Chapter 4
Joint Explorations of the Sunken Past: Examples of Maritime Archaeological Collaboration Between Industry and Academia in the Baltic

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Abstract This chapter examines the benefits and constraints of collaboration between an archaeological research unit and a commercial company, using as examples joint research conducted by MARIS (Maritime Archaeological Research Institute at Södertörn University) and the Swedish commercial marine survey company MMT. The examples presented here included the detailed reconstruction by remote sensing of deeply submerged shipwrecks and the mapping and discovery of submerged archaeological landscapes and associated artefacts such as fish traps, which can then be examined more closely by archaeological divers. The benefits to archaeologists of collaborating with well-equipped commercial companies are obvious, but the benefits are mutual. The demands of archaeological research can generate new technological solutions that have commercial application, as well as producing results with wider educational and social benefits. Provided that archaeological investigations are embedded in the normal commercial operations of the company, such collaboration can be cost-effective for both parties, and is further enhanced by collaboration with film companies, which generates wider public interest and publicity for all concerned.

4.1 Introduction

The Baltic Sea is one of the best places in the world for underwater archaeology thanks to the unique conditions for preserving wood and other organic material in the brackish and cold water. The Maritime Archaeological Research Institute, MARIS, based at Södertörn University in Stockholm, is focused on investigations and interpretations of this special 'Baltic sunken past'. However, archaeological studies of shipwrecks, maritime defence systems and submerged landscapes require special techniques, skills and equipment. This is particularly evident for work carried out at great depths, where underwater robotics, multibeam bathymetric systems and other sub-sea survey technologies are necessary. Developing and improving different methods for underwater survey, mapping and excavation has therefore also been a part of MARIS activities. Since 2008 this has been done in close cooperation with the marine survey company MMT and with Deep Sea Productions, a film production company. In 2011 the tech diving company Ocean Discovery also became a part of this collaboration.

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The marine survey company MMT is based in Gothenburg but the company works worldwide. MMT's clients are primarily found in the oil, gas, renewable energy and cable industries, and in governmental organizations. MMT operates a fleet of fully equipped Survey and ROV vessels and smaller workboats (Fig. 4.1). All ships are equipped with precision navigation and work on seabed mapping assignments. The company employs 200 individuals with various specialties in the field of marine survey work. MMT combines experience in marine survey operations with new techniques, the latest sub-sea equipment, and different types of survey vessels in order to meet the demands of the commercial market. It is important for the company to be flexible, innovative and reliable in order to deliver cost-efficient marine survey solutions.

The differences in perspectives and aims between a small research-based archaeological institute such as MARIS and a commercial survey company such as MMT are obvious. But there are, nevertheless, interests in common, and our aim in this chapter is to describe our ability to work together, assess the benefits of industrial collaboration, and outline some of the ways in which the relationship can be optimized for archaeological purposes.

The collaboration between MARIS and MMT has focused on the improvement and adaptation of underwater technologies and methods for archaeological use (Holmlund 2014a, b). A particular aim has been to develop new standards for documentation and evaluation of source material on the sea floor that is out of range of ordinary diving or where diving is too time consuming or risky. The work includes both the documentation of minute details on the exterior and inside of shipwrecks and the mapping of large areas of underwater landscape.

Fig. 4.1 MMT research vessels *Franklin* (*left*) and *Triad* (*right*) are two of the vessels which have been used for the fieldwork described in this chapter

Although the emphasis of this volume is on submerged landscapes, we will first describe some joint work on shipwreck projects, in order to demonstrate the benefits of our collaboration, and then proceed to present new technologies and techniques for deep-investigation that also have potential application to studies of prehistoric landscapes.

4.2 Shipwrecks

In 2003 Deep Sea Productions (DSP) and MMT discovered a shipwreck in the middle of the Baltic Sea, which even for the Baltic was exceptionally well-preserved (Figs. 4.2 and 4.3). In complete darkness and 130 m below the surface lay an almost intact Dutch *fluite* (a sailing cargo vessel) from the mid-seventh century. Since 2009, the wreck, called 'The Ghost Ship' by the team, has been studied as part of an international scientific project coordinated by MARIS and with MMT providing the key logistical platform. The work has also been documented for TV by Deep Sea Productions (Dixelius et al. 2011; Eriksson and Rönnby 2012a,b).

Sampling, salvaging and archaeological documentation have been achieved using Remotely Operated Vehicles (ROVs). The robots have in essence replaced the work of the diving archaeologists. The total darkness at this depth in the Baltic demands considerable artificial light. For detailed inspection the limited view from standard ROV video is sufficient, but to achieve an overview, the entire vessel needed illumination. This was provided by four LED lights mounted above the ROV as well as a 50,000-lumen light ramp lowered from the aft A-frame of the survey vessel. The lights had to be

Fig. 4.2 The Baltic Sea in the region of southern Sweden showing the location of sites and other features mentioned in the text

lowered between the wreck's mast tops. This required very precise position-holding by the vessel, with a capacity to ensure that ship movements never exceeded 0.2 m (Dixelius et al. 2011).

An almost intact three-dimensional ship is an archaeological challenge. Thorough video documentation was recorded for the archaeological site plans and sketches of the ship. Thanks to accurate measurements by laser technology, these plans could be drawn with precision and are correct in scale. This work combines archaeological drawing skills with the use of advanced techniques (Eriksson 2012; Adams 2013, pp. 85–95). Mini-robots and cameras mounted on an extension arm have also allowed the research team to 'board the ship', and see actual details on the inside of the hull.

During the 2010 expedition, MMT's vessel *Ice Beam* was equipped with a single transducer Reson 7125 multibeam echo sounder mounted under a SubAtlantic Mohican ROV. It recorded reference points for the entire wreck site (Fig. 4.3). The beams of the echo sounder penetrated the upper deck and the holds, so that very accurate measurements of the inside of the hull, the quarters, the holds and the forecastle were taken and presented in detail. The final 3-D model of the Ghost Ship makes it possible to look inside the ship, study its inner construction and the location of bulkheads and deck levels, which allows for interpretation of the various functions performed in different areas of the ship. The model, which collates over six million depth soundings, can also create cross-sections of the ship, both lengthwise and across the beam from bow to stern. This can be turned into a construction design for a small seventeenth-century ship more than a 100 years before such design drawings were made.

In the summer of 2011, two new spectacular shipwrecks were discovered in the central Baltic Sea. After years of searching, the well-preserved remains of both *Mars* (1564) and *Svärdet (The Sword)* (1676) were found. Both were large Swedish royal naval ships that went down after tough and lengthy sea battles (Rönnby 2012; Rönnby 2013a, b, pp. 12–14; Eriksson and Rönnby In press).

MARIS and MMT worked together in the exploration of these new ships together with Deep Sea Productions and Ocean Discovery. The ongoing documentation of the two wrecks highlights the violent nature of the conflict and the chaotic environment on board during the course of the battles. The sites with all their heavy bronze guns and the ships themselves are well-preserved 'maritime battlefields'.

Mars is situated at a depth of 70 m and *Svärdet* at 90 m. Some of our work at the sites was achieved through technical diving, but most of the documentation has been completed using ROV and multibeam echo sounder. In this respect, the experience from the Ghost Ship was invaluable.

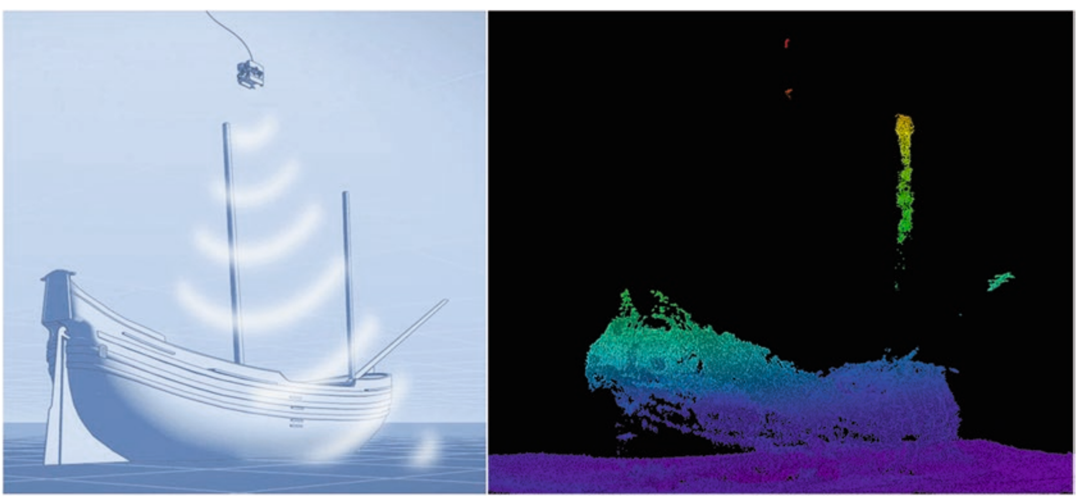

Fig. 4.3 'The Ghost Ship', a Dutch fluitship from around AD 1650, found at 120 m depth. The archaeological and hydroacoustic information was acquired with ROVs (Photo MMT/Deep Sea Production)

As part of the ongoing effort to find new solutions, MARIS and MMT have initiated a bottom based Blueview scan of *Mars* (Fig. 4.4) which is stitched together with the ROV MBES data from above the wreck. The equipment used is a 3D BV5000 1.35 MHz Blueview and Subatlantic Mohican ROV equipped with a R2Sonic 700kHz UHR MBES. The equipment was operated by MMT staff and the results were processed jointly by the surveyor and the archaeologist working together. The scanner sends out 256 beams with a range resolution of 1.5 cm in a 45° swath; this swath is then rotated with a mechanical motor through 360° with different tilt angles, creating a spherical image of the surroundings. Maximum range with 1.35 MHz is around 30 m.

The preliminary results are very promising, and the final data outcome will form a three-dimensional point cloud of the wreck that the investigating archaeologist can view and turn on all axes, while taking measurements and obtaining curvatures of the hull. It is also possible to place the scanner inside the wreck to obtain a three-dimensional image of the inside.

Initial work on some other sites, for example *Gribshunden* (1495) (Rönnby 2015) and also on a Viking age pole blockage (defensive structure) in Gamlebyviken indicates that the method is suitable for various types of archaeological remains. The BV50000 3D is further rated to 4000 m, hence it can be placed on a deep-water rated ROV and sent down to investigate wrecks at depths that are unsuitable for divers.

A spectacular photo-mosaic of the total wreck-site of *Mars* was completed in 2012 (Fig. 4.4). The mosaic was made by combining more than 600 separate high-resolution photos. Recent fieldwork included documentation with photogrammetry. Our ongoing work combining the Blueview results with the photogrammetry is very promising. This can be used for archaeological interpretation and can also provide 3D virtual reconstructions for museum exhibitions.

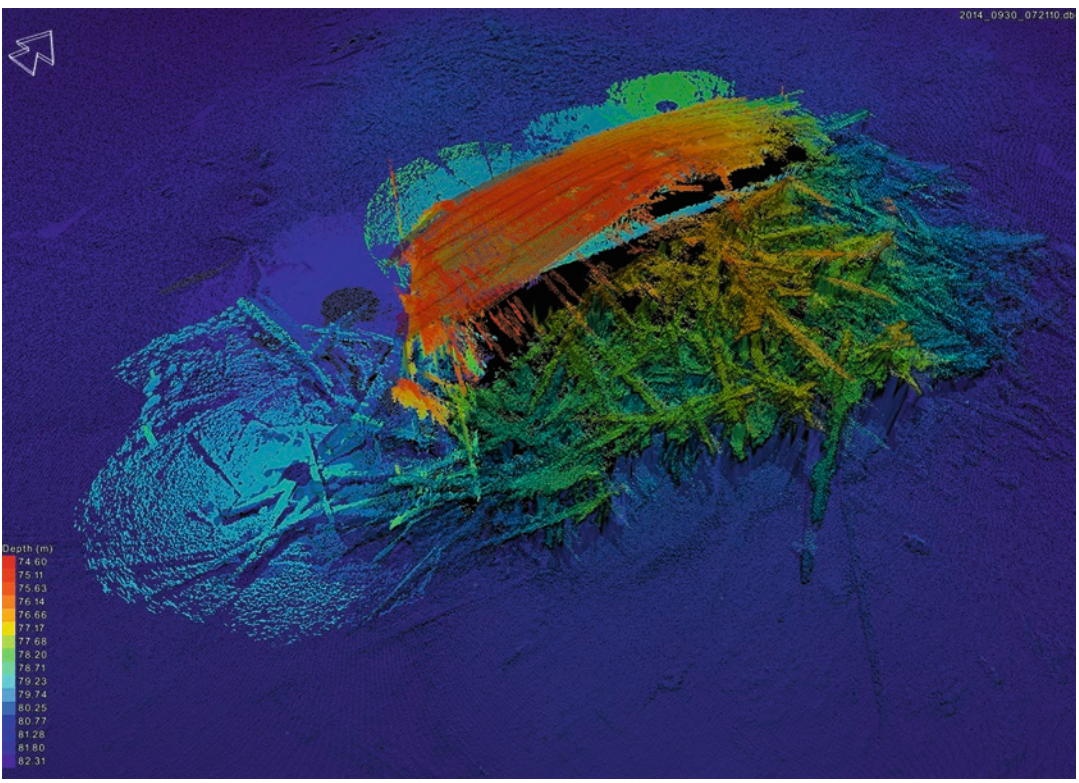

Fig. 4.4 Blueview scan over the stern of *Mars* (Rendering: Joakim Holmlund, MMT)

4.3 The 'Landscapes Lost' Project

A third joint project that MARIS and MMT have been working on is the investigation of the submerged Stone Age landscapes in the southern Baltic (Nilsson and Sjöström 2012; Törnqvist 2013; Nilsson et al. 2016; Nilsson et al. 2017).

During the Early Holocene in southern Scandinavia sea-levels changed dramatically (cf. Björck 2008; Hansson et al., Chap. 13). It has long been known that there exist large areas in the Atlantic and the Baltic which for long periods of time were dry land. The scientific knowledge of such inundated landscapes has gained new prominence in recent decades, not least in archaeology and Quaternary geology (Benjamin et al. 2011). This is partly due to increased commercial interest in the continental shelf particularly from oil, mining and aggregate industries, wind farms, and the growing need to create infrastructure for communication and energy transfer over marine areas. In addition, and partly an effect of the above, improved availability of high-resolution hydro-acoustic mapping (at sub-metre scale) and cost-effective photogrammetric 3D modelling (sub-centimetre scale) has made surveys, fieldwork and visualization of the submerged landscapes easier.

Consequently, industrial companies, researchers, policy makers concerned with the natural and cultural heritage, and other stakeholders have converged in their need for a better understanding of the sea-bed environment. It is in this context that the Landscape Lost project was developed. The aim is to bring together archaeology and other landscape disciplines from the fields of geology, geography and biology. An overarching question is how a better understanding of the inundated landscapes of the Early Mesolithic affects the general understanding of this period, and how, at a national level, we can map, monitor and preserve these submerged cultural heritage sites (Nilsson 2012; Nilsson et al. 2016).

One goal is archaeological survey, examination and interpretation of the submerged landscapes of the early Holocene. Two main study areas have been chosen (Fig. 4.2): The Haväng area, located at the Early Holocene river mouth of Verkeån in south-eastern Scania, and the Blekinge archipelago with several now-submerged estuaries. So far, hydrographic survey and archaeological exploration have been completed from the MMT research vessel *Triad* using MBES and Topas parametric sub bottom sonar. Nearly 15 km^2 have been measured so far.

The main focus is on the period that comprises the Early Mesolithic Yoldia Sea, the Ancylus Lake and the initial Littorina Sea (c. 11,500–8,500 years BP). The Geology Department at Lund University has played a significant role, including since 2014 a PhD student involved in the underwater exploration (Hansson et al., Chap. 13). In Blekinge, the project is a collaboration with Martin Jakobsson, Professor of Marine Geology and Geophysics at the Department of Geological Sciences, Stockholm University.

Here we summarise work in the Haväng area, which has turned out to be the most rewarding so far, as well as the most complex area. The work here builds on a 30-year history of geological research (Björck and Dennegård 1988; Gaillard and Lemdahl 1994) and involves new surveys and sampling which have revealed fish traps dated to 9000 years BP (Nilsson and Sjöström 2012). These constructions have been found in Mesolithic lagoonal sediments, and consist of baskets, weirs and different kinds of wattle made of selected hazel withies (Fig. 4.5). The river sediments are still visible on the sea bed, as are preserved stumps and logs from the forests which were growing there 11,000 years ago.

As in the two earlier collaborations, the archaeological questions have determined the mapping methods. Thus, the main goal of the survey was to find eroded sediments and sections, remains of old submerged beach ridges, river mouth palaeochannels and even standing tree stumps. We were in great need of high-resolution 'diving-maps' to facilitate georeferenced exploration and sampling (Fig. 4.6).

Diving on the submerged sites also revealed possible threats (Fig. 4.7). Hydro-acoustic measurements can provide a future monitoring system to monitor such threats, but this is still under development and evaluation since it requires continuous surveys over a longer time.

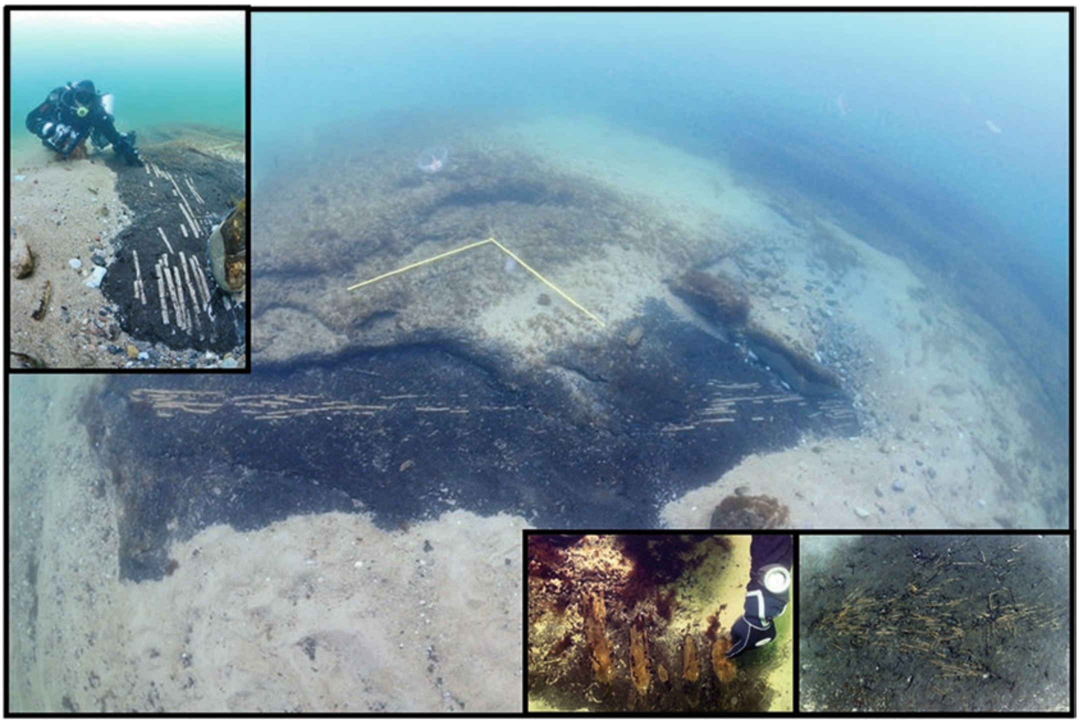

Fig. 4.5 At the Haväng site several remains of different types of stationary fish traps and fish weirs have been found. The fish weir in the lower right image measures 0.75 m. The oldest have been dated to 9000 cal BC (Photo: Arne Sjöström, LU/MARIS)

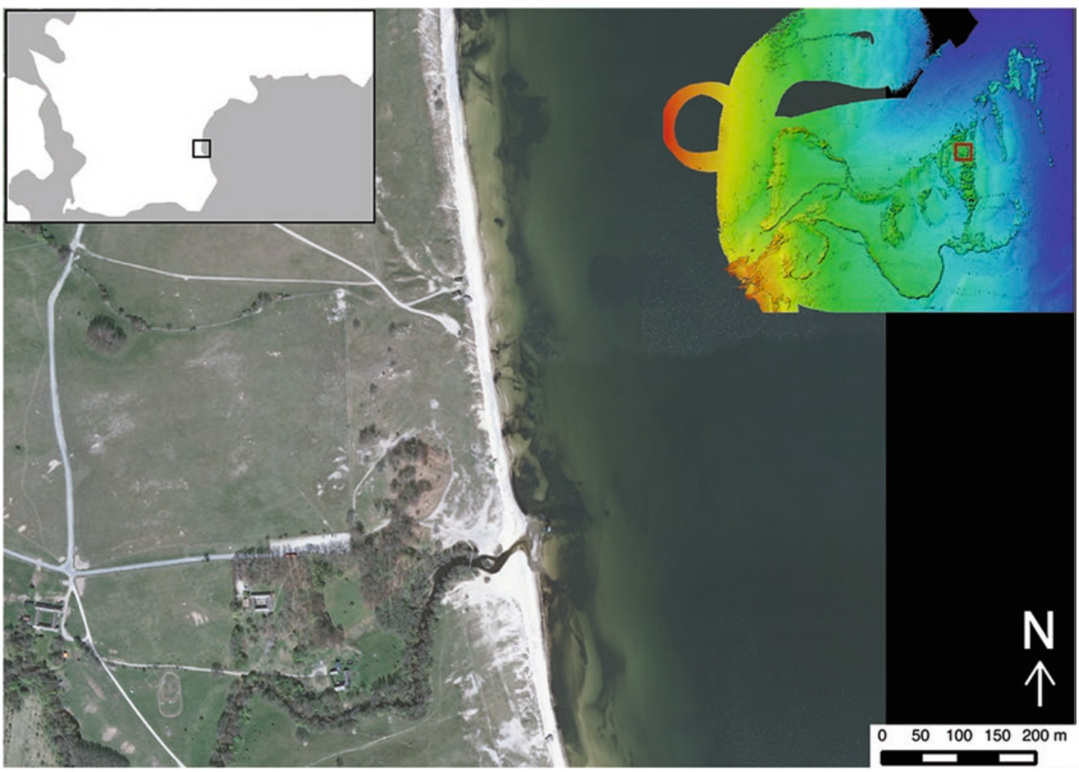

Fig. 4.6 Multibeam measurements showing the submerged lagoon landscape of the Early Holocene Verkeån River mouth, SE Scania, Sweden. For further detail see Hansson et al., Chap. 13, Fig. 4.1

Fig. 4.7 A threatened heritage. Wires tied to nets or anchors cut through the sediments. The actual photo lies in the vicinity of the site pictured in Fig. 4.5 (Photo Arne Sjöström, LU/MARIS)

In addition to the acquisition of archaeological and geographical data, the project was also an attempt to optimize the way different specialists work together on board. The skipper, the surveyor and the archaeologist together contribute to a dynamic process of investigation in which it is possible to alter a previously established route plan. In this way it is possible to cover large areas, but also to concentrate on places with the highest archaeological potential (Fig. 4.8). The surveyors and the archaeologists have a mutual interest in learning how each discipline operates and gathers sea floor information. The archaeological demand for 'high-resolution' and 'unfiltered' data generated considerable discussion and new technical solutions, and the integration of different skills and disciplines created new and valuable scientific knowledge and optimal use of research funds.

4.4 General Constraints and Benefits of Collaboration

The high daily cost of a vessel equipped with ROV/survey systems, including the ship and survey personnel, makes it important to have a detailed plan for the vessel at all times. Any interruption in commercial production, or dead time at the pier, will result in extra costs for the survey company. In all projects, one has to consider these costs when it comes to mobilization and transit time. Hence in order to undertake non-profit projects, such as those involving collaboration with MARIS, it is necessary to have a good plan and a lot of patience. Ideally, one tries to make use of the vessel while it is passing by, or when it is in the proximity of the research area. A model so far for our joint work has also been to develop new techniques or evaluate new systems for industrial applications, testing them on archaeological sites, an activity of mutual benefit to both partners. We have also found it helpful to establish simple means of communication involving personal contact. The more information and understanding that the commercial operator has about the needs of archaeological research—and the more archaeologists understand about the constraints of commercial operations—the more

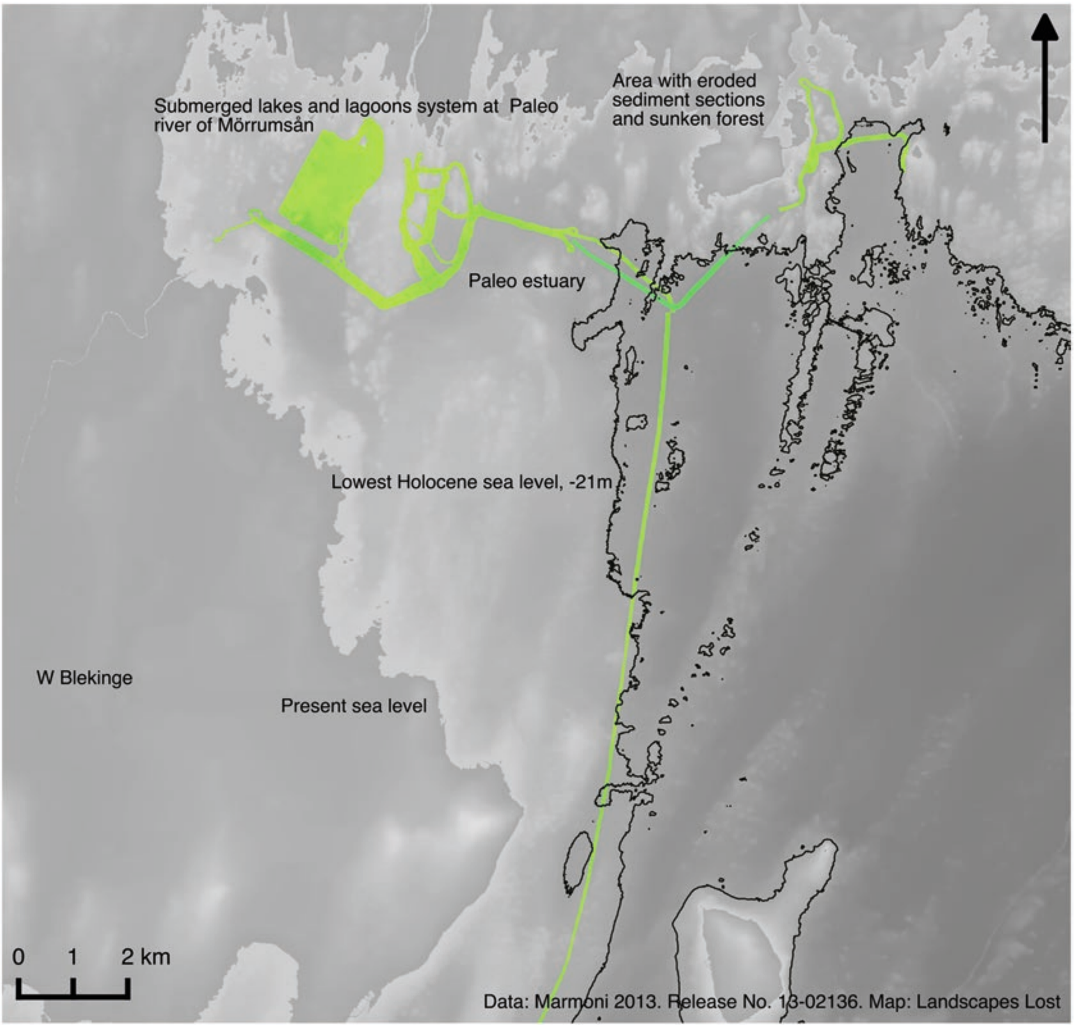

Fig. 4.8 The irregular trajectory of an archaeologically effective survey, showing 48 h of continuous survey in the Hanö Bight. LU/MMT

efficient the use of the vessels is. This also helps to ensure the optimal methods for a specific archaeological project.

Our intention is to continue to develop the ongoing collaboration between MMT and MARIS (and our other partners) regarding investigation, documentation and interpretation of archaeological material on the seabed. For MARIS the benefit of this is obvious; together with MMT we have been able to explore places and sites which we would never have been able to access otherwise. The fact that several of our mutual projects have been carried out as part of filmmaking projects with Deep Sea Productions and Ocean Discovery has also stimulated the archaeological research—the need 'to tell a story' has had a creative effect on the projects.

For MMT, challenging new sub-sea projects need new creative solutions, and finding novel ways to solve archaeological problems can be a way for the company to develop skills and technologies that attract other jobs and commercial contracts. The archaeological knowledge and experience can also assist in the development of faster and more efficient interpretation of survey results of benefit to commercial contracts, for example mapping for new pipelines or wind farms. A series of lectures on basic principles of maritime archaeology has been held at the MMT office for project and offshore managers and further courses and lectures are also planned. PhD students from Södertörn University and MARIS have been able to join expeditions with MMT, and have used the resulting data in their work (see Eriksson 2014a, b).

A further important step in this collaboration is our new joint near-shore survey and diving vessel. MMT and MARIS have together obtained a new small research catamaran, *Svanen* (the *Swan)* equipped during 2015 for archaeological survey and sampling. This will further strengthen our collaboration. The vessel will be able to carry out detailed and effective near-shore investigations and surveys, important not least in finding shipwrecks and inundated prehistoric settlements in shallow water. An important challenge for us to tackle regarding this in the future is to find old archaeological material which is located beneath a covering layer of sediment. New methods for acoustic penetration of sediments combined with core sampling will be tried in selected areas with high potential for prehistoric human activity.

Our experience convinces us that this kind of cooperation between academia and industry can give new insights and perspectives, generate new scientific results and also contribute to strengthening a company's abilities and competitiveness.

Finally, regardless of current political agendas, economic outcomes and the possible commercial benefits of collaboration, we want to stress that the archaeological aspect is the real core of our joint work. What really links us together is our mutual interest in exploring the sunken past.

Acknowledgements Many dedicated friends and colleagues have been (and continue to be) involved in the projects described above, and we want to thank them all. We are very pleased that they share our interest in 'solving mysteries'. We especially wish to thank three people who have been instrumental in making this unique collaboration between MARIS and MMT possible: Malcolm Dixelius, Carl Douglas and Ola Oskarsson. Besides the institutions and companies already mentioned in the text, we also acknowledge support from The Knowledge Foundation, The Foundation for Baltic and East European Studies, National Geographic and Stiftelsen Olle Engkvist Byggmästare.

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