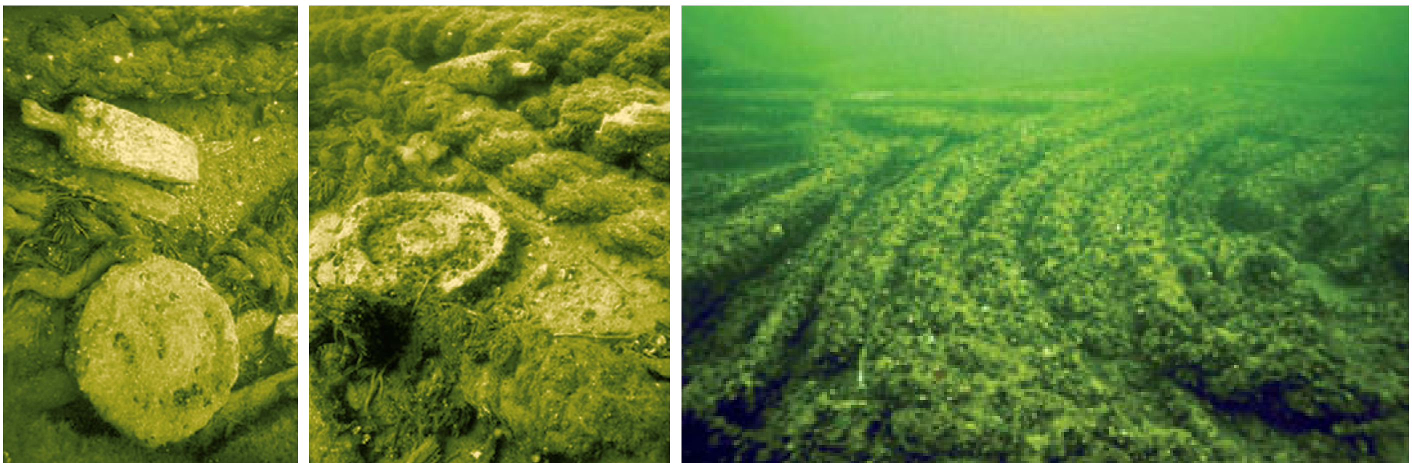


FIGURE 3: Riksäpplet wreck. During the period of 10 years an elevation wedge is moved around on the anchor rope. The MACHU fieldwork shows that the wedge now is missing. PHOTOS: MIRJA ARNSHAV, JIM HANSSON, SMM

A PROTOTYPE WEB GIS APPLICATION FOR MACHU

HERMAN HOOTSEN RWS & **WIM DIJKMAN** RWS

An important part of the MACHU project is the building of a prototype web GIS application that enables the share of information between EU partners on the management of cultural heritage underwater[1]. Since the start of the project in the fall of 2006, a lot of effort has been made developing the building principles, to determinate the functional needs, specifying the necessary map layers and data formats, collecting and processing data, to construct web services and the actual building of the MACHU GIS web application. In the summer of 2008, the first version of the MACHU GIS, build by Grontmij Nederland B.V.[2], has come ready for use.

CHARACTERISTICS

MACHU GIS connects information on cultural heritage sites underwater to information on the (physical) environment, available research data (sources) and other area related information considered to be of importance to the management of the cultural heritage.

MACHU GIS opens possibilities to:

- A cross-border exchange of information on the presence and management of cultural heritage underwater;
- Project sites within their spatial context and thereby creating insight in the relation to other area related information. (E.g. available research data or legislation in the vicinity of site locations);
- Visualize area related developments that may become a threat to the preservation of cultural heritage;
- Get an insight in site assessment and management decisions (decision support);
- Monitor long-term effects of site management.

The MACHU GIS application is constructed in a way that fits in with the European guidelines for geographical information, as presented by the INSPIRE directive (Infrastructure for Spatial Information in Europe)[3]. This, among other things, resulted in the development of a web based GIS in which partner countries (and third parties) can exchange data by using web services. Distribution and management of the data presented in the GIS thereby stays the responsibility of each individual data provider *(figure 1)*.

The web GIS application now exists of 2 parts:

1. An administrator's module that allows an application manager to add available web services to the viewer and classify them by theme.

2. A viewer that allow users to consult available information *(figure 2)*. The user of the MACHU GIS has several possibilities to consult this information. Main possibilities are visualizing map layers in the viewer, identifying objects, execute (multiple) queries, linking sites to management plans and consulting metadata of individual data sources. These main functions are explained by a case study further on in this chapter.

The MACHU GIS distinguishes itself from other applications, as it is able to combine data from different services into one map layer. This means a user can consult the information of a map layer as if it was originated from one data source. To establish the application to perform this way, data formats have been developed for the main map layers. For example, all cultural heritage sites can be consulted through a single map layer, but the actual site information is derived from individual services of MACHU partners. Each contributor commits itself to the use of these formats.

The main map layers of the MACHU GIS currently are:

- Cultural Heritage Underwater, containing detailed information on individual sites e.g. type, age, archaeological value and linkage to its management plan;
- Research areas, containing indications on availability of research data by location and research characteristics e.g. research techniques used like multi beam or side scan sonar. This layer can also be used to add images of the research data to the view and gain access to resource information on individual research datasets (by metadata);
- Legislation, containing legislation that

THE KEY PRINCIPLES OF INSPIRE[7]

- Spatial data should be collected once and maintained at the level where this can be done most effectively.
- It must be possible to combine seamlessly spatial data from different sources across the EU and share it between many users and applications.
- It must be possible for spatial data collected at one level of government to be shared between all the different levels of government.
- Spatial data needed for good governance should be available at conditions that are not restricting its extensive use.
- It should be easy to discover which spatial data is available, to evaluate its fitness for purpose and to know which conditions apply for its use.

applies to the management of cultural heritage underwater;

- Administrative boundaries, containing the outer boundaries of countries on land and sea;
- General Bathymetric Chart, containing a subset of the General Bathymetric Chart of the World (GEBCO) One Minute Grid.

The MACHU GIS also contains a temporary map layer MACHU test areas, defining the areas where each partner focuses on collecting data to benefit the MACHU project developments.

Because part of the information presented in the GIS application is confidential, the MACHU GIS itself is only accessible by a restricted group of users (scientists, policy makers and managers of cultural heritage underwater). A demo of the application can be found on the MACHU website:
www.machuproject.eu/gis-01.htm

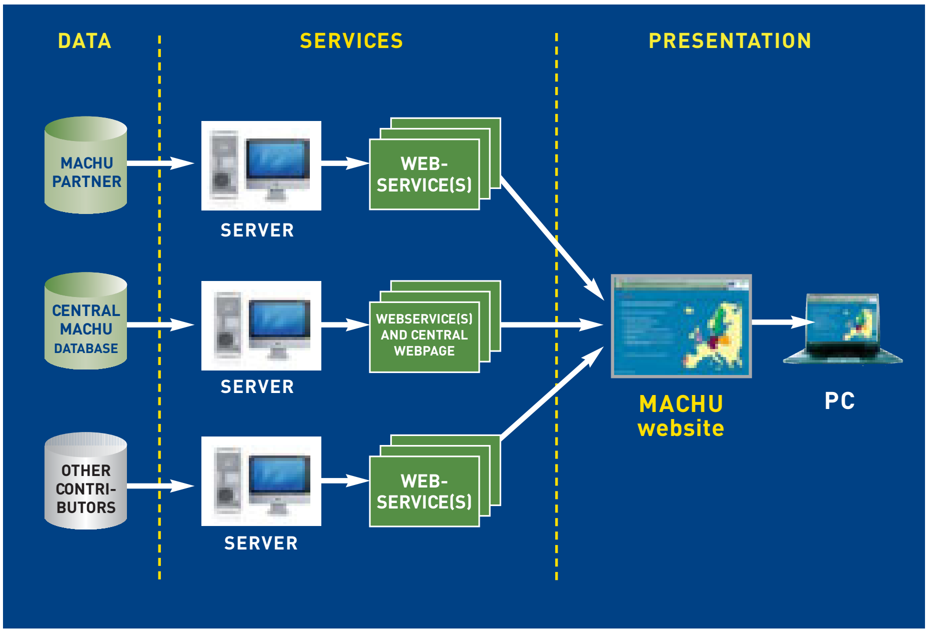


FIGURE 1: MACHU GIS principle Model

DEVELOPMENTS

The building of the MACHU GIS is a pilot project. During the following phase of the MACHU project, more efforts will be made to improve the system on both content and functionality. The technical execution on these matters will be supported by the data and ICT department of Rijkswaterstaat[4].

For the GIS to function well, the availability of data is crucial. The forthcoming year therefore extra efforts will be made to gain and serve new data, now including data located outside the predefined MACHU test areas. This will be done by adding new data into existing themes, as well as by adding new map layers to the GIS. These new map layers could be topographical like historical maps or map layers that give information on area related developments and threats like sedimentation and erosion of the seabed or the effects of scuba diving near wreck sites. The contribution of these extra themes may differ per country.

For the extension of archaeological data, inquiries are made into the possibilities of developing an automatic system for extracting data from the national databases of each partner and translate this data into MACHU data formats. Because of the differences between the national databases, this won't work without custom-made applications. Therefore, the ambition is not to create a single solution for all partners, but creating a system that could function as a basis for each custom-made application that has to be developed.

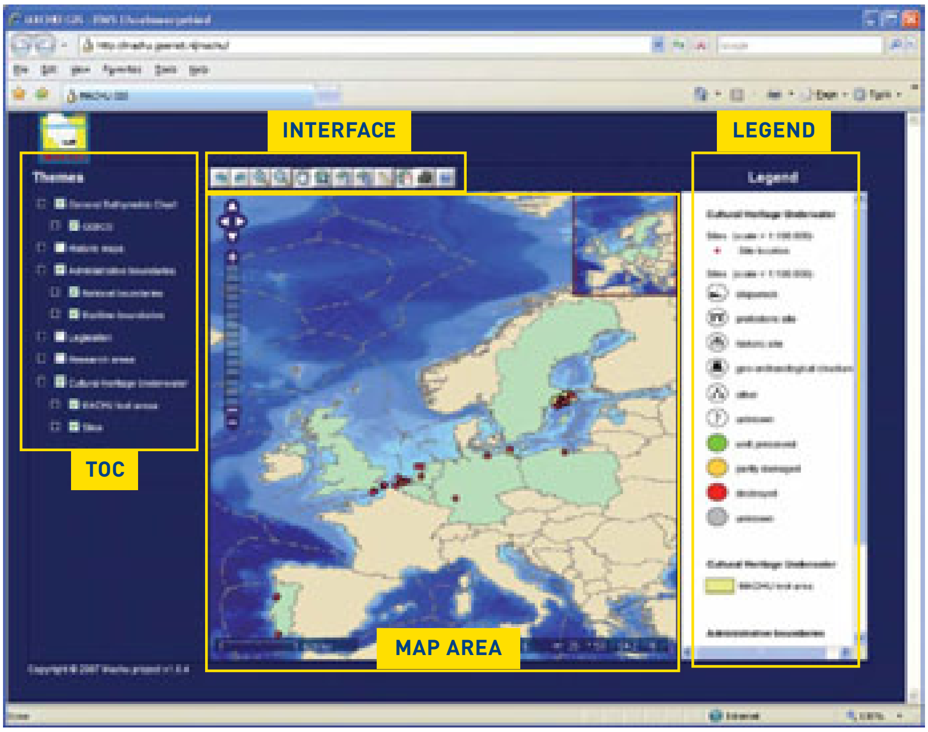


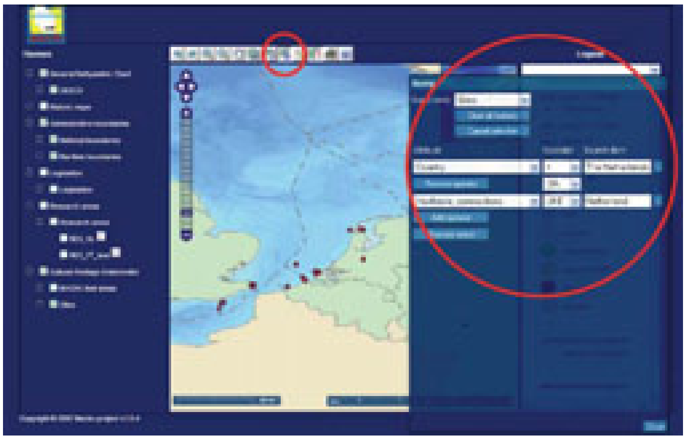
FIGURE 2: Schematic representation of the MACHU. GIS Viewer. The Viewer consists of four main sections: the Table Of Contents (TOC) containing the functions to add and remove map layers; the Map Area, wherein the map layers are viewed; the Interface, which holds the buttons to interact with the Map Area, and the Legend section where the symbols of the map layers is explained.

Also this year the construction of web services for individual MACHU partners will begin. Momentarily all content web services are hosted by the data and ICT department of Rijkswaterstaat. However, finally each partner is expected to provide its own web service containing its own data. The possibilities to do so differ per partner. Therefore it's not to be expected that all individual web services can be made available in the forthcoming year. Nevertheless, the goal will be to realize at least some of the individual web services before end of the project. ■

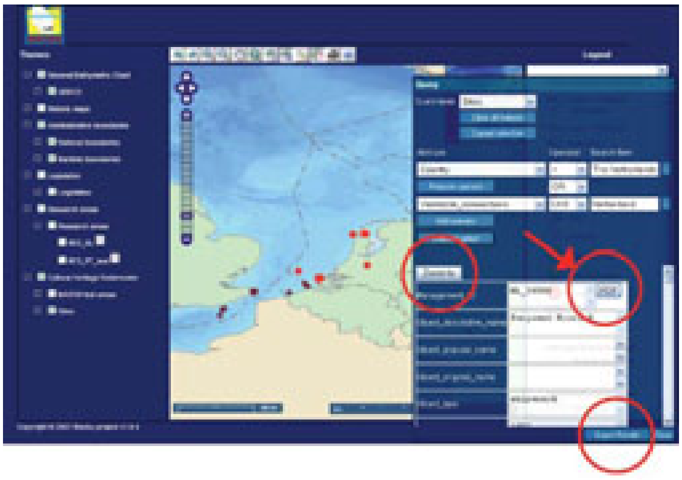
For further information on the MACHU GIS, please contact machu@racm.nl.

MACHU GIS - A CASE STUDY

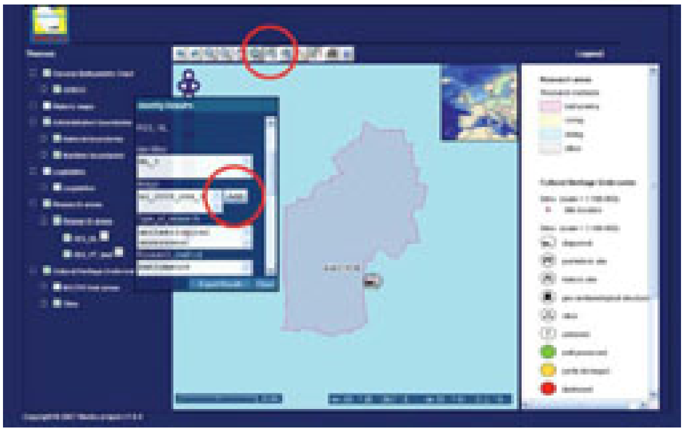
This case study shows some basic possibilities of the MACHU GIS.



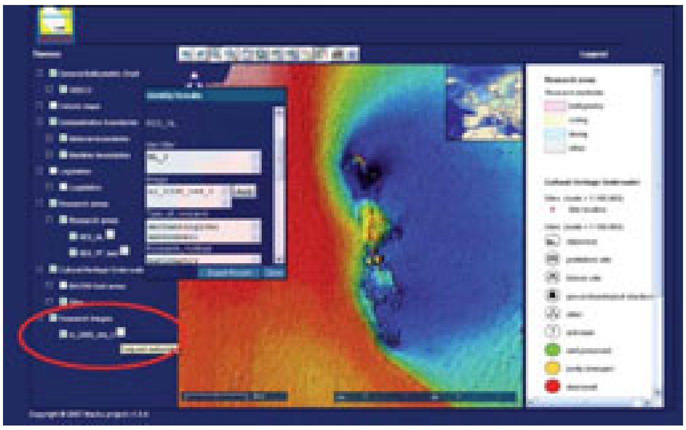
Imagine this, for a research you would like to know which sites are situated in Dutch waters or which sites, also elsewhere in Europe, have verifiable connections with the Netherlands. First thing to do: use the query-tool. Choose the necessary attributes to compose a search string and perform a selection of sites that matches the defined conditions.



The result of the query will appear in a pop-up window and the selected sites will colour red in the map. After this you have several options: You can e.g. export the results, read the contents of each individual site, zoom to an individual site or link through to the management plan of a site (pdf).



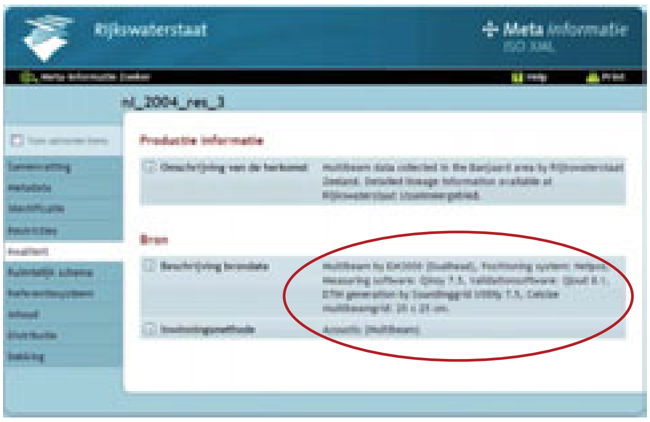
Let's say, the results leads to a specific site of interest and you would like to know what kind of research has taken place in the vicinity of this site. To find out, first turn on the layer research areas in the TOC. The map will show any research areas near the site. After that, use the identify-tool and click in the map on a research area of interest. A pop-up window will show you the related research information (Note: more research areas can be identified at once by using the query tool)

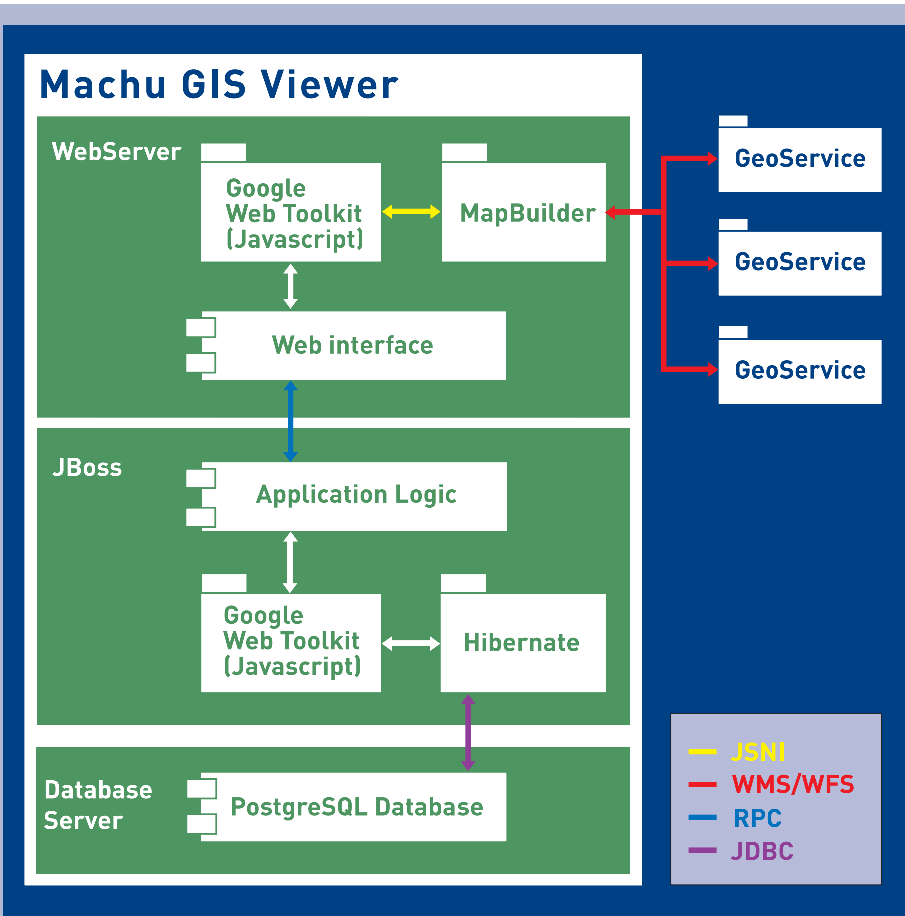


When available, it is possible to add an image of the research data to the map. In this example a geo-tiff of some multibeam measurements can be made visible.
If you like to have more information on the represented data, for example detailed information on data quality, you can request for source information by using the metadata-button

By clicking the metadata button, a new pop-up window appears, presenting the source information (originally stored as XML-file). To find more information on

data quality, look at 'Quality' (momentarily still presented in Dutch as kwaliteit) 5. If more information or real source data is needed, you're required to contact the owner or maintainer of the data, which information should also be available by metadata.
To find other area related information, search the TOC for available map layers. ■





COMPONENT DIAGRAM OF THE MACHU GIS VIEWER 1.0[6]

The application setup for the MACHU GIS Viewer 1.0 uses MapBuilder to provide the functionality of the Interface and Map Area segments and Google Web Toolkit (GWT) to create the TOC and Legend elements. GWT is also used to manage the interaction between the client and server and the connection between the server and the database via a secondary library: Hibernate. During the evaluation on the GIS system in the coming months, this set up might change e.g. due to requirements on system management.

SOURCES

[1] *Building the GIS system; MACHU Report* nr. 1; January 2008.
[2] Grontmij Nederland b.v, w.grontmij.com
[3] *Infrastructure for Spatial Information in Europe (INSPIRE)*, www.ec-gis.org/inspire
[4] Rijkswaterstaat (RWS), www.rijkswaterstaat.nl
[5] Meta Data Tool (RWS) At this moment the tools is in Dutch. Within the project this will be replaced by an English version.
[6] *MACHU GIS Application, Technical design of the Machu GIS Viewer.* August 11, 2008. Grontmij Nederland bv
[7] The key principles of INSPIRE, www.inspire-geoportal.eu

THE CONCEPT OF DECISION SUPPORT SYSTEMS AND RELEVANCE TO THE MACHU PROJECT

CHRIS PATER EH

MARTIJN MANDERS RACM

At the start of the MACHU project in 2006 it was decided to create a proto-type Decision Support System (DSS) as a tool for management of underwater cultural heritage. In the world according to Wikipedia, for example (accessed on 11th December 2008) a Decision Support System is described as: 'a specific class of computerized information system that supports business and organizational decision-making activities. A properly-designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions'.

How does this description relate with the actual MACHU project objectives? In essence the project does aim to provide spatial and textual information as follows:

- the Web based Geographical Information System (GIS) developed in MACHU does act as an information inventory of what we presently know about the underwater cultural heritage and its environment;
- an ambition of the project was to provide further information through the GIS about physical conditions of the seabed and the archaeological sites that can help us to predict the (state of the) unknown archaeological resource and to develop well founded in situ protection systems; and
- means to test the consequences of different decisions in the way they may affect such sites.

In a way the GIS now functions like a DSS and with this tool scientists, heritage officers and policymakers are able to compile and compare data and information about the historic environment (i.e. the underwater cultural heritage) in conjunction with detail about the natural environment and infrastructural seabed works, all present in the same area. However, what is still lacking is a guideline on how and what kind of information and data should be taken into consideration while managing the underwater cultural heritage in different situations. These can be areas with numerous infrastructural activities or, for example, areas with identifiable changes in natural conditions, such as seabed topography. The MACHU group has therefore changed its focus towards a more manual approach to a DSS model by presenting examples of good practice that set out the parameters for decision making, for example, as relevant to the types of projects that are subject to evaluation under the European Union Environmental Impact Assessment Directive *(http://ec.europa.eu/environment/eia/eia-legalcontext.htm)*, such as commercial ports, offshore wind farms and seabed pipelines.

FIGURE 1: Dredger near the Millennium Dome in London. PHOTO: EH

The approach advocated is that individual notes and descriptions are provided that collectively provide information on how historic environment is addressed in the completion of Environmental Impact Assessment (EIA) or any similar assessment system that evaluates ecological, natural, social and cultural impact in an area. In this way it is possible to compare and contrast the approach adopted across MACHU project partners. In the first instance the inclusion of the historic environment must be considered across the key components of the EIA process: screening; scoping, the environmental statement; and review. Within most MACHU partner countries, the approach adopted is for the developer to prepare the entire EIA process and in doing so appoint consultants and specialist sub-contractors as necessary to deliver the overall project EIA. Public bodies such as English Heritage (in the UK) and the RACM (NL) are invited to comment on the screening and scoping stage which is particularly important if archaeology is considered within the EIA. This consideration might have to be challenged and the counter argument presented based on available information as held by records contained within the national archive. The advice a public heritage agency provides, such as English

FIGURE 2: Wind turbines on the Kentish Flat, UK. PHOTO COURTESY ELSAM.

Heritage is sent directly to the respective the UK Government Department that has particular responsibility for licensing (i.e. consenting construction within England) for the seabed development in question. For example, in the UK the Department for Energy and Climate Change takes responsibility for offshore renewable power generation projects such as offshore wind turbines within the English area of the UK Territorial Sea and adjacent Continental Shelf.

In effect decisions about whether to consent a seabed development are not made by public heritage bodies. In the UK the national public heritage agencies, such as English Heritage, provide advice that informs decision making by the licensing authority through the EIA process. In which case, the important matter is to ensure that such information as relevant to the historic environment is included within the decision making framework informed by an EIA. This is even more complicated if considering implications of cumulative developments of the same kind or different, but with the same increasingly congested sea space. Any attempt therefore to embrace DSS technology must be designed to take full account of all aspects of the EIA evaluation procedure. This is summarised as:

- access to spatial data to inform decision making – such as where do we know we have historic environment interests and where might such interests be discovered;
- the capacity for analysis in terms of how the information about the historic environment – known and unknown – contributes to the sum of knowledge necessary to inform a decision about the environment implications of the development proposed; and
- the ability for a DSS to project how historic environment resources might be affected through a process of setting different controls and parameters.

CONCLUSION

It is clear that there have to be an enormous amount of parameters taken into account while protecting and mitigating for underwater cultural heritage. These parameters can be combined within the MACHU GIS and this system already acts, to a certain extent, as a Decision Support System. However, still lacking are guidelines on what should be taken into account while managing the underwater cultural heritage in different situations.

Therefore, in the coming months the project team will include examples of good practice on the MACHU website to support consideration of management and protection of our historic environment subject to different natural and anthropogenic processes and activities that may affect this rich archaeological resource. **www.machuproject.eu* ■

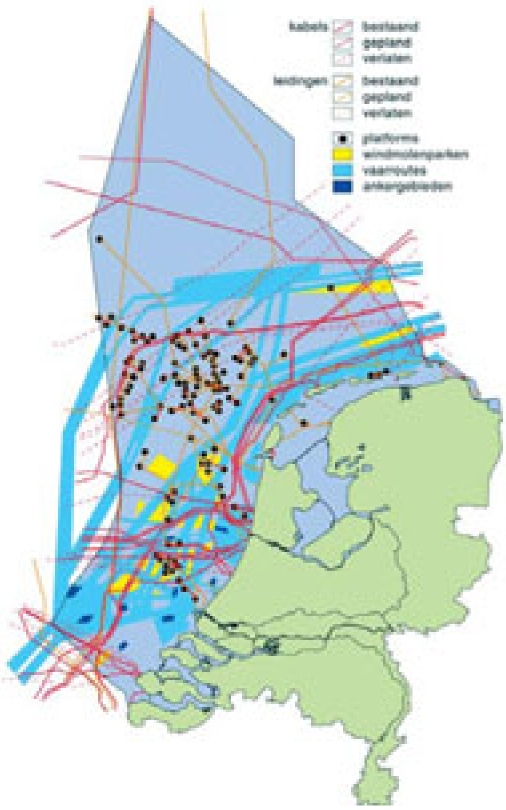


FIGURE 3: A quick view on planned and executed infrastructural works on the North Sea seabed shows us the scale of (potential) threats for the underwater cultural heritage. Guidelines and examples of good practise can help to protect the known and unknown resources. PICTURE: M. KOSIAN

FIGURE 1: The map 'De vermaerde stroemen, Tvlie ende Tmaersdiep…' (The well known currents, Vlieland and Marsdiep) by Lucas Janszoon Waghenaer (1584).

GISING DEAD-RECKONING

HISTORIC MARITIME MAPS IN GIS

MENNE KOSIAN RACM

FIGURE 2: 16th century navigational instruments. PHOTO M. MANDERS

The Dutch maps from the 16th and 17th centuries were famous for their accuracy and detail level. When we look at these maps with modern eyes they seem distorted and unreliable; the relationship between different areas on the map appears warped, coastal lines seem either sketchy, or with excessive detail, and the maps are not in a recognizable projection. Yet these maps contain a wealth of information that can provide much insight in the maritime landscape in that period. It is possible to place these maps in a geographic information system (GIS), in which the information can be used for modern research. At this moment the MACHU project is experimenting with this. This paper we will discuss which maps are used and how these are made suitable for the MACHU-GIS.

It is possible to place these maps in a geographic information system (GIS), in which the information can be used for modern research. At this moment the MACHU project is experimenting with this. This paper we will discuss which maps are used and how these are made suitable for the MACHU-GIS.

NAVIGATION

Orientating on board ships was mainly done in two ways: by dead-reckoning and by measurements. Dead-reckoning was done by plotting a course-line from a known point where speed, compass-course, drift and currents were included in the calculation. In addition ships carried instruments with which the position of celestial bodies could be measured. With these celestial measure-

ments the latitude could be calculated. But these instruments were primitive and difficult to read *(figure 2)*. There were calculation methods to determine the longitude using instrument data, but they were very unreliable and even more sensitive for calculation errors and misreading. Only with the invention of the chronometer in 1762 by John Harrison could the longitude be determined correctly. For a long time the most reliable way of determining ones position remained triangulation between two or more points along the coast.
Mapmakers had the same problem, especially with maritime charts. Moreover, precise angle measuring instruments, such as mirror quadrants, were only invented in the 18th century. In many cases information from existing maps, that were considered reliable, was used and often copied.

LUCAS JANSZOON WAGHENAER

Lucas Janszoon Waghenaer (ca. 1533-1606) was *'Navigator in Enchuijsen'* and completed in 1584 the first part of his *'Spieghel der Zeevaerdt'* (Mirror of Navigation). These charts depicted the European coast from Texel to Cadiz. Since there are no indications that Waghenaer copied his charts from existing sources, it is assumed that these charts were based purely on his own observations and knowledge of navigation, which he had acquired as a navigating officer.
The map that I use as an example is that of *'De vermaerde stroemen, Tvlie ende Tmaersdiep'* (The well known currents, Vlie and Marsdiep, *figure 1*), the most northerly sheet of the first part of his 'Spieghel'. At first glance the province of North-Holland appears too broad and plump, Friesland relatively too small and the Wadden islands north of Texel are positioned in too straight a line. Despite this, the map was reliable enough to navigate; Waghenaer's almanac was widely used.

TRANSLATING THE MAP INTO GIS

To place this map in a GIS, we first have to determine for what purpose this map was made, so what degree of reliability was needed. As I said before this map is the most northern sheet of a series of navigational charts from Texel to Cadiz. That means that this map was made for navigating the shipping routes to the southern regions of Europe. The main routes through the Wadden Sea for these destinations were either through the Marsdiep or through the Vliestroom, and are therefore the most detailed parts of the map. Friesland north of Harlingen and the islands north of Terschelling are only to 'complete' the map image, and didn't need to have the same level of detail or degree of accuracy.
To georeference the map I applied the same techniques as those which whom the original map was created: small parts of coastline charted using triangulation and sightlines. I started with the area around Enkhuizen. Looking at Waghenaer's map, it is clear that this particular area is pretty well charted; the angles between Enkhuizen, De Kreupel sands, Stavoren and Enkhuizen, Medemblik are properly depicted, and the relative distances are reasonably correct. By vectorising this part it could be transformed into a modern projection, and the names, depths and other information added to a database. This way the entire map was put into a GIS, Friesland and the northern islands were more or less 'sketchy' digitized, similar to the original. After the various parts were combined, the distances between some reference points on both maps were compared, and adjusted where necessary *(figure 3)*.
That gave a map in which all data from the chart from 1584 could be compared with modern data.

PIETER GOOS

Pieter Goos (1615-1675) was a bookseller and engraver in Amsterdam and became in 1650 one of the major publishers and retailers of seaman's almanacs and charts. In 1666 he published his *'Zee-atlas of the waterwereld'* (Sea-atlas or water world). The actual charts were not by Goos himself, but were copied from the *'Zee-atlas ofte water-waereld'* (Sea-atlas or water world) by Hendrick Doncker, also from Amsterdam. Doncker's atlas was published in 1659 and, being regarded the most accurate in maritime cartography, was copied by several other publishers. The chart from the *'Zee-atlas'* I use as an example is the *'Pascaerte vande Zuyder-Zee'* (Portulan map of the Zuijder-Sea, *figure 4*). As the title indicates, this is a portulan map, a small-scale map on which a route could be plotted. To ensure the route could be plotted by compass course, this map was set in a Mercator projection. This has the advantage that the angles on the map equal the angles in reality, so a compass course gives a straight line on the map. Because most modern maps

FIGURE 3: Check of reference distances on the map in modern projection (left) and on the original map (right).
GIS-MAP BY MENNEKOSIAN (2008)

are also in a Mercator projection, Goos's map looks more familiar to the modern reader than that of Waghenaer. However, this map is similarly hard to place under a modern map. To put it into a modern GIS I used the same technique as I did with Waghenaer's map. Although Goos gives more detail information in the northern part of the Wadden Sea, this portulan, like the map from the *'Spieghel'* was also mainly intended for navigation on the Zuider Sea and the routes to the southern North Sea.

WAGHENAER AND GOOS COMPARED

If we compare these two maps it is immediately clear that the shoals in the western Wadden Sea and the indicated deep-water channel have moved westwards *(figure 5)*.
We have to realize that these maps were not only very popular, but also very expensive, so it is not inconceivable that many captains did not, as nowadays, replace their maps regularly. That would have led, certainly in cases of poor visibility and bad weather, to dangerous situations. When we plot the known wreck-sites on these maps in the GIS, we see that where on the 16th century map the safe deep-water channel is located, on the 17th century map the edge of the shoal is, and the concentration wrecks *(figure 6)*! Despite the fact that pilots were an obligation in the Dutch waters, navigation errors, especially in that era, cannot be ruled out.

CONCLUSION

Old maps are not only a pleasure to watch, they are also an important source of information about the geographical situation at that time. To place them into a GIS it is necessary to first determine the purpose of the map (and with that its most accurate part). The title is often a good source of information. Then should be determined how the original map was charted. Fixed points along the coast, charted navigational- and sightlines offer clues for this. Then the map should be vectorized in several small, coherent areas, whereby point data such as depths, buoys, beacons and so could be put into the database. After these separate parts are combined and the in-between distances are checked, all the information from the historical map can be compared to the modern maps. In a way, the historic maps are being translated for use in present time. Therefore they do not immediately look like the original although the data they contain is the same. The original maps can be viewed on the MACHU website. ■

FIGURE 4: The 'Pascaerte vande Zuijder-Zee' (Portulan map of the Zuider-Sea - Pieter Goos 1666)

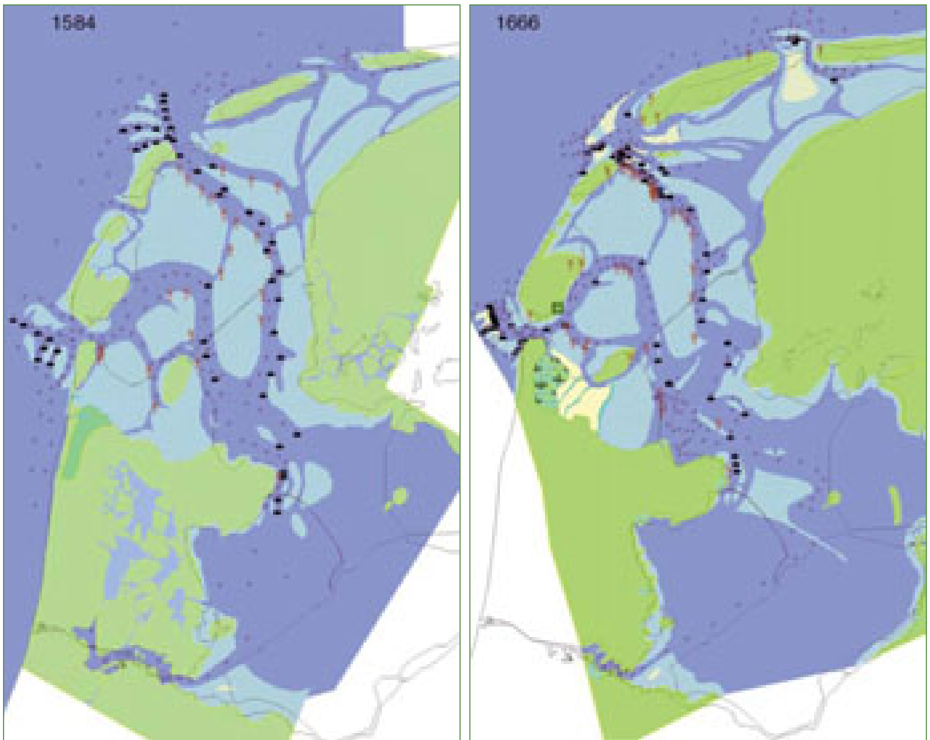


FIGURE 5: The Waghenaer (left) and Goos (right) maps compared GIS-MAP BY MENNE KOSIAN (2008)

INTRODUCTION

There are many individuals and organisations involved directly and indirectly in the Management of Underwater Cultural Heritage. The best way to protect and manage UCH is to make sure that these stakeholders – or at least the most important ones – are being informed, heard and that they are encouraged to be active partners in management. In the end, if only archaeologists think the UCH is worth protecting, there is no use in trying to do so. Because then there will be other things regarded being more important.

This is why creating awareness is so important. MACHU tries to do this especially by working together with several groups of stakeholders and by making information available for these groups in ways that appeal especially to them (See also MACHU Report 1). All the stakeholder groups have to be addressed differently: The language spoken is different and the goals and ethics they have as well. The focus in co-operation is different because they play a different role in the process of protecting cultural heritage underwater.

However, stakeholders are not just groups that are a companion in the effort to protect our UCH, some stakeholder groups might be the strongest opponent or enemy in the effort to do so. By knowing their needs, vision, values, culture and ethics you will have a better understanding of what is driving the different groups. Consequently they can be approached in the right way to negotiate, influence and involve them.

In the next articles, the MACHU partners have described the way they have approached different stakeholder groups in their effort to manage the underwater cultural heritage in a better way. These articles show the variety of stakeholder groups and the ways to approach them. Hopefully these examples are of help to others and that these will initiate further co-operations between stakeholders in the protection of our underwater cultural heritage.

COOPERATION WITH NON-ARCHAEOLOGICAL SCIENTIFIC INSTITUTES, ORGANISATIONS AND INDIVIDUALS

INE DEMERRE VIOE

FIGURE 1: The VIOE can use the research vessel 'Zeeleeuw' (property of Governmental ship owner 'Vloot' and managed by the VLIZ) for its archaeological diving prospections. © VIOE

The Flemish Heritage Institute (VIOE), Belgian partner in the MACHU project, carries out its work with the support and cooperation of several scientific institutes, other organisations, and private individuals.

GENERAL STAKEHOLDERS

Since 1992 the VIOE has worked closely with the **Province of West Flanders**. The origins of this relationship are to be found in the archaeological project investigating the medieval fishing village of Walraversijde. The Province presented the results of the research project to the public at the provincial museum of Walraversijde (Ostend). The museum is now home to the VIOE maritime team and is the base from which the team undertakes its archaeological research and parts of its conservation.

Beside this major support, the province is the most important partner in the dissemination of research results to the public, by exhibitions, publications, symposia, the co-development of the maritime database: www.maritime-archaeology.be etc.

The **Flanders Marine Institute** (VLIZ) coordinates marine scientific research in Flanders. The VLIZ is a valuable repository of information but is also the forum through which the VIOE has established links with marine scientists working in related fields, providing the potential for cooperation on mutually-beneficial projects (e.g. geological and sedimentological research; see below). The VLIZ provides important support for MACHU prospection work through use of the marine research vessel 'Zeeleeuw' (*figure 1*) and of the VLIZ library, as well as through its maintenance of the server on which the maritime database www.maritime-archaeology.be and other data are held.

Alongside the Province of West Flanders, the VLIZ also has a significant role in presenting maritime archaeological research to the marine scientific world and to the general public.

SPECIFIC SUPPORT FOR MACHU RESEARCH

The first step in the archaeological investigation of the two test areas in Belgian territorial waters was the gathering of existing information, and in this task the assistance of **Flemish Hydrography (Department of Coast, Agency for Maritime and Coastal Service)** was invaluable. Flemish Hydrography research regarding obstructions threatening shipping traffic and wreck archives were made available, including location details, 'multibeam' and 'side scan sonar' recordings, measurements, and also in some cases reports by divers, fishermen, dredgers and other relevant parties.

The new 'multibeam' recordings (EM 3002 Kongsberg) made by Flemish Hydrography

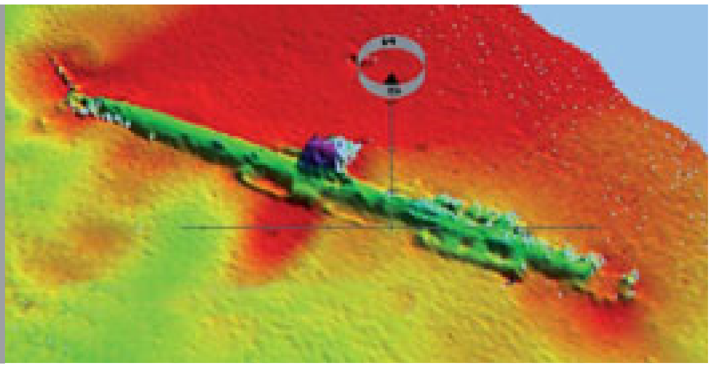


FIGURE 2: Multibeam image taken of the unidentified U-boat wrecksite B125/306b in the Vlakte van de Raan area (EM3002 Kongsberg). © MDK-Afdeling Kust-Vlaamse Hydrografie

on specific wreck locations in the MACHU test areas are of benefit not only to the VIOE project but also for a better accuracy of Flemish Hydrography information *(figure 2)*.

The Fund for Sand Extraction (Federal Public Service Economy, SMEs, Self-employed and Energy – Continental Shelf) is charged with coordinating the sustainable exploitation of the mineral resources of the Belgian Continental Shelf. This way, they could provide data (EM 1002 'multi-beam' recordings) regarding wrecks and specifically mapping, for the development of the sediment-erosion model during the MACHU project.

The Renard Centre of Marine Geology (Department of Geology and Soil Sciences, Ghent University) is assisting in the research project in several ways.
First of all, RCMG arranged to make side scan sonar prospections of specific wreck positions in the MACHU research areas as part of its own practical training programme.

Next, Dr Tine Missiaen of the RCMG carried out, in cooperation with the MACHU project, a geological investigation of the seabed and subsoil through marine seismic methods. The seabed and subsoil of two research areas *(including the Buiten Ratel wreck site - see the article on page 8)* were studied using high resolution acoustic echo-soundings.

As a result of the relationship between the RCMG and the MACHU initiative a cooperation was started up with a doctoral research project in geological science, commenced in January 2008. Matthias Baeye is investigating 'Small-scale sediment dynamics near objects in the Belgian part of the North Sea' under the supervision of Marc De Batist and Vera Van Lancker, and the Buiten Ratel wreck area is the site to be studied. The research results should be of direct relevance to the archaeological studies and ought therefore to contribute to the MACHU project.

The cooperation of fishermen, divers, not-for-profit associations, private collectors, and museums was central to the compilation of an inventory of collections of marine artefacts from the North Sea.
Among these, several fossil bones from these museum and private collections have been examined by Dr Mietje Germonpré of the **Royal Belgian Institute of Natural Sciences (KBIN)** in the first stage of what is to be a more comprehensive study *(figure 3)*.
Finally, the physical investigation of the wreck sites would not be possible without the group of 34 experienced **North Sea divers** who have volunteered to assist with the archaeological wreck prospections organised by the VIOE since 2006 *(figure 4)*. In April 2008 a course for the dive volunteers on maritime archaeological techniques was held in cooperation with the Nautical Archaeological Society (NAS) at the 'Walraversijde' provincial visitors centre.
The marine research is done from the Flemish Government 'Vloot' vessel 'Zeeleeuw' which operates under the management of the VLIZ for marine scientific purposes (see above). The VIOE also hires two private vessels, the 'Ephyra' and the 'Divestar' for wreck prospection work.

By way of summary, in carrying out its maritime archaeological research for the MACHU project the VIOE is dependent upon the cooperation and support of a range of partners: not only scientific institutions and government organisations, but also local, regional, national and international associations, and private individuals, many of whom offer their assistance and expertise on a voluntary basis. ■

FIGURE 3: Research on fossil bones spread over different maritime find collections was carried out by Mietje Germonpré of the KBIN. © VIOE

FIGURE 4: Systematic prospections on wrecksites in Belgian territorial waters is only possible by a group of enthousiastic divers volunteering in the project. © VIOE

THE GREIFSWALD SHIP BARRIER

MANAGEMENT OF CHANGE

FRIEDRICH LÜTH RGK **&**
KATHRIN STAUDE RGK

Between 1700 and 1721 the great Nordic War took place in the Baltic Sea Region with Sweden troops fighting against an alliance formed by Denmark, Poland-Saxony, Prussia and Russia. During this war – in the year 1715 - while the Swedish Army was based in Greifswald in North-East Germany, their army was under pressure. In order to secure the harbours of the towns Stralsund and Wismar the direct access through the Bay of Greifswald between the Islands of Ruegen and Ruden had to be blocked.

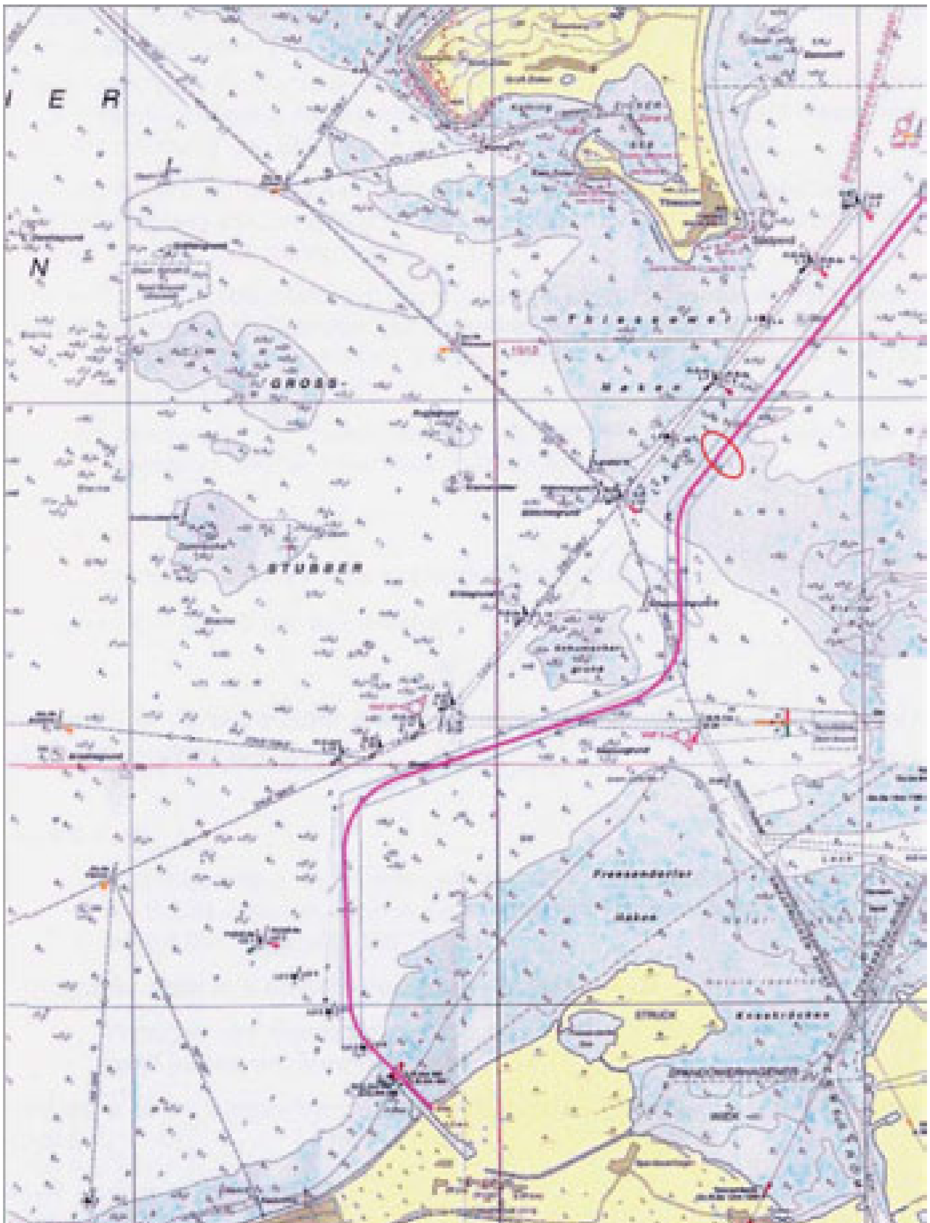


FIGURE 1: Map showing the planning of the pipeline and (the red dot) the ship that has to be removed. PICTURE: RGK

The Swedish troops confiscated all the vessels lying in the harbour of Greifswald, filled them up with ballast stones and sunk the vessels in shallow waters of the bay at a depth of 2 to 4 metres on a sill with broad sand banks *(figure 1)*. The strategic position between each of the sunken vessels covered a distance of 15 to 45m. The vessels lying on the seabed ever since form a chain like a string of pearls *(figure 2)* in a length at about 1000 meters.

The site was discovered through aerial photography and is now a scheduled monument. Written sources in the Swedish military archive and maps revealed important information about the event and form the basis for a scientifically based description of the historic value of this site.

Not all of the vessels have survived through history. The 20 remaining are small and medium-sized trading vessels and/or fishing-boats acquired from surroundings. They are different types of ships that vary in size and construction. According to some dendrochronological dates these wrecks originally have been built between 1653 and 1692. These samples show the use of older and newer vessels. The selection gives an important insight into what a fishing and coastal trading fleet of the 16th century in the Baltic Sea might have looked like, what types of ships and boats were in use at the same time, what kind of building-techniques were used

FIGURE 2: Areal photography of the ship barrier. PHOTO RGK

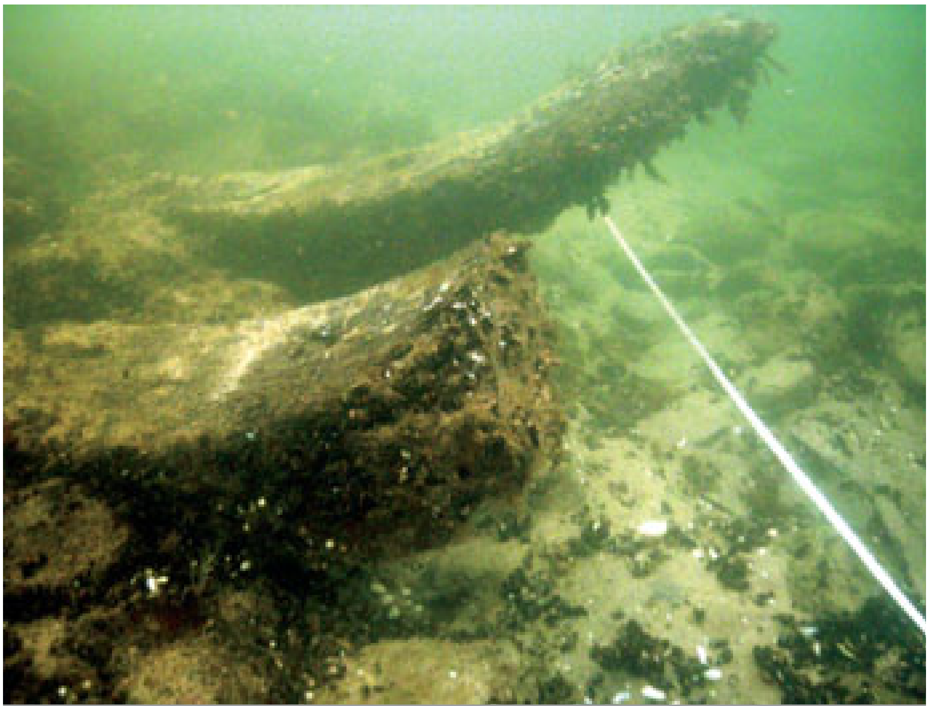


FIGURE 3: Underwater footage of a frame from one of the ships in the Greifswald ship barrier. PHOTO MCCLEAN 2008

and in what kind of tradition the vessels were built. This kind of information is not included into any historic source and can only be received through archaeological investigation on this important historic resource. Moreover this historical monument has an immense importance for the regional and Northern European history and forms an important archaeological source for the reconstruction of naval wars.

During recent years the site came into the focus of the cultural heritage management again. Some investigations were carried out in order to get information about the quality of the overall archaeological resource of state of Mecklenburg-Western Pomerania and this has led to important knowledge about this site. At the same time planning activities were suddenly directed at the ship-barrier when the Nord Stream AG started their activities on planning a major gas-pipeline from Vyborg in Russia to Lubmin near Greifswald in Northeast Germany. This project is financed by a Russian-German consortium, half-owned by Gazprom, carrying prominent chair people like Vladimir Putin and the former German chancellor Gerhard Schröder.

The 1220 km long pipeline project shall be completed in 2011 and this ambitious project includes the management of the historic environment. After an initial phase of recording the state of the site, its quality and the surroundings of the site, one of the vessels will have to be removed, while all the other neighbouring vessels shall be protected by sandbags. The vessel that will be removed will be recorded and excavated using state of the art technology. After investigation it shall be reburied in a wet environment, within a sweet water lake in a former gravel pit to preserve it in its own waterlogged position.

This former gravel pit is already in use containing two wrecks from other sites that could not be kept in situ either. The three wrecks will form the start of a new 'underwater museum' where objects that are not conserved for traditional museum storage facilities are presented and preserved in waterlogged condition.

This project and the backgrounds of the ship barrier are also published on the Nord Stream website (*http://www.nord-stream.com/de/press0/press-releases/press-release/article/nord-stream-to-raise-historic-shipwreck-near-german-ruegen-island.html?tx_ttnews[backPid]=24&cHash=c9bc1cc4ef*, last access 9.10.08). The presentation on this website shows the the change in attitude turning from what was once viewed as a hindrance into a cultural generator: a project that might also result in positive publicity for an infrastructural company.

FIGURE 4: Historic map dating from the Nordic War showing the Greifswald ship barrier. MILITAIRY ARCHIVES STOCKHOLM

URBANISTIC AND INFRASTRUCTURAL DEVELOPMENT OF WATERSIDE URBAN AREAS

MACHU GIS AS A PLANNING

VANESSA LOUREIRO DANS & JOÃO GACHET ALVES DANS

Portugal, an 88,619 km² country, has 845 km of seashore and about 298,521 km² of river drainage areas, more than half of the total Iberian drainage area. Sea and rivers historically played an important role in the development of the territory, fact clearly expressed on a Portugal chart: the biggest and more developed towns are located on the coast or near rivers' mouths.

Not always, however, the country was like this. On the 13th-century, when the Portuguese boarders were definitively established in the sequence of the conquest of Algarve, the most significant harbors, platforms of commerce and exchange of goods and ideas, rested within the rivers. One magnificent example is the city and harbor of Silves, the ancient Muslim *Xelb*, which was located upstream of Arade river[1]. Gradually, Portuguese rivers started silting up. According to the writing sources, this was a problematic situation around the 15th-century, generic to the majority of the most important harbors. On the mouth of Arade river, the village of Portimão was born by this time, and its harbor substituted Silves, which was only then reached by small tonnage ships. The town, around 8 000 inhabitants before the Christian *Reconquista* (Torres Bálbas, 1985), soon became a village and felt abandoned.

The 20th-century saw the building boom of coastal towns when buildings, hotels, seaside homes were built in a response to the increase on tourist demand. On the 2nd-half of this century, waterside development aggregated the governmental concerns, which explains the 70's dredging missions in the majority of the Portuguese harbors. Arade river's mouth started to be dredged in 1968. In 1970, 830 000 m³ of sand were took from this area. Thousands of archaeological artifacts, from different chronologies, were launched with the sand in beaches around the town. At least five shipwrecks were impacted and destroyed. Only one, the Arade I wreck, survived to be located in 2001 and excavated by archaeologists between 2001 and 2005. In the late 80's, Arade river received a new dredging campaign. Again the underwater cultural heritage was forgotten.

Only the creation of the Portuguese Institute of Archaeology in 1997 and the promulgation of decrees concerning the protection of cultural heritage changed the status quo. Nevertheless, the situation was far from ideal. During the building of Portimão marina, a year later, archaeologists were called to keep up with the works but no previous archaeological analysis took place. Three

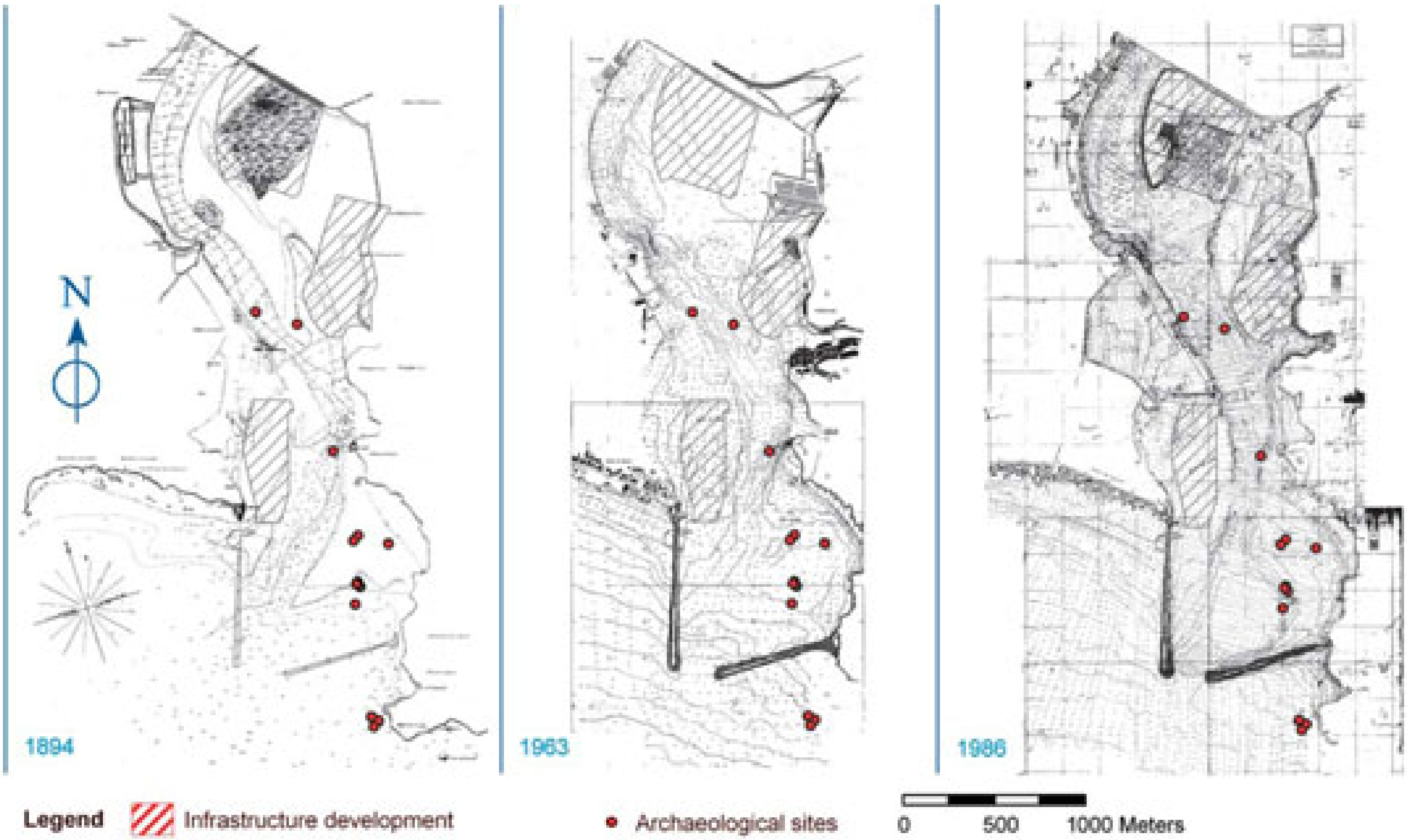


FIGURE 1: Urbanistic, infrastructural development, coastal and seabed change between 1894 and 2005 in and around the Arade River. MAPS: DANS

TOOL?

underwater sites (fortunately, dated from the 20th-century) were summarily recorded and destroyed. Aware of the archaeological potential of this river, the National Center of Nautical and Underwater Archaeology, helped by local entities, developed a survey program of the riverbed, as well as a policy to collect information about archaeological discoveries or recoveries among the population. Between 2000 and 2002, with exception of the already referred Arade I site, no coherent shipwreck or structures were found. However, The Arade river revealed fragments of wooden pieces and ceramic shards, sometimes even entire artifacts in ceramic or metal, all over the bottom. The impact of the dredging works was clear.

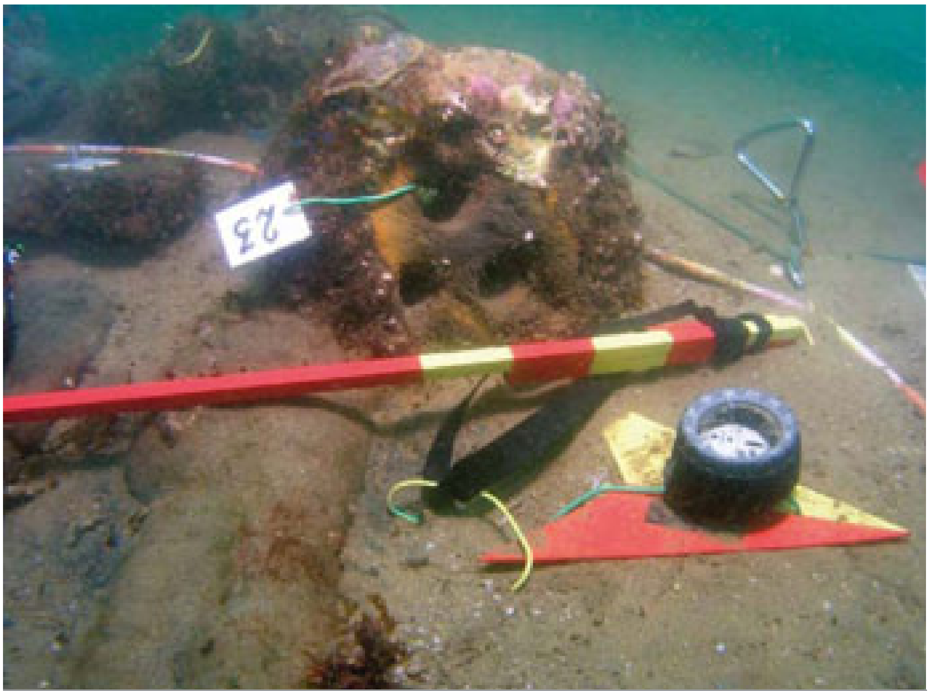
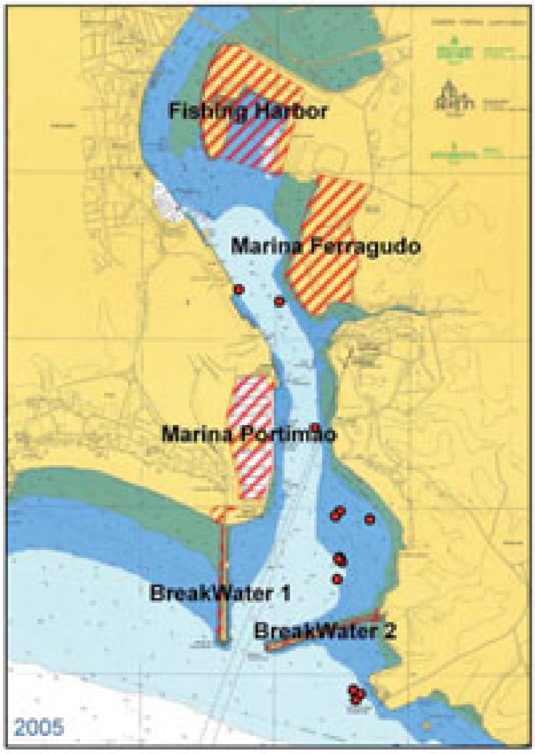


FIGURE 2: Measuring equipment on the Arade 23 wreck. PHOTO: DANS

On 2003, a new dredging plan was developed. The inexistence of any kind of Decision Support System delayed the project as the construction of a rotation basin in the mouth of the river would oblige the dredging of areas never impacted. The project was changed to preserve potential archaeological sites, however, intensive archaeological geophysics surveys needed yet to be done to prevent further heritage destruction. A new site, Arade 23, was discovered and an 18th-century shipwreck already known, but never assessed, was recorded. The protection of the later obliged to further changes to the project. The dredging started only on 2007.



How could MACHU GIS have helped? Arade river mouth is one of the Portuguese test areas within MACHU project. From 2006 on, all archaeological sites or isolated artifacts were monitored. Also a huge work regarding the understanding of the sedimentation process of the river was done, which comprehended the assembly of historical and bathymetric charts as far as the 15th and the late 19th-century, respectively. All data was combined in order to feed MACHU GIS.

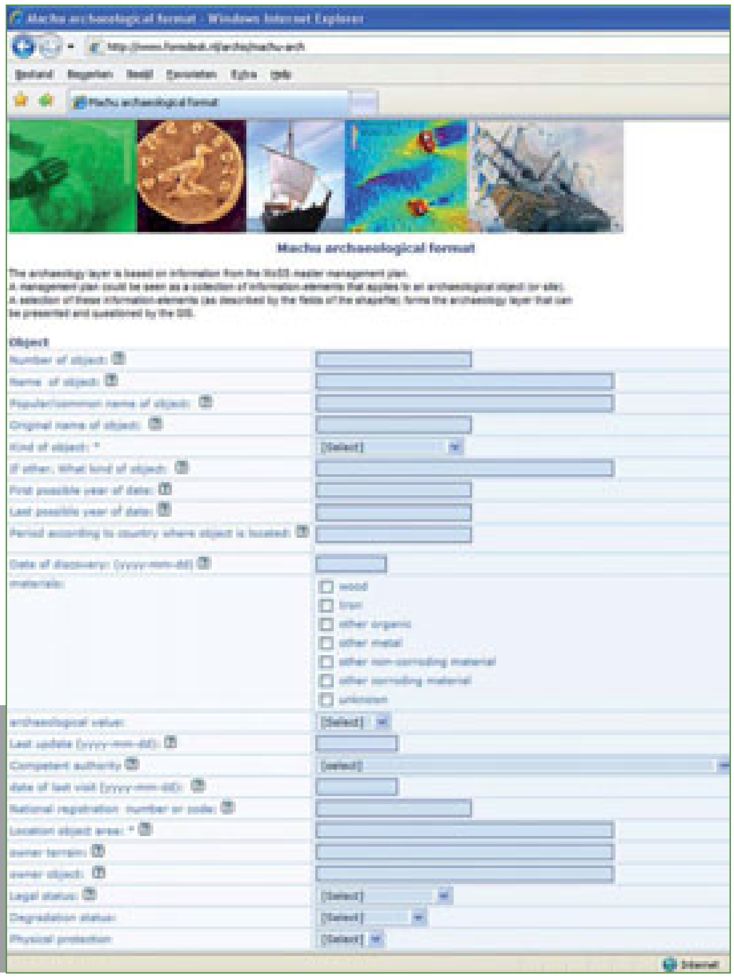
It is, in fact, still a work in progress; however, it was already helpful as a planning tool. In the opposite shore to Portimão marina, a project for a new marina was released in 2007. The Ferragudo marina predicted the reconstruction of the village fishing harbor, the construction of a tourist marina, as well as the building of houses near the shore. To allow the entrance of ships and vessels in the marina, areas of the Arade river never impacted need to be dredge. The project was already designed when archaeologists became aware that it would destroy several archaeological sites. Nevertheless, due to the work done for MACHU GIS was possible to advise minor changes that would compromise infrastructural development with the protection of underwater cultural heritage. The Ferragudo marina, however, will not be built, but not due to archaeological concerns.

Ideally, policy makers, infrastructural developers and cultural heritage managers should be able to dialog before projects see the light. MACHU GIS existence, in the specific case of Arade river, would have allowed significant time savings as the Ferragudo marina project would have been, from the very beginning, sensitive to underwater cultural heritage. In a deeper extent, this heritage can be a valorization component of urbanistic and infrastructural projects on waterside urban areas, sustainably explored in name of science, knowledge and tourism. ■

[1] The example is not occasional, as Arade river estuary is one of the Portuguese test áreas within MACHU.

MACHU AND THE AVOCATIONAL DIVERS COMMUNITY

WILL BROUWERS RACM



The digital MACHU Archaeological Format, for the avocational divers to report new sites.
SOURCE: MACHU

Historically there is a somewhat uneasy relationship between the avocational divers community and the professional archaeological world. In the last decades attraction or fascination in diving has increased enormously. Wreck diving is very popular for obvious reasons. In The Netherlands there are more than 20.000 divers active in one way or another. There are companies who advertise with wreck diving trips.

In the media, diving on archaeological wrecks is being portrayed as an adventurous and exciting way of diving. The awareness of – and necessity of protecting UCH isn't that obvious for a broader public and even within the diver community itself. So we can conclude that the UCH is being enjoyed by a large community, but not very well protected. Even though the policy towards wrecks is clear – preservation is the key word – a lot of wrecks are being damaged intentionally or unintentionally.

Luckily there is a growing awareness within the avocational divers community of the vulnerability of the UCH and quite a few of them are eager to learn to approaching wrecks in archaeological scientific ways. Therefore the RACM organizes courses in underwater archaeology for and with the divers. These courses are focusing on the non-intrusive documenting of underwater sites according to archaeological standards and are similar to the courses of the Nautical Archaeological Society. In reverse the growing diving community can contribute largely to the knowledge of UCH in our waters. There is already a lot of information concerning UCH within the diver community. Specific knowledge of regional conditions and sites are sometimes only exclusively known by these groups.

MACHU is trying to integrate these avocational diving groups into the project to share the rich knowledge they have and to make it visible in the MACHU GIS. In The Netherlands there are several diving groups who are specialized in archaeological wreck diving. Most of them (almost 150 persons) are member of the National Working Group for Archaeology Underwater (LWAOW).

THE BANJAARD

MACHU is working in the Banjaard test area with two diver organizations: The Nehellenia Archeologisch Duikteam (NAD) and the Wrak Duik Stichting Roompot (WDSR). They have a lot of data and information but most of it is not validated and checked scientifically. With these groups we started a pilot project to analyze and validate the information gathered by the divers and integrate it into the MACHU project.
At the moment wreck locations collected by the NAD & WDSR are being validated by surveying and diving by themselves. Because the information is being processed in the MACHU standard formats and guidelines, the information validated in this way can be added to the MACHU database and the MACHU GIS. For this purpose there is an online form in which amateurs fill in the data concerning UCH and upload it to the MACHU GIS. Already several wrecks have been added in this way.

The collaboration with the avocational diving groups in the Banjaard/Zeeland area proves to be very promising for the future. It gives the local organizations more responsibility to care for their 'own' heritage.

If the awareness of the vulnerability of sites underwater and the importance of wrecks as potential archaeological sources of information, instead of sources for souvenirs, is being recognized by all amateur divers, then the richness and preservation of the UCH is better guaranteed for future generations to come. ■

The primary goals of the MACHU project are to develop tools for the management of underwater cultural heritage and to raise awareness about our shared underwater cultural heritage. The project is intended for policy makers, academics, as well as the general public.

BUCKETS FULL OF STORIES, LOST BELOW THE SURFACE AND FOUND AGAIN

ANGELA MANDERS
ARTEKINO

The exhibition at the National Archaeology Days in Lisse, the Netherlands. PHOTO: ANGELA MANDERS

MACHU - AN OUTREACH INITIATIVE

Different facets of underwater archaeology are presented in 10 different buckets with a diameter of 83 cm. PHOTOS: ANGELA MANDERS

Underwater Archeology is an integral part of both our national and international history, yet the general public is largely unaware of it. Due to the fact that managing cultural heritage is moving towards in situ preservation, it seems that the general public will only become less and less involved. Objects and stories can connect us with this past. The presentation Buckets Full of Stories, through the telling stories, aims to make our underwater cultural heritage more accessible.

Buckets full of stories is a traveling presentation about Underwater Archaeology. The research location, Burgzand-Noord near Texel (The Netherlands) is the setting for various stories. Ten buckets and six banners show different facets of Underwater Archaeology, namely: research techniques, the history surrounding archeological objects, the place of the RACM in the field of underwater cultural heritage and the European co-operation in the MACHU project.

The exhibition aims, not only to inform the general public of this little known aspect of Dutch national history, but also to offer them a direct practical experience.
Buckets full of stories gives visitors the chance to experience what it is like to be an underwater archeologist through active participation and research. What is there to discover underwater? And how do you do that?

Bucket Full of Stories is a traveling exhibition and can be seen at various cultural events in The Netherlands. RACM hopes in this manner to reach a large public.

In 2008 the Buckets were exhibitioned at three occasions in the Netherlands. From 6th till 8th June on the National Archaeology Days at Lisse. July and August it was at the RACM Amersfoort building for the Open Monuments exhibition. Finally it was at the Tall Ship races event in Den Helder the Dutch marine harbor in the week of 20th till 24th August. More than 250.000 people were visiting the event in Den Helder. At this moment the exhibition can be visited at the Maritime Museum in Oudeschild, Texel.

MACHU is a European project in which 7 different countries are involved. A similar educational initiative in partner countries is an ideal way to further this partnership. Buckets Full of Stories is a concrete manner to bring people, especially youth, in contact with Underwater Archeology and encourage them to think about the importance of preserving our maritime heritage.

For more information about this educational project or in case you are interested in developing a similar project, please contact *machu@racm.nl*

Bucket Full of Stories has been developed for MACHU and RACM by ArteKino (www.artekino.nl) and Nico van Maastricht.

LEGISLATIVE MATTERS IN UNDERWATER CULTURAL HERITAGE MANAGEMENT

ANDREA OTTE RACM

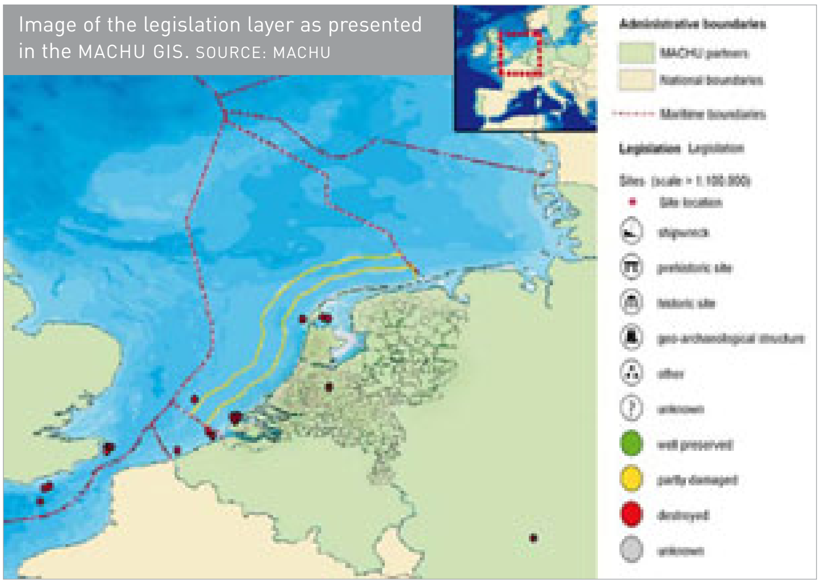


Image of the legislation layer as presented in the MACHU GIS. SOURCE: MACHU

The legal system that is of relevance to the underwater cultural heritage, envelopes a complex of regulations and legislation at national, European and international level. This complexity is due to differential jurisdiction applying to territorial waters and the continental shelf, as well as legislation and engagements spread over several competent authorities.

Within the Machu GIS system a legislative layer has been developed to give an overview of all relevant legislation. In practice this means that a geographical overview is being created to show in which area what kind of legislation for the protection of the underwater cultural heritage can be applied. This information can be of use to heritage managers, but also to other stakeholders to decide what rules they have to take into account when dealing with underwater cultural heritage and to find out what competent authority to approach.

All countries involved in the Machu project have heritage *legislation* to protect and manage the archaeological resource. Although this legislation differs from one county to another, generally speaking these acts offer the possibility to protect archaeological sites, licensing of disturbing activities and supervising on the quality of archaeological research. In some cases there is a single legislative system that covers all archaeological sites both land and sea (e.g. the Dutch Monuments Act 1988), while in others there is separate legislation for the seabed archaeology with emphasis on shipwrecks and much less regard for the prehistoric component.[1]

Besides the sectoral heritage legislation most countries also have spatial and environmental legislation and *policies*, that seek to integrate archaeology within planning schemes and other developments that directly or indirectly affect the archaeological resource. In practice, this often means that in order to get a licence for a specific activity the results of a preliminary archaeological study and assessment have to be provided.[2] However, only a limited part of the sea is only under national jurisdiction. The legislative regime for this area is determined by the United Nations Convention on the Law of the Sea (UNCLOS)[3], aimed first and foremost to regulate the exploitation of the sea and its natural resources.

According UNCLOS the first twelve nautical miles from the coastline are defined as territorial waters under total sovereignty of the coastal state. National heritage legislation may be applied here to the full extend.[4] UNCLOS also offers the possibility to regulate the handling of archaeological and historical objects in the next twelve nautical miles.[5] Beyond territorial waters and contiguous zone the possibilities for protection of archaeological heritage is considerably less. Coastal states are allowed to regulate the use of the sea, the exploitation of natural resources and the protection of the (natural) environment on their Continental Shelves which can extend to over 200 nautical miles from their coastline. This offers the opportunity to protect archaeological remains through development schemes that regulate activities such as aggregate extraction and the erection of wind farms.

The Convention itself has limited protective working sphere towards cultural heritage.[6] To make a mend at this, a separate convention for the protection of underwater cultural heritage has been drafted in 2001. This Convention will come into force on 2 January 2009. Although of the Machu project members only Portugal is signatory to the Convention, the underlying principles (the so-called Annex) are commonly acknowledged and appreciated. It is therefore no coincidence that the Machu project aims at creating management tools that will facilitate the Convention's heritage management rules.

REFERENCES

[1] Such as the Belgium *'Wrakkenwet'*, accepted by parliament in 2007, not yet into force; and the UK *Protection of Wrecks Act*, 1973 (soon expected to be replaced by the Marine Bill).

[2] E.g. the UK *Planning and Policy Guidance: Archaeology and Planning (PPG16)*, 1990.

[3] United Nations *Convention on the Law of the Sea*, Montego Bay, Jamaica 1982.

[4] This depends on the way national heritage legislation is formulated. In the Netherlands the Monuments Act is applied to the territorial waters in the same way as on land, except for aspects like find reporting which, onshore, are authorized by local authorities. In the territorial waters the sole competent authority for archaeological heritage is the Minister of Education, Culture and Science.

[5] UNCLOS, Article 303.2. Until now not many countries have made use of this possibility. One of the exceptions is the Netherlands. From September 2007 the working sphere of the Dutch Monuments Act has been extended to cover the contiguous zone.

[6] Articles 149 and 303 describe that States are responsible for the protection of archaeological and historical objects at sea. One of the main points of departure of this convention however is the freedom of the seas, which means that States have very limited jurisdiction beyond their territorial waters. The dilemma is how to protect heritage without the (legal) instruments to do so.

INTRODUCTION

Within the MACHU project some (rather) innovative techniques within the field of management of underwater cultural heritage are used.

The innovative element can be lying in the introduction of a new technical equipment or method that is being used for the first or nearly the first time in underwater cultural heritage.
Sometimes however, the innovative part lies in the fact that information is being collected, combined and presented in a way never done before, which is also the case for the MACHU GIS. It has not been the primary aim to introduce new techniques within the MACHU project. The here introduced techniques have been all used in the purpose to find ways for a better and more effect management.
The forthcoming articles all talk about combining and retrieving information from the environment that is só influential for the condition of the sites and therefore important to assess and consider and even predict the changes in the overall management for the underwater cultural heritage.

COMBINING OPTICAL DATING, GRAIN SIZE ANALYSES AND CHEMICAL PROXIES

INVESTIGATING SEDIMENT DYNAMICS IN AND AROUND SHIPWRECKS

MARTIJN MANDERS RACM
BERTIL VAN OS RACM
JACOB WALLINGA NCL

All photos: P. VOORTHUIS, HIGHZONE PHOTOGRAPHY©

The knowledge of sediment dynamics is of great importance for the management of shipwrecks on the seabed. On the one hand, transport of sediment will allow for rapid burial of the wreck. On the other hand, sediments transported by currents can be highly erosive which can eventually lead to the complete destruction of a wreck site. In this study we will investigate the applicability of an integrated approach including optically stimulated luminescence (OSL) dating, grain size analysis and anthropogenic metal analysis, to determine the sediment dynamics in and around a ship wreck. The effectiveness of in situ preservation using polypropylene netting will also be investigated.

The aim of our research is to determine the time of deposition of the sand below, beside and on top of the shipwreck. Why could this information be a helpful tool for preservation of shipwrecks? By accurately dating sand, the age of when the wreckage occurred could be narrowed. Additionally, of the depositional age of sand in and on top of the ship could give us an indication how fast and when a ship is buried beneath the sediment and if there is a history of erosion and sedimentation on the site. Furthermore, if younger sand is found below a shipwreck, the ship probably moved after sinking or the environment in which the shipwreck is lying is highly dynamic. The possible cargo will likely be affected under such conditions This can be important for assessment of the value or priority of the ship for *in-situ* preservation or excavation (preserving information *ex-situ*). Finally, it is important to know if *in-situ* preservation is working well. By knowing something more about sediment transport and burial rates, preservation methods like for example the use of polypropylene netting could be improved.

Optical dating is the most versatile tool to determine the time of deposition and burial of sandy deposits. However, application of the method to sediments in the Wadden Sea is not straightforward, because light exposure of the grains prior to deposition and burial may be too limited to completely reset the OSL signal ('set the OSL clock to zero'). Any remaining OSL signal will result in a positive age offset; the OSL age on such deposits overestimates the true burial age. To counteract such problems, one can use the part of the OSL signal that is most light sensitive (i.e. has the best chance to be reset), and one can try to use only those grains for which the OSL signal was reset (i.e. the grains or subsamples giving the youngest results). Both approaches have been successfully used to determine the age of fluvial deposits. So far they have not been applied to Wadden sea sediments. A prerequisite for optical dating to be successful is that the most light-sensitive part of the OSL signal should be erased to negligible levels for at least part of the grains at the time of deposition. Given the highly dynamic environment of the Wadden Sea, we expect this prerequisite to be met.

In this study we not only applied OSL dating but also used grain size distribution and anthopogenic metals to investigate sedimentation processes and the provenance of the deposits. By studying grain size distribution, questions such as if sedimentation is continuous or occurs during events or if sediment is transported through waves (fining upward sequences), or is deposited from the water column during periods of low energy, may be answered. In addition to grain size analyses, anthropogenic trace metals and stable lead isotopes can be used. Stable lead isotope can be used as a fingerprint for anthropogenic lead. From 1950 until 1983 lead was added as an anti-knock agent in petrol. This lead originated from Broken Hill, Australia, having a very different lead isotopic ration compared with European industrial lead and natural lead. By studying metal profiles in the

sediment, the onset of the industrial revolution, the introduction and use of anti-knock agent and the last 20 years can be dated. In addition, if the metal profiles and stable lead isotopes could be used to indentify sedimentation events this will provide useful information like rate and frequency of burial or erosion events of shipwrecks in dynamic sandy environments in shallow (less than 30 m) continental seas.
By also measuring major elements, carbon and sulphur contents in the sediment, the occurrence of sulphate reduction can be established. Sulphate reduction can cause sulphidisation of metal (iron) objects in shipwrecks, like nails. Also it will hamper the exposition and conservation of the ship after lifting because of oxidation of the previously formed sulfides. These will produce sulphuric acid causing all kind of problems.

In this study we apply optical dating, grain size analysis and chemical pollution studies to sediment from two cores taken near shipwreck BZN 10. The aims of this specific study were:

1. To investigate the application of OSL dating on sediment transported and deposited below the water level in the Wadden Sea.
2. To date sand layers below, in and on top of a physically protected shipwreck (BZN 10).
3. Underneath the wreck: To test the hypothesis that shipwrecks sink down into the soft Holocene sediment of the Wadden Sea until the hard Pleistocene subsurface.

FIGURE 2: Research ship the Geonaut with the drilling installation at the stern.

FIGURE 3/4: Changing of the Ackerman cores.

OPTICAL DATING

Optical dating is short for optically stimulated luminescence (OSL) dating. The method determines the last exposure to light of sand or silt-sized minerals. Optical dating makes use of a tiny light signal (luminescence) that can be emitted by quartz minerals. The luminescence signal is proportional to the amount of ionizing radiation ('radioactivity') absorbed by the quart grains since their last exposure to daylight. Optical dating assumes that the luminescence signal was completely reset at the time of burial, i.e. that light exposure during transport of a grain (e.g. by wind or water) was sufficient to 'bleach' the mineral and reset the luminescence clock. A few minutes of intense sunlight or equivalent exposure to less intense light is needed. After deposition the luminescence signal builds up due to exposure of the mineral grain to ionizing radiation from natural radionuclides in its direct vicinity and a small contribution from cosmogenic rays. The intensity of the luminescence signals is a measure of the time elapsed since deposition and burial.
The age of a sample is given by the equation: Age = Equivalent dose / Dose rate. The equivalent dose is the amount of radiation received by the mineral since burial. The dose rate is the amount of ionizing radiation received by the sample per year.
The age range for which optical dating can be successfully applied is site and sample dependent. Saturation of the luminescence signal usually limits reliable application of quartz optical dating to the last 150 ka. At its lower end, the age range is confined by the completeness of resetting of the luminescence signal. In ideal cases luminescence dating can be applied to deposits of only a few years old. The accuracy attainable through optical dating is about 5 to 10% of the age of a sample. For samples older than 80 ka and younger than 1000 years the accuracy is normally less.
For determining the equivalent dose, quartz grains are extracted from the samples using a combination of sieving and chemical treatment (HCl, H_2O_2 and HF). The luminescence signal of small subsamples (aliquots) containing a few hundred grains are measured using a Risoe TL/OSL reader. This machine is equipped with blue LEDs for optical stimulation and a Sr/Y beta source for irradiating. The natural OSL signal of an aliquot is compared to the signal induced by a laboratory beta dose; the equivalent dose is the beta dose that is needed to induce an OSL signal equal to the natural signal. The Single Aliquot Regenerative dose (SAR) procedure emplyed several internal checks and a correction for sensitivity changes.

For determining the dose rate, the material is ground and mixed with wax to obtain a puck of fixed geometry. Radionuclide concentrations are then determined using a Canberra broad energy HPGe gamma spectrometer. The spectrometer was calibrated using quartz flour spiked with K_2SO_4, Uranium ore and Thorium ore. From the radionuclide concentrations the dose rate can be calculated, taking into account the effects of grains size, burial depth (for cosmic dose contribution) and water contents.

4. In the wreck: Use drilling as a tool for finding in situ shipwreck related debris. In this way, excavation by diving is not necessary.
5. Above the wreck: To investigate the effectiveness of the method for in situ preservation in the Wadden Sea: covering shipwrecks with polypropylene nets. These nets can be used as a marker for the calibration of the OSL dating since the year the site has been covered is exactly known.
6. To collect data about the seabed sediment that can be included in the MACHU GIS.
7. To evaluate the application of OSL dating for shipwrecks in a dynamic environment.

MATERIAL AND METHODS

The BZN 10 was a 17th century trader of possible Northern German origin and carried a cargo from the Iberian Peninsula. It was selected for this research for several reasons. It is lying in one of the MACHU test areas, it is a in situ preserved and already extensive information about the site and the ship is available through the MACHU website. At the 27th of November 2007, the samples were taken from the site with the vessel Geonaut from BAM-De Ruiter Boringen en Bemaling BV. Two Ackermann cores were drilled; one through the wreck (9108) and one just next to it (9208). These cores had to go through the whole Holocene layer and one or two metres into the Pleistocene layer.

PRELIMINARY RESULTS

There are clear changes in grain size visible in the cores. The grain size follows the lithology of reasonably well. Several layers of sedimentation caused by events can be distinguished. The observed changes in grain size distri- butions are also reflected in the geochemical patterns.

FIGURE 5: Dr. Wallinga investigating the changing structure of the sediment.

FIGURE 6: In the laboratory little sediment grains are being pick out for further investigation.

At the top of core 9108 – the one drilled through the wreck site – the clay mineral content is somewhat higher, also reflected in the finer grain size. It is interesting to note that the increase in heavy minerals is coinciding with the *in-situ* preservation net. It is possible that the net trapped the heavier particles leading to the observed heavy mineral enrichment.

Anthropogenic metals in general show a decrease going from the top to the bottom of the cores. The content of these metals, however, are very low and fall in the natural variation of these elements. Until now we only analysed the top half of these cores so it is still possible that below the analysed parts concentrations are even lower, suggesting that until a depth of 4 meters the age of the sediment is possible younger than 1850.

ONGOING AND FURTHER RESEARCH

At this moment the deeper parts of both cores are analysed for trace and major elements and stable lead isotopes. By doing this we hope to elucidate the provenance of the metals that might be of anthropogenic origin. This will pinpoint in the sediment the onset of the industrial revolution (1850) and the introduction of leaded gasoline (1950), thereby strengthening the possible outcome of the OSL study.

An OSL profiling study was carried out to select the most promising samples for full optical dating analysis. The profiling study indicated an increase of optical age with depth – which is promising – but also showed that OSL signals of a significant part of the grains was not reset at the time of deposition. This precluded interpretation of the profiling results for age determination, and hence we do not present this data here. Based on the OSL profiling and grain size and chemical analysis we selected 7 samples from core 9108 and three samples from core 9208 for full OSL analysis. This will be executed in the following months. The final results of this study will be presented at length in the final MACHU report.

FIGURE 7/8: In the laboratory several little samples taken from the cores are being prepared for the OSL dating.

HYDRODYNAMICS IN THE GULF OF GDAŃSK

dr inż MALGORZATA ROBAKIEWICZ

Two of the three test sites for the MACHU project in Poland are situated in the Gulf of Gdansk. These are the Puck Medieval Harbor and the Gdansk old harbor area. The overall management of these sites is partly depending on the knowledge of the natural conditions in this area. Important parameters are salinity, temperature and current. These three have an influence on the condition of the (partly) submerged cultural heritage on and in the seabed. Temperature and salinity can have an effect on the rate of biodegradation. Current can cause mechanical deterioration like abrasion, but also erosion of the seabed making the archaeological sites venerable for all sorts of deterioration.

The existing knowledge on hydrodynamic conditions in the Gulf of Gdańsk is based on in situ observations carried out by regular observations (within the national observing and monitoring program carried out by meteorological service) carried out for over 50 years, some ad hoc measurements carried out within scientific and commercial projects. Recently results from numerical models of the area of interest also become an interesting source of information with regards hydrodynamics.

Discussing hydrodynamic conditions in the Gulf of Gdańsk the following parameters will be taken into account: water temperature, salinity, water currents.

The Gulf of Gdańsk, located at the southern part of the Baltic Sea, is a wind driven water body. Its dynamics is very much dependent on wind conditions which have a character of a random process. Below an overview of measuring techniques used as well as some historical overview of measurements will be given. Next analysis of salinity, temperature and currents variations in time and space will be presented.

FIELD MEASUREMENTS OF HYDRODYNAMICS IN THE GULF OF GDAŃSK

In situ measurements are the basic source of information on dynamics in the analyzed water body. Quantity and quality of available data very often is the basic limit to understand the natural processes there. To enable better explanation of the present state of our knowledge it makes sense to have a closer look on measuring techniques and their potential and limitations. *In situ* measurements of hydrodynamic conditions can be done using different methods. Taking into account the spatial aspect of planning we can distinguish:

- Euler method (registrations are carried out in a chosen fixed locations)
- Lagrange method (registration covers tracking of the floating object).

Taking into account the length of measurements, we can distinguish:

- short-term registrations (e.g. seconds, minutes);
- long-term registrations (e.g. hours, days, months or even years).

We can also distinguish the following methods of measurements:

- direct (e.g. water temperature, traditional water level gauges);
- indirect (e.g. salinity using conductivity gauge, satellite images, etc.).

From this general overview of possibilities of *in situ* measurements with regards coverage of the area of interest in space and in time, it is quite clear that to get a spatial distribution of any parameter it is necessary to have a number of instruments running simultaneously. In practice it is not possible to cover the Gulf by a set of instruments running in parallel for a certain time. This quite well explains that we still come across problems with presenting a well documented picture of changes in hydrodynamics.

WATER TEMPERATURE – CHANGES IN TIME AND SPACE

Water temperature changes seasonally in the Gulf of Gdańsk, however it is not uniform in the whole water body. The layered structure of temperature is observed there. The *upper layer* reaches the bottom in the shallow parts (i.e. in the coastal zone), whereas in the deeper parts its boundary is located at the depth of 40-60 meters, sometimes reaching even 70 meters. Below, up till the bottom, *the lower layer* can be distinguished. In between those layers *the intermediate layer*, characterized by the minimal water temperature, can be observed. The intermediate layer most commonly appears at the depth 60-80 meters, sometimes it can reach even 90 meters.

In the upper layer changes of water temperature are closely related to seasonal changes of meteorological parameters (e.g. air temperature, solar radiation), and are modified by vertical processes (i.e. convection, mixing due to wind, mixing due to Vistula river inflow). Based on observations carried out at the coastal stations it was found that the largest differences in water temperature in the basin are observed between stations in Hel and Świbno. The biggest can be observed in the period April-July (max. 6.8°C - July 1980).

Based on water temperature measurements

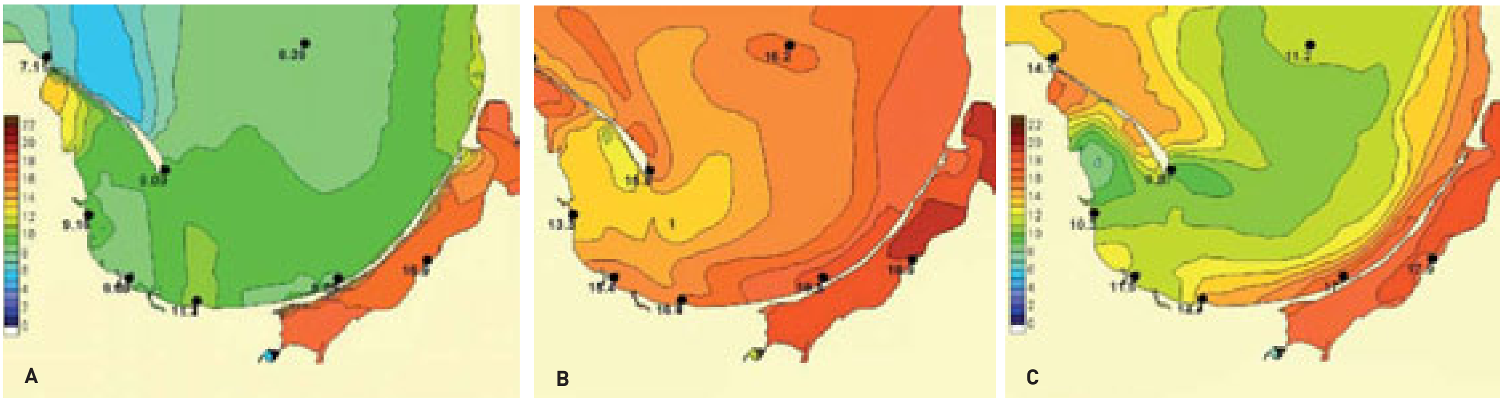


FIGURE 1: Surface temperature in the Gulf of Gdańsk in chosen moments (data from UG model): **A** - N-side Hel Peninsula / **S** - S-side Hel Peninsula / **C**

carried out in the years 1950-1975 within the monitoring program, the Institute of Meteorology and Water Management (IMGW) prepared maps of mean monthly surface temperature. The well pronounced differences can be noticed between the coastal zone and the deepest part of the Gulf. The lowest water temperature was observed in the Vistula River mouth in January (i.e. 0.1 – 2.0°C) and the north-eastern side of the area (close to Vistula Spit; 1.4 – 2.2°C); in February in the shallow parts of Gulf (in the eastern and western part – approx. 1°C) and in the deep part (2.5°C). The smallest differences in the surface temperature within a year were observed in February.

In the spring time water temperature increases; in the same time the difference between the extreme values (up to 7°C) increases. Spring is a season when very distinct increase of water temperature is observed in the Vistula River mouth; as a consequence the water surface temperature in the southern part of Gulf also increases.

In summer water surface temperature differences between different parts of Gulf decrease; in August they become quite uniform (differences reach only 2.3°C). In the same time water temperature reaches the maximum absolute value within the year (16.1-18.4°C). In the southern part of Gulf, being very much influenced by the Vistula river, the maximum temperatures are observed in July. In the north-western part of Gulf (the Puck Bay region) the maximum is observed in September. Starting from September temperature starts to decrease, the most dynamic in shallow parts of the Bay. The most pronounced decrease is observed in November. The mean monthly water surface temperatures vary within a year in the range 14.3 and 17.1°C.

In the deepest part of Gulf (below 80 m) water temperature shows slow increase to maximal temperature. Due to no contact with the atmosphere temperature of the deep water does not follow the seasonal changes observed in the upper parts of water column. The annual variation of temperature there is related to inflow from other regions of the Baltic Sea.

Very distinct short term changes of surface water temperature are observed in the Gulf of Gdańsk. They are mainly due to wind currents which in some conditions specific conditions 'push' the surface water seaward while in the same time, to compensate, inflow of deep water encounters. Using traditional techniques of measurements i.e. point measurements it is very difficult to detect them; however satellite images and numerical modeling very much increased our knowledge with this respect. From the results of the forecasting hydrodynamic model of the University of Gdańsk it can be seen that the upwelling can be observed in some locations of the Gulf *(figure 1)*.

SALINITY IN THE GULF OF GDAŃSK – CHANGES IN TIME AND SPACE

Measurements of water salinity in the Gulf of Gdańsk are in general carried out jointly with water temperature. Analysis of salinity in the Gulf will be based on measurements carried out by IMGW, some measurements carried out occasionally, and using knowledge coming from numerical modeling. IMGW measurements cover stations from the sea and also from the coastal stations. Comparisons of the mean monthly differences of salinity in the years 1951-1980 (Majewski, 1990) have shown the highest salinity can be observed in Władysławowo (7.52°/oo) and Hel (7.32 °/oo), and lower values in the southern part of Gulf – Gdynia (7.30°/oo); Gdańsk – Nowy Port (5.99°/oo). We have to consider those results as an 'estimate' as in that period (1951-1980) no automatic instruments with very high frequency of measurements were available. From more recent measurement it is known that in some locations big variations in a short-time scale can be observed.

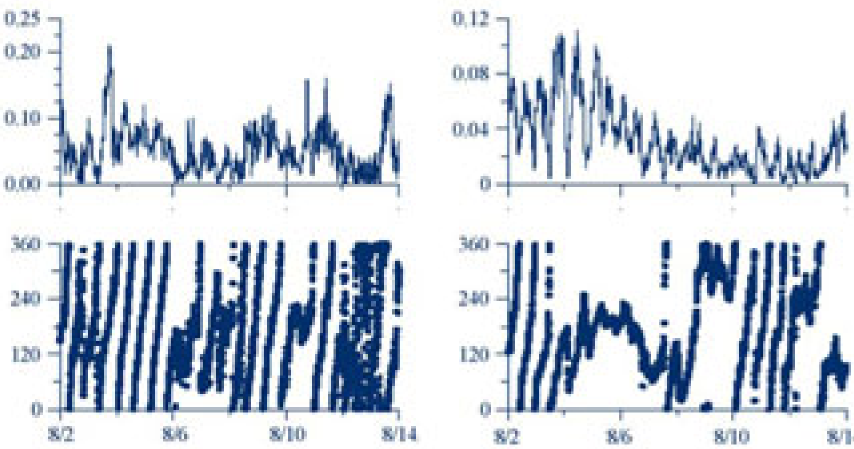
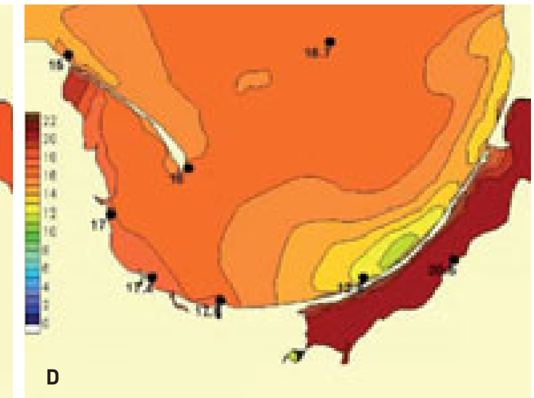


FIGURE 3: Currents as measured in location ibw (55o28'N, 18o10'E) in the period 2-14.08.96; left - depth 13 m / right - 75 m (Robakiewicz, 2004)



- SW-coast of the Gulf / **D** - SE-coast of the Gulf

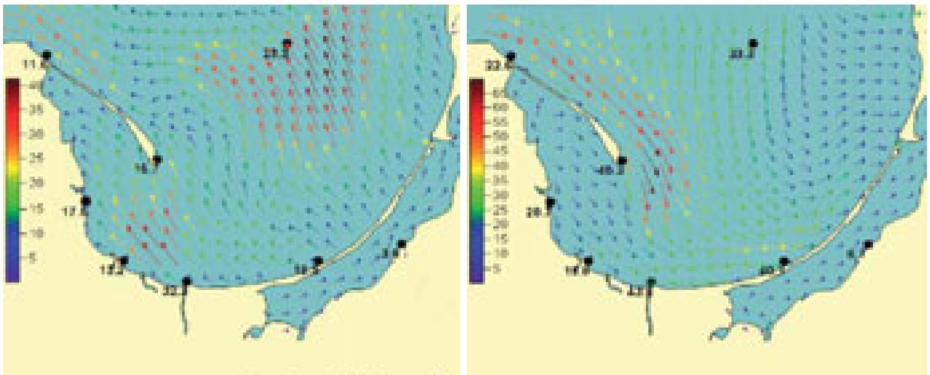


FIGURE 2: Surface currents as obtained using numerical model of University of Gdansk - exemplary results. SOURCE: UG-WEBSITE

Spatial differentiation of salinity is very much dependent on morphological conditions. In this respect we can distinguish rather distinct differences between the coastal zone, deep parts of the Gulf, and the Baltic Proper. The shallow part of the Gulf is very much dependent on the Vistula River; in that region salinity is below 7°/oo, Influence of riverine water is observed in the surface layer in the deeper parts of Gulf; in extreme cases it can be measured close to Hel Peninsula.

Based on field observations it is known that in case of wind from W, N and E riverine water cannot spread easily in the Gulf thus it spreads along its coast. In case of NE wind water moves west wards while in case of NW wind - towards east. Wind from S and SW allows for free spreading of riverine water in the Gulf. It is also well known that weak winds (not exceeding 2-3 m/s) support spreading of riverine water, whereas strong wind induces mixing close to the river outflow. Available statistics (1980-85; see Majewski 1990) indicate that dominates spreading east- and north-east ward (50% of time), while north-ward spreading takes about 25% of time, and in 16% of time water was spreading on both side of the river outflow. Seasonal changes of river outflow have a direct influence of seasonal salinity changes, especially in the surface layer in the coastal regions. The lowest salinity is observed in spring-summer, i.e. periods of the highest river discharge (e.g. 4.5°/oo in May, close to Vistula river outlet), while in winter time in the coastal zone it can be estimated as 6°/oo. Similarly as in case of temperature also we observe salinity stratification. In case of salinity we distinguish *surface layer*, where salinity can have gradients of 0.25°/oo-0.35°/oo, *isohaline layer* with no gradients (of salinity 7-8°/oo), and below *bottom layer* where salinity can reach (8-11°/oo, on average).

WATER CURRENTS IN THE GULF OF GDAŃSK

In the Gulf of Gdańsk wind is the main generator of water motion. *Wind driven currents* are generated as a consequence of wind stress acting on the free surface normal to it. This force makes the surface move, and due to energy momentum is transferred into the deeper parts. Wind stress generates *drift currents*. Wind driven currents develop relatively quickly in steady wind conditions. It was suggested by some authors that after about 48 hours of steady wind currents are in the Gulf reach steady state; however the *in situ* observations and numerical modeling do not confirm this hypothesis.

Gradient currents are generated by wind lasting for a long time; in such a case the water level increases in some parts of the water body while in the other decreases. In such cases horizontal pressure gradients are generated; they are the mechanism of those currents. The gradient currents develop slowly; similarly they also slowly decrease. *Density currents* are also observed in the Gulf of Gdańsk. They are created when non-uniformity of water density occurs. The density difference in the Baltic Sea is due to exchange of water masses between Baltic and the North Sea; however in the Gulf of Gdańsk the main 'source' of density differences is Vistula river inflow. Density currents are smaller than those of wind origin, however they can not be neglected. In practice *in situ* measurements include all types of currents without distinction by their origin.

The flow pattern in the Gulf is rather complicated to measure and to interpret. Currents differ in space and in time substantially, so in situ measurements deliver a rough picture only. Nowadays only numerical models deliver the spatial distribution of currents. Two chosen results from the model worked out by Gdańsk University are given in figure 3. The accuracy of models is very much related with the horizontal and vertical discretization of the modeled area. The obtained result deliver information about *averaged* conditions in the area covered by individual grid cell.

It is worth looking on *in situ* measurements from the region to have an idea on the real situation. An example of long-term measurements in one chosen location are presented in figure 3. It is well seen substantial great variability in time and differences between currents in the same location but on different depths. Due to local variations of currents model results are not able to represent the real situation with very high accuracy at the moment.

For the management of the underwater cultural heritage in this area it means that an extensive monitoring program is important to carry out. At this moment there are no existing models that can tell us in enough detail how salinity, temperature and current develops in this area. By systematically collecting data during the monitoring schemes, in the future we might be able to get more grip on the natural changes in this area. This data can then be used for a model in this area and presented as an extra layer in the MACHU GIS.

REFERENCES

- Majewski A. (Ed.) (1990), *The Gulf of Gdańsk* (in Polish: *Zatoka Gdańska*), Wydawnictwa Geologiczne
- Robakiewicz M. (2004), *Some chosen problems in mathematical modelling of the Gulf of Gdańsk* (in Polish: *Wybrane problemy matematycznego modelowania hydrodynamiki Zatoki Gdańskiej*), IBW PAN

MODELLING SEDIMENT MOBILITY

TO SUPPORT THE MANAGEMENT OF SUBMERGED ARCHAEOLOGICAL SITES

JUSTIN DIX*
DAVID LAMBKIN**
TIM RANGECROFT*

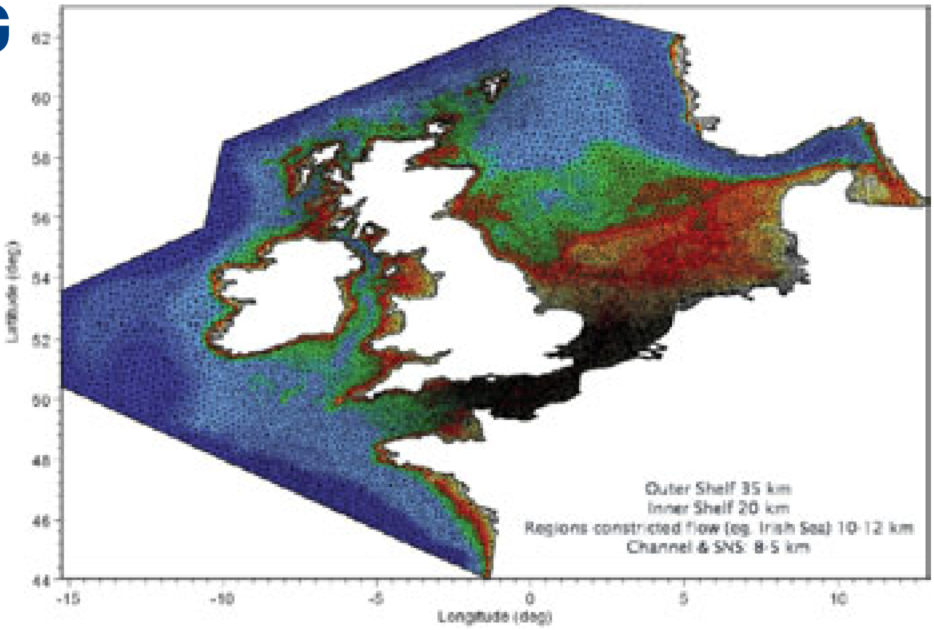


FIGURE 1: Final NW European mesh for the numerical hydrodynamic model.

During the last twelve months there have been significant developments on both the numerical model for the calculation of regional sediment transport pathways and the development of physical models of specific MACHU wreck sites. After significant testing it was deemed necessary to extend the model domain to terminate in deep water enabling the global ocean input parameters to be truly representative of the real inputs. This required the model domain to now include the entire NW European continental shelf which was then represented by a scaled mesh that decreased in size from 35 km resolution at the Outer Shelf to 8-5 km resolution in the areas of core interest, namely the English Channel and the Southern North Sea (figure 1).

The extended domain has enabled us to increase both the quantity and the quality of the extant data used to calibrate the model. Iterative calibration and sensitivity testing of water level data from the south-west approaches through to the Swedish coast has been completed. Similarly, tidal current speed and direction calibration and sensitivity testing for 12 sites in the Southern North Sea and including the Dover Straits (the location of our final test site - the Goodwin Sands) has been concluded. We now regard the model as being complete in terms of tidal currents and so we are currently adding the wind and wave domain prior to running the final sediment transport pathway model and ultimately the nested local model of the Goodwin Sands.

In tandem with the numerical modelling work we have also been undertaking physical modelling of wreck sites in environments dominated by tidal currents. Using approaches developed in part by an English Heritage Aggregates Levy Sustainability Funded project (3365). The ultimate aim for this part of the project is to recreate in a laboratory flume the dynamics of a subset of the individual wreck sites being studied as part of the MACHU project. The first phase of this work involved detailed calibration of the flow regime created within the tank, in order to create a working area with uniform flow in a model velocity range of c. 12-14 cm^{-1} (which scales to a field flow of 35-40 cms^{-1}).
On completion of the tank calibration a series (8 runs in total) of standard experiments with a prototype vessel were undertaken, with the vessel being oriented 22°, 45° (x3), 66° and 90°(x3) to the flow. The resulting scour patterns (*e.g. figure 2)* were scanned with a Minolta vi-910 laser scanner (spatial accuracy < ± 0.22mm) to facilitate quantitative comparison with prototype scale swath bathymetry data.
Currently, we are creating a scale model of the 17th Century scale models of the Burgzand wreck cluster based on swath data provided by the RACM partners. The swath data was analysed using a series of contour and surface representations of water depth, slope angle, slope aspect and temporal bathymetric change (from the five annual surveys available). Having identified the true morphological expression of the site we are using a scaled version of the final XYZ data to drive a CNC (computer numerical control) router to cut a perspex version of each of the wreck sites. In the next phase these will be used to drive a physical model of each site.

*UNIVERSITY OF SOUTHAMPTON, FOR ENGLISH HERITAGE, UK.
**ABPMER, FOR UNIVERSITY OF SOUTHAMPTON

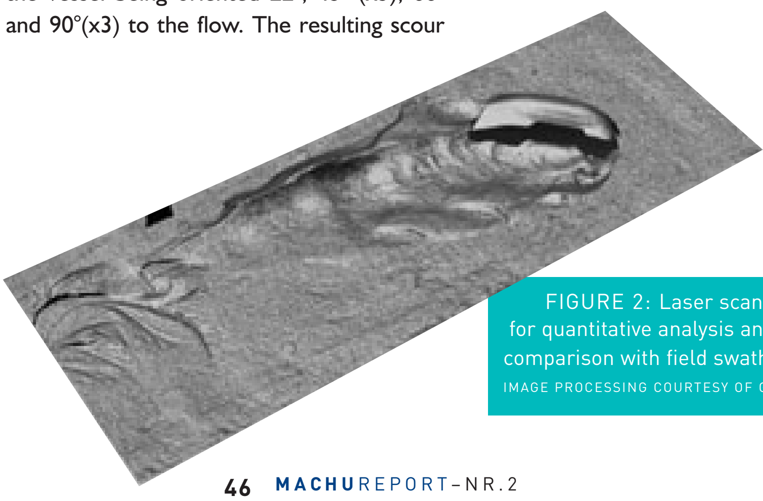


FIGURE 2: Laser scanned bed for quantitative analysis and direct comparison with field swath data.
IMAGE PROCESSING COURTESY OF G. EARL

MACHU WEBSITE NEWS

WILL BROUWERS RACM

Since the last MACHU Report the MACHU website contains new topics, giving not only information on managing UCH but also on archaeological and historical topics. MACHU is not only concerned in dealing with the normal corporate information but also wants to trigger enthusiasm for the UCH.

As an extra feature The MACHU website is presenting news items from the field MACHU is related to. This means presenting historic and archaeological information on shipwrecks and other sites underwater. In the special web section 'wrecks', sites are furnished with a 'wreck ID'. These are short presentations of archaeological sites within European waters. Basic information on wrecks about type, date and location is complemented with historical information, archaeological background, video and/or pictures. This gives an insight in the diversity of wrecks in MACHU waters besides illustrating the (often) well preserved state of UCH. On the same web page one can access historic map information in the same way as the wreck ID. Basic information can be found about several maps which can be explored in detail as well. ■

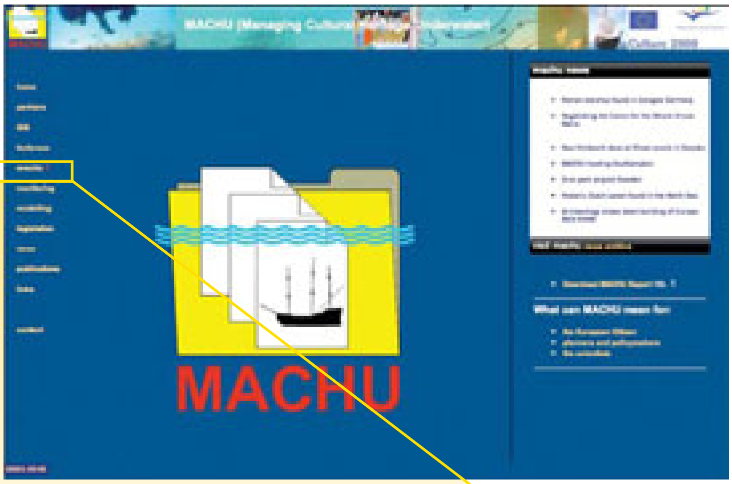


FIGURE 1: Take a look at www.machuproject.eu, click on WRECKS.

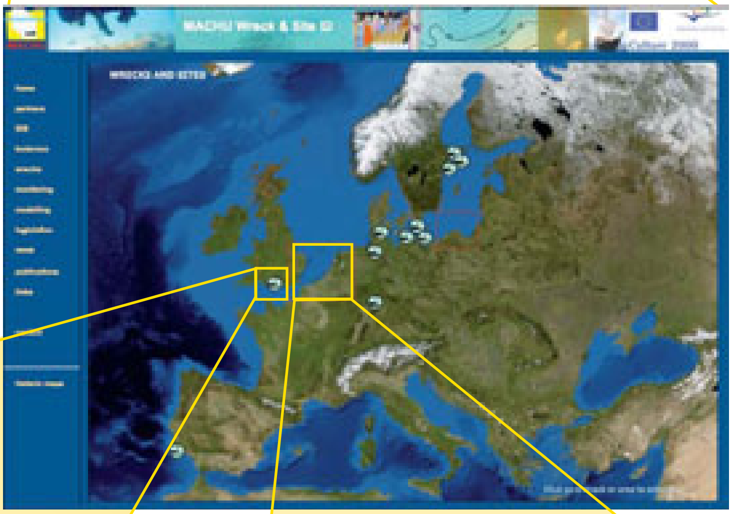
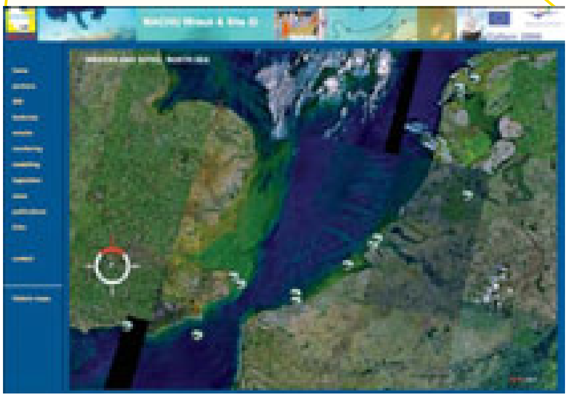


FIGURE 2: Choose a wreck symbol to explore a wreck.



The squares that are visible on the WRECKS page are areas with multiple dots. To enlarge these areas, please click on them.

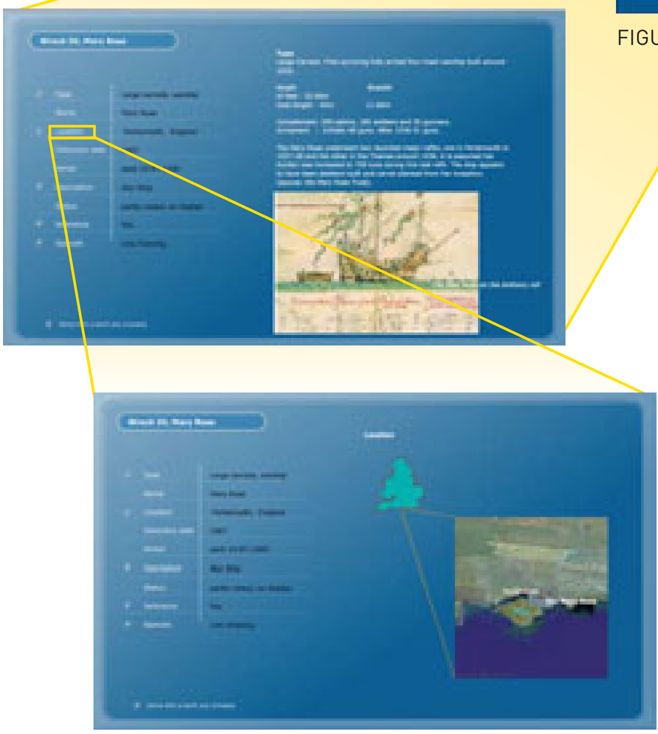


FIGURE 3: A wreck ID card of the Mary Rose.

SOME REFLECTIONS ON UNDERWATER CULTURAL HERITAGE MANAGEMENT

ANDREAS OLSSON
SWEDISH MARITIME MUSEUMS

FIGURE 1: Margaretha av Vätö Wreck, sunken in 1898. PHOTO: JIM HANSSON, SMM

In my everyday work I tend to picture the cultural landscape as a space. In this space there are acting people and physical surroundings, things you can touch. The cultural heritage is part of these surroundings. The cultural heritage becomes meeting places, where we in relation with the cultural heritage understand ourselves, our past and future.

Cultural heritage is in this respect not only monuments as defined by heritage acts; it's rather defined by us in meeting the cultural heritage. Cultural heritage can because of this be hard to identify and describe. This doesn't mean that we shouldn't take on the challenge. Cultural heritage management is about identifying, registering, doing our best to interpret and protect the cultural heritage, but it is also about helping people find their own understanding of cultural heritage. However, this also means that every time a cultural heritage is visited, in mind or body and no matter who the visitor is, its value or meaning gets redefined. In this respect cultural heritage is ever changing.

Adopting a concept much used in art or psychology, cultural heritage is *spiritus loci* – a place where the spirit of identity, past and present manifests *(Greer 2003)*.

CHARACTERISTICS OF SHIPWRECKS

The most common cultural heritage found under water is shipwrecks. In Sweden there are around 3000 known shipwrecks and 12 000 registered losses of ships. There is a vast and increasing scuba diving activity and it is mostly shipwrecks that are visited by these divers. The 'terrestrial' cultural heritage management sector actually envy us as their maritime dittos just because we have such a large and dedicated target group.

Besides this, it is also clear that shipwrecks in great extent tend to allure also the non-diving public. Each year, over one million people visit the Vasamuseum in Stockholm!
So, how do we capture the *spiritus loci* of shipwrecks? Is it possible to outline the cornerstones of this fascination for shipwrecks? I don't know and I won't make a serious attempt here either, only try to show a possibility. The French philosopher Michel Foucault (1986) touches upon the subject in a lecture given in 1967, briefly sketches a western notion of space. He launches the term *heterotopia* in order to describe a conflicting space, a place-less place. He argues that:
The boat is a floating piece of space, a place without at place, that exists by itself, that is closed in on itself and the same time is given over to the infinity of the sea and that, from port to port, from tack to tack, from brothel to brothel, it goes as far as the colonies in search of the most precious treasures they conceal in their gardens, you will understand why the boat has not only been for our civilization, from the sixteenth century until the present, the great economic development, but has been simultaneously the greatest reserve of the imagination.

These arguments can easily be transferred also to shipwrecks and in some extent also to cultural heritage in general. Shipwrecks are places that are understood within two poles. They are in great extent both real and illusionary in relation to other spaces. As situated underwater they are isolated and abandoned. At the same time they are possible to reach through diving. Furthermore, they have strong temporal qualities, often described as time-capsules. Foucault describe ships are hetereotopias par exellance. It seems as if shipwrecks are an even stronger example of heterotopias.

AN ILLUSIONARY CULTURAL HERITAGE?

Shipwrecks are, probably more than other categories of cultural heritage, threatened by wear and looting. However, Foucault's ideas only explain our fascination of ships and shipwrecks. How can we understand this phenomenon?

Of course looting and the selling of objects from shipwrecks to collectors is a criminal behaviour that has other mechanics. Also, it seems that this activity is of lesser importance in the Baltic Sea in comparison to wear caused by scuba diving. On the most visited shipwrecks finds are constantly being moved around, pieces of timbers accidently, but very often, broken off. Souvenirs of personal use are being collected. It seems as if this is done by people who are aware of that shipwrecks are protected, and who don't show a criminal behavior in other situations. So, how do we explain this behavior?

FIGURE 2: The Vasa was lifted in 1961. PHOTO COURTESY SMM

Trompe-l'œil[1] (Trick the eye) is an art technique with very realistic imagery in order to create the optical illusion[2] that the depicted objects appear in three-dimensions, instead of actually being two-dimensional. The *trompe-l'œil* art, wants us to reach out and touch the objects in the art. It is our human instinct to touch what we see and the art aims to puzzle us with an illusion. In combination with the fascination of shipwrecks, is this why ordinary people can't stand the temptation of touching a vulnerable shipwreck, picking up finds etc? This might also be enforced by the fact that objects, because of light breaking differently underwater, seems closer to us than they are.

FIGURE 3: A little beardman Jug lying between the construction elements of the well preserved Dalarö wreck in Swedish waters. PHOTO: JENS LINDSTRÖM SMM

A GREAT POTENTIAL

Shipwrecks are clearly a very exiting cultural heritage with a very much unexplored potential. In the Baltic Sea, preservation conditions for wood are amongst the best in the world. Shipwrecks are found standing fully intact, vulnerable and exposed, on the bottom with masts standing and finds and sculptures in place. The Baltic Sea has a seafaring history that involves the greater part of northern Europe. The numbers of shipwrecks are unknown, but could probably be up to 100,000.
Theoretical understanding of how cultural heritage, and especially shipwrecks, are perceived and interpreted will help us not only find proper protect strategies but also see the role of cultural heritage management and cultural heritage in future development of our societies. ■

[1] http://en.wikipedia.org/wiki/Art

[2] http://en.wikipedia.org/wiki/Optical_illusion

REFERENCES

■ Foucault, M. 1986. *Of other Spaces.* Diacritics 1986.

■ Greer, J M. 2003. *The New Encyclopedia of the Occult.* St. Paul, MN, Llewellyn Worldwide. p. 449-450.

THE FUTURE OF MACHU

MARTIJN MANDERS

The MACHU-project as funded by the Culture 2000 Programme of the European Union will end on the 1st of September 2009. Until that date, the eight partners in the project will make sure all the criteria and the aims of the project will be attained.

The MACHU GIS will be filled with data, the sedimentation-erosion models connected with the GIS and also other data will be worked up as layers in the GIS. The updating of the website and the GIS will be an ongoing process. At the end of the project a final report will be published as well as a popular publication will be made. In June 2009 the MACHU project will have its final symposium at the new head quarters of the RACM in the Netherlands.

The MACHU project will end. What then? It has been the intention of the MACHU group to create products that have their use far beyond the MACHU project. The formats that are developed to register data from different sources and countries in the same kind of way might become standards for others to be used as well. The MACHU GIS itself could even be used as a standard GIS in Europe and beyond. One could for example think of adding shipwrecks of mutual heritage that are found any where in the world. The GIS could be used to present data and pre produced layers produced by others; archaeologists but also other stakeholders in the field of UCH. It is evident that the international oriented underwater cultural heritage needs a place where information can be shared. Data shared with other scientists, but also other stakeholders that might collect data that can be of use for the protection and management of common UCH.

MACHU therefore will strive to promote its specific products within the countries of the European Union and the European Union itself. Ideally MACHU aims to be a central European GIS for the maritime archaeology. For this reason MACHU will also be experimenting with methods to filter data directly from central databases that are used in the different countries to register archaeological sites, like ARCHIS in the Netherlands. In this way the MACHU GIS will always be using up to date information.

All these high ambitions can only be attained when the critical user group is going to be extended. We therefore ask other institutes with a central registration system to join us in creating this overview of our underwater cultural heritage: a powerful tool for management and research! ■

COLOFON

PUBLICATION

MACHU

PRODUCTION

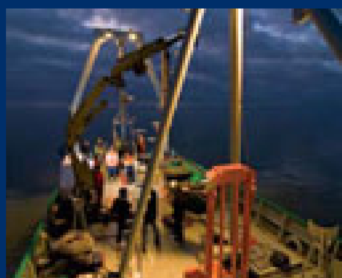
Educom Publishers BV
Mathenesserlaan 347
3023 GB Rotterdam
The Netherlands
T +31 (0) 10 425 6544
F +31 (0) 10 425 7225
E info@uitgeverijeducom.nl
www.uitgeverijeducom.nl

EDITORS

Martijn Manders
Rob Oosting
Will Brouwers

PHOTO BACK COVER

Research ship the Geonaut with the drilling installation at the stern.
PHOTO: P. VOORTHUIS
HIGHZONE PHOTOGRAPHY



MACHU

Education and Culture

Culture 2000

WWW.MACHUPROJECT.EU