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Practical approaches to management of the marine prehistoric environment

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Abstract

Since so little is still known of the marine prehistoric environment, present management actions tend to be guided by the gathering of disparate sets of data obtained as part of regulatory practice and/or from opportunistic finds that are not necessarily specifically targeted towards archaeology. Our view is that we need to develop a clearly defined set of questions about the marine prehistoric cultural resource to enable the design of targeted scientific research, as part of both the regulatory process and marine management generally. In this paper we argue that it is crucial to understand both natural and anthropogenic context, and this necessarily includes work on the Quaternary geology. Furthermore, we argue for a greater regulatory emphasis on identifying and initiating what we *should* do (for the long term) rather than what we *can* and are doing (for the short term) to identify the best means to manage the prehistoric marine environment.

Keywords: heritage management, marine archaeology, prehistory, regulation

Introduction

Management of the marine cultural resource, which includes prehistoric land surfaces, is a simple thing to write but rather more complex to design and enact. There is a wide range of natural factors, such as sediment erosion, transport and accumulation, biological and geochemical processes, and other agents of archaeological deterioration that play a role in the formation of the 'archaeological landscape'. However, some factors are poorly understood at present, and many are not amenable to scientific methods of assessment or to quantification. Furthermore, and a step beyond these factors, management requires knowledge about location and context ('archaeological potential'), the assignment of significance ('value') and the determination of risk.

We consider that, at present, any practical approach to management is limited by the largely unknown archaeological potential of the North Sea's submerged geology, and our weak ability to assess the 'value' of and potential 'risks' to ancient land surfaces from natural processes and/or human activities (Ward & Larcombe, 2008). These assessments are, however, key parts of designing and prioritising management efforts. There is a need to improve our identification of the nature of past, present and future impacts, both natural and anthropogenic, as well as to deal effectively with the thorny issue of 'cumulative impacts' (those impacts resulting from interactions between multiple human activities and/or natural processes). At the same time, the perspectives of a wide range of different interest groups, such as the marine aggregate industry, the trawling fleet, recreational fishermen and sports-divers, scientific researchers, local archaeological groups and interest groups, also need to be considered. The key issue is a lack of understanding and the major uncertainties this induces in the management process.

From the above, we think that what is needed is:

(a) a clear recognition and definition of the overall problem(s), which appears a pre-requisite for the production of a firm assessment methodology, and

(b) a range of practical options for the different user groups and regulators to support effective heritage management.

At present, such problem definition and practical tools are largely incomplete or absent. In this paper, we highlight some of these inadequacies and suggest some better ways to prioritise the cultural resource and developing practical approaches towards management, bearing in mind the needs of and collaborative opportunities for those with interests in the North Sea. Our focus is not on techniques (e.g. see Green, 1990; Delgado, 1998; Ballard, 2008), but rather on the use of scientific wisdom to guide cultural heritage management. We thus describe key ingredients for a research-based approach to the management of submerged prehistoric sites and landscapes, drawing on current insights into the geology and archaeology of the southern North Sea (see Cohen et al., 2014; van Heteren et al., 2014; Roebroeks, 2014; Peeters & Momber, 2014).

This paper is structured around an analysis of three key issues:

(a) understanding the natural and anthropogenic contexts – do we know enough?
(b) analysing the current approach to marine heritage management – is it fit for purpose?
(c) determining the priorities – what do we need to do?

We draw on the experience and status of marine land surface and cultural heritage management in the UK, with an eye on the leading work in the Netherlands.

Understanding natural and anthropogenic context

Prioritisation of those prehistoric cultural heritage assets located in the modern marine environment needs to be considered from other perspectives than just one of their cultural values. The natural and cultural processes to which these sedimentary deposits are subsequently subjected also need to be taken into consideration because they control the location and preservation of archaeological deposits. These issues have been discussed for the southern North Sea by Ward & Larcombe (2008) and an updated summary is presented here.

Past environmental context

A number of authors have provided generic associations between landform, sediment and archaeological and/or environmental features in both terrestrial (Rapp & Hill, 1998; Howard & Macklin, 1999; Waddington & Passmore, 2006) and marine environments (Ward & Larcombe, 2008; Dix & Lambkin, 2008; Dix et al., 2009). These associations not only provide a clear geomorphological rationale for identifying areas of archaeological potential (e.g. Gaffney et al., 2007; Ward & Larcombe, 2008; van Os & Kosian, 2011; van den Brenk, 2012), but can also help identify sites of potential for geological and palaeontological research (see also Knight et al., 1999). Antiquarians and archaeologists are used to finding stone artefacts and animal bones within ancient river deposits or at coastlines, either uplifted and now exposed on land, or drowned and located offshore (e.g. Bell et al., 2006; Bridgland, 1996 Bridgland et al., 2006; Howard et al., 2007). Equally, they recognise that layers of peat are the remains of the previous land surface in which prehistoric objects and structures can be found. Such associations have formed the basis for provisional interpretations of the archaeological potential of the North Sea (Coles, 1998; 2000; Westley et al., 2004; Deeben et al., 2002; Deeben, 2009).

The main area where understanding could be improved is that of the sedimentary history of those deposits in which archaeological remains are typically preserved. As well as the general aspect of improving the chronological control of geological sequences, other aspects include, but are not limited to:

- improving the definition of the offshore limits of the British and Scandinavian Quaternary ice sheets (e.g. Coles, 1998; Carr et al., 2006)
- improving the delineation and description of the variety of post-glacial coastal facies (Ward et al., 2006) and buried river channels (Fitch et al., 2005; Dix & Sturt, 2011)
- gaining more evidence on the preservation, age and relative depth of (brackish-water) basal peat that marks the onset of Holocene marine sedimentation in the North Sea (Oele & Schuttenhelm, 1979).

Whilst some work would inevitably include those sedimentary facies that contain archaeological remains, our essential message is to promote work on the Quaternary geology in a broad sense. Indeed we would argue that the identification of contextual deposits is fundamental to identifying these prehistoric assets, and certainly agree with Bell et al. (2006) that the most complete and informative sedimentary and palaeoenvironmental sequences are not necessarily associated with archaeological sites themselves. At the same time we applaud the work of Bates et al. (2007), which cautions against extrapolating patterns from land to offshore in the absence of any geological investigation, noting that we should anticipate different landscape formation processes and patterns of landscape evolution particularly in those areas of the shallow shelf area formerly occupied by drainage basins during sea-level low stands.

To date, offshore discoveries of palaeontological and archaeological material have largely been revealed as a by-product of the activities of trawlers (Flemming, 2002; see also Ward & Larcombe, 2008) and aggregate dredging, the latter recently aided by the implementation of the Protocol for Reporting Finds of Archaeological Interest (see http://www.wessexarch.co.uk/projects/marine/bmapa/dredged-up). Such finds can be spectacular and promote much scientific, regulatory and public interest, but the dredged material usually remains dissociated from the sedimentary source material and the essential palaeoenvironmental context. Placing such finds into geological, geographical and chronological contexts can be a major challenge (see also Ward et al., 2006; Ward and Larcombe, 2008) because these finds are often only roughly located, having been caught on a track of several miles long or located only to a remote area where dredged material was sourced.

The contextualisation of chance finds is possible, however, as demonstrated by the fortuitous discovery of 28 Palaeolithic handaxes at a wharf in the Netherlands (Firth, 2011). In this particular instance, the gravel came from a licensed marine dredging area in English waters known as Area 240 – some 13 km off Great Yarmouth – lying in water depths of about 25 m. Detailed geophysical survey, vibrocoring and grab sampling recovered worked flints within the area where the handaxes were recovered and achieved a detailed understanding of the chronology and palaeogeographic development of the seabed (Tizzard et al., 2011; Tizzard, 2013). These additional surveys demonstrated that it is possible to obtain reliable knowledge about the provenance of such material to help address key archaeological questions, emphasising the importance of focused geological and stratigraphic investigations. However, this work in Area 240 is so far the exception rather than the rule. Such procedures might only be implemented at other sites if they produced equally important material in areas where it could not be avoided by the developer, prompting investigation to offset or compensate for the likely archaeological impacts.

As well as being directed to chance finds, such studies can be used to test the three-dimensional (3D) stratigraphic models developed from regional sub-bottom geophysical datasets, for example in the central and southern North Sea (Gaffney et al., 2007; van Heteren et al., 2014), Irish Sea and Bristol Channel (Gaffney et al., 2011), and the Thames (Dix & Sturt, 2011). To be fully utilised by the archaeological community, such models require ground-truthing using cores, with associated dating (e.g. Dix & Sturt, 2011) and palaeoenvironmental analysis. In doing so, progress is made from simply seeking patterns from massed records towards more targeted collection of samples and mapping data.

The Cultural Heritage Agency of the Netherlands (RCE) is currently working on a so-called Indicative Map of Archaeological Values 4D (IKAW-4D) for the seabed (see: http://www.cultureelerfgoed.nl/archeologie/maritieme-archeologie/programma-maritiem-erfgoed/kennisopbouw/project-ikaw-4d-waddenzee). Focusing on the North Sea, Wadden Sea and Markermeer, an indication is made of the archaeological potential for different areas, related over space and time. This last distinction accounts for the dynamics of the seabed that have an effect on the quantity and quality of what may still exist. A combination of these IKAW-4D maps provides some insight in the use of the seabed from the prehistoric period, when it was still terrestrial, and later when the marine environment was used for transport, war at sea and fishing. Furthermore, a pilot study has focused on the geoarchaeological assessment of a part of the Dogger Bank area of the Dutch continental shelf (Erkens et al., 2013), using lithological and geophysical data.

Holocene marine inundation

The most recent drowning of the UK continental shelf may have occurred at or before *c.* 9000 BP (Eisma et al., 1981; Shennan et al., 2000 Fig. 5c), the significance of which is that in many parts of the southern North Sea, early Holocene and Pleistocene sediments from former shorelines and headlands would have been reworked into the surrounding palaeovalleys and depressions (Streif, 2004). In order to fully assess the potential extent of reworking of sediments and archaeological materials during the post-glacial transgression, information is needed on coastal and marine sedimentary processes and the changing regional patterns of sedimentation during this period, which are best obtained using the types of geophysical and geological work described above.

Recognising the absence of such information, Ward & Larcombe (2008) used first principles to infer such transformations, noting in particular the major changes in sedimentation driven by the opening of the Dover Straits and, later, the likely widespread erosion of tidal flat and saltmarsh peat deposits resulting from the strong, new, regional tidal regime in the southern North Sea (Austin, 1991; Scourse & Austin, 1995; van der Molen & de Swart, 2001a,b; Dix et al., 2010). Broadly, the detrimental impacts on archaeological preservation in the post-glacial southern North Sea region are likely to have been concentrated:

- in shallow strongly tidal areas near the Dover Strait during its opening and broadening
- later, in broad tidally dominated areas of open shelf
- most recently, in shallow nearshore and coastal areas during storms.

Whilst this might appear to imply a very wide spatial spread of likely disrupted archaeological material, there are areas on the continental shelf which probably have good preservation – the key question is where. The presence of freshwater and salt-marsh peat in cores and some dredges, and indeed the discovery of Mesolithic artefacts within patches of these peats (Louwe Kooijmans, 1970/71; Verhart, 1995; Peeters & Momber, 2014), constitute clear evidence of former coastal environments. Other kinds of depositional settings that were considered most favourable for human occupation or use, including infilling valleys, river deltas and some tidal and back-barrier environments, are also likely to preserve archaeological material relatively well, especially if buried reasonably deep.

The preservation of peat deposits clearly indicates that the sedimentary processes of the late transgression and highstand have not removed all traces of the former land surface. As such, there is a discrepancy between larger scale predictions of preservation and fine-scale patterns in reality: large areas of low potential can contain small pockets of preservation depending

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on local topography, bathymetry, wave and tidal conditions, inundation and burial history. Thus, it is important to define local palaeogeographies and sedimentary history in order to assess the preservation potential of individual areas (Bates et al., 2007), especially where these sit close to commercially attractive sand and gravel deposits, offshore construction sites (e.g. windfarms, oil rigs, etc.) or other development activities.

Present environmental context

In the southern North Sea, those present-day natural processes with the greatest impact on sedimentation and hence possible reworking of cultural remains are the tides and, to a lesser extent, storm-associated currents (Southern North Sea Sediment Transport Study, 2002; Ward & Larcombe, 2008). Modern sedimentation and tidal patterns were essentially established by around 6000 BP (van der Molen & de Swart, 2001b) and under predicted oceanographic conditions for the next century or so, no further major regional changes in bathymetry are expected. However, local seabed changes, such as the migration of tidal sandbanks (Dyer & Huntley, 1999), may influence early and mid-Holocene layers by either exposing them for (short) periods or burying them completely. Although burial is beneficial for preservation, it makes discovery much more difficult. Hence, there is a slight paradox in development activities which can disturb archaeological sites, but which can also provide opportunities for discovery.

In contrast, exposed layers and any cultural material within them are vulnerable to a wide variety of deterioration processes (see Ward et al., 1999). The Mesolithic barbed point dredged up in a lump of peat somewhere between the Leman and Ower Banks (Louwe Kooijmans 1970/71; Verhart, 1995) is likely to have originated from an exposed surface in the depressions between these banks rather than having been eroded from the banks themselves. Yet the present alignment of these and other large sand banks in the North Sea may have differed significantly during the Holocene. Consequently, the potential for locating archaeological material cannot be limited to depressions. The study of modern sedimentation and changes in the Late Holocene seabed is of the utmost importance not only for estimating the archaeological research potential (although it may help indicate in which areas we can focus studies of exposed Early Holocene and Pleistocene layers), but also regarding the development of management strategies (see also http://www.machuproject.eu/machu_gis_00.htm).

Potential anthropogenic impacts

In addition to understanding the natural context, research is urgently needed to understand and quantify those anthropogenic processes that influence preservation of prehistoric assets. Even where possible, mitigating archaeological impacts in the marine environment can be very expensive. Therefore, it is extremely important to delineate those areas where natural or human processes are most likely to impact archaeological material as well as archaeologically significant palaeoenvironmental contexts. Where prehistoric land surfaces are concerned, 'archaeological exclusion zones' can be established in which, for example, aggregate dredging or trawling is excluded. Such an exclusion zone was quickly put in place after the discovery of handaxes within Area 240 and has subsequently been reviewed in the light of targeted archaeological evaluation (see below). Whilst such evaluation methods do provide some test of the value or effectiveness of such zones, more measurable assessments still need to be developed. A preliminary assessment of a range of anthropogenic impacts by Ward & Larcombe (2008) concluded that although a significant proportion of the area of the North Sea shelf is being disturbed, very little of this disturbance is likely to have far-reaching impact on the buried Palaeolithic/early Mesolithic archaeology. However, it should be emphasised that this preliminary conclusion is limited by a paucity of archaeological and palaeoenvironmental data.

Moreover, as noted above, it must also be understood that it is often not just the impact of one anthropogenic process alone that may influence site preservation, but cumulative effects from other natural and human processes like erosion, aggregate extraction and trawling (Ward & Larcombe, 2008; Otte, 2009). Therefore data and knowledge are needed that assist identification, quantification and distinction of direct and indirect human processes and natural processes, and assess the significance of the combined impacts. Such work should not be driven by models, but rather by question setting and ground truthing. This is by no means a simple task because comparing the impacts between different anthropogenic impacts, which have different spatial, temporal, physical sedimentary and biogeochemical signatures (amongst others), and which themselves are poorly documented in the field, is extremely complex. At present there are few relevant studies being performed which might allow such integration. To begin to resolve this situation calls for careful and intense collaboration between industry (and other stakeholders) and the relevant sciences. With expanding commercial development in the North Sea, the challenge is to minimise the threats and maximise the opportunities for data collection and exchange, monitoring and management of the marine cultural resource. Clearly, a great deal of archaeological and non-archaeological information is required, but is lacking at present.

Understanding the current approach to marine heritage management

In order to manage the historic environment it must be established whether there is sufficient information available. At present our understanding of marine prehistoric environments is poor, and management systems have been struggling to obtain the necessary information to improve the situation, not least because of the cost

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of marine operations. Indeed, the task of understanding the prehistory of submerged land surfaces in the North Sea is so great that continuous collaboration and exchange of information is needed. This necessitates collaboration between academic research departments, government laboratories, archaeological practices, museums, amateurs and offshore industries (Flemming, 2004), and thus on several levels, use of different methods.

In 2006, seven countries, including Belgium, the UK and the Netherlands, initiated the Managing Cultural Heritage Underwater Project (MACHU), which aimed to develop new methods and co-operation for a more effective management of the submerged archaeological resource, getting different stakeholder groups involved in the process (see Manders et al., 2009a). The main stakeholder groups were vocational divers, fisherman, policymakers, scientists, governmental (-related) agencies, offshore (North Sea) and inshore companies (Wadden Sea, inland rivers and lakes), and those active in law enforcement. The project ended formally in 2009, but the resulting GIS system is still in use as a platform to capture, manage and exchange data in the Netherlands between the Rijkswaterstaat (Ministry of Infrastructure and the Environment), the RCE and the hydrographic office of the Royal Navy.

The major emphasis of MACHU was to access and combine data and information on underwater archaeological sites and their environmental contexts, to inform and create awareness between the different stakeholder groups and, if possible, provide support for good management of underwater cultural heritage. The gathered data can be viewed in a web-based GIS system accessible to scientists and policymakers, enabling information to be shared between different partners on the management of cultural heritage underwater (Hootsen, 2008; Hootsen & Dijkman, 2009; http://www.machuproject.eu/machu_gis_00.htm). The GIS connects data about specific underwater cultural heritage sites with data 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 (e.g. relevant legislation). It also visualises developments that may become a threat to the preservation of cultural heritage, and thus helps the development of site assessment and management decisions (e.g. through management plans) as well as long-term monitoring of sites and areas. It also provides a universal language to communicate between different stakeholders.

Although MACHU focused on the whole spectrum of underwater cultural heritage, including shipwrecks and submerged structures like bridges and drowned villages, it also includes prehistoric sites and land surfaces. For the North Sea environment, current work involves the creation of a series of maps to illustrate the development of the prehistoric land surface, as well as details such as the locations of commercial cores taken in any particular area of interest that can be of use for research and management. As much of the data (e.g. multi-beam bathymetry) was originally acquired for different purposes, the major problem concerned the processing of the data in order to reveal information more relevant to archaeological purposes. Within the MACHU GIS system, site-specific locations can be viewed and the aim is to build layers to display aspects such as fishing tracks in which prehistoric objects were found, or potential direct impacts. Models of dynamic sedimentation (e.g. Dix & Lambkin, 2008; Dix et al., 2009, 2010; van Os & Kosian, 2011; van den Brenk, 2012) will be of extra value in visualising the possible threat to this potentially very rich but still hardly known resource. By superposition of information, a qualitative overview can be gained of the existing data for this area. It is an aim that the MACHU system will be incorporated into the GIS being developed for the Dutch Archaeological Community ARCHIS3. MACHU also has been and is still in use for EU projects like Wreck Protect (http://wreckprotect.eu/) and SASMAP (http://sasmap.eu/).

Whilst not discounting the importance of collating and reviewing previously acquired data, it is probably new and future data that are likely to provide the greatest insights into marine prehistoric cultural resources. A particular success has been the network of communication created by the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest (MAI Protocol) and the associated Guidance Note developed by the British Marine Aggregate Producers' Association (BMAPA) and English Heritage (see http://www.wessexarch.co.uk/projects/marine/bmapa/arch-interest.html). The MAI Protocol is a leader in its field, and the aggregate dredging industry should be applauded for its adoption. Indeed, there is now a similar protocol in place for the Offshore Renewables Industry (http://www.wessexarch.co.uk/projects/marine/tcerenewables) and a pilot study exists for a fishing industry protocol, based in Sussex (http://fipad.org/). However, a finds protocol can be no more than a safety net to capture remains – and only relatively robust remains – that might otherwise be lost. As such, any protocol does not offer a substitute for proper assessment of the footprint in advance of development using archaeological, geophysical and geotechnical data.

Another important success has been the integration of archaeological objectives into regional-scale multidisciplinary surveys, known as Regional Environmental Characterisation (REC) surveys (e.g. http://www.cefas.defra.gov.uk/alsf/projects/rec-projects.aspx). The initial REC-type surveys did not include archaeologists in either the survey acquisition or interpretation phases, but the data acquired were of sufficient quality to be re-interpreted archaeologically at a later stage (Gaffney et al., 2011; Wessex Archaeology, 2011). As a consequence, archaeological interpretation was built into the subsequent phase of REC surveys, so that archaeologists formed part of the multidisciplinary consortia and were able to share and contribute to seabed characterisation methods (British Geological Survey et al., 2011a; EMU and University of Southampton, 2009). Subsequently, archaeologists joined the consortia for the third phase of REC projects from the very start, took part in acquisition and were able to influence survey strategies and the choice of survey locations (British Geological Survey et al., 2011b; CEFAS et al., 2011; James et al., 2011).

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The REC programme successfully established that archaeologists could work directly alongside other marine scientists to obtain high-quality geophysical and geotechnical data that – although still driven principally by ecological and geological concerns – was equally capable of addressing archaeological questions.

The MACHU project, the MAI Protocol and the REC programme are examples of a more probabilistic approach to marine cultural resource management based on information gained from regulatory, legislative purposes or other opportunistic data. Ultimately, however, they are not driven by archaeological research and risk lacking direction in terms of what questions ought to be addressed from such data. Archaeological and related data from the waters surrounding the UK are sparse and difficult to acquire, so, as is often the case, it is has been necessary to make the best use of whatever information is available. Whilst we acknowledge that such information gathering is still necessary, we think that it would be better to apply a more deductive approach, in which we identify what is needed (at least in theory) and to make strategic efforts to promote progress along those lines. Overall then, the current management system has made good progress, but some redirected effort is required before it could perhaps be considered fully fit for purpose.

Understanding the priorities: what do we need to do?

Maarleveld & Peeters (2004) argued that, despite our present (limited) level of understanding and the limitations of the present regulations for protection of archaeological remains, with conviction, we can start to influence how we manage the marine archaeological resource. The key is in understanding what we are aiming to gain and understand from the resource, and working towards resolving this in the context of focused evaluation questions. These questions should help provide us with the practical 'tools', by which we mean clear and transparent mechanisms to take the science evidence and convert it, via a series of rules, into a decision with which to manage the marine prehistoric cultural resource. The following outlines some considerations in determining and addressing these evaluation questions.

Who's asking the questions?

Those with interests in the North Sea marine environment include developers and operators, consultants, regulators, 'independent' scientists and other stakeholders. Each of these groups has different aims, perspectives and expectations, with a focus ranging from economic to ecological and to heritage (see also the summary of discussions and drafting groups in Flemming, 2004; Manders et al., 2009a). The questions that we need to ask and the decisions on how best to manage the marine prehistoric environment need to be determined together. The question of who is asking (and who is providing funding) also has consequences for collaboration (see below). Thus, a first step in developing a practical approach/tools for marine heritage management is the establishment of user requirements and an evidence-based assessment of how these might be met.

Ideally, this should be performed using an ecosystem focus that recognises the human society (past and present) as a central part in the ecosystem, and a need for increased integration across different science disciplines and over a range of scales depending on the question or particular issue of interest (see also Atkins et al., 2011). An ecosystems approach can also be useful to predictive modelling for cultural heritage through a better understanding of prehistoric settlement and subsistence systems (e.g. Verhagen & Whitley, 2012). As outlined by Barker (1996), archaeologists (cultural resource management specialists) need to be seen as part of regional planning and management as they were for the REC surveys. Although the ecosystem approach does appear in European management and policy documents (see Atkins et al., 2011 and references therein), it is unfortunate that the archaeological heritage was not included within the scope of the recent European Marine Strategy Framework Directive (http://ec.europa.eu/environment/water/marine/directive_en.htm).

Firth (2004) argues that there are some commonalities in the fundamental questions that are asked of development-led archaeology, heritage management and the research-orientated community. It is not possible, for example, to undertake development-led, seabed prehistoric archaeology without questioning what might be out there, what it might mean and what ought to be done (Firth, 2004). Archaeology is pitted against questions of how to proceed and, in the regulator's assessment, whether the social or economic benefit of a development going ahead outweighs its likely scientific, cultural and environmental impacts. Where a prehistoric land surface or deposit is also valued for other reasons (e.g. as a habitat, a site of geological interest or a source of aggregate), the consideration of special interest (see Archaeological value/significance below) should take into account other public interests in accordance with the guidance offered by English Heritage's Conservation Principles (English Heritage, 2008).

Recently a research framework for the maritime, marine and coastal archaeology of England has been developed (Adams et al., 2013). It is intended that the research framework will enable long-term strategic planning, inform policy and provide a statement of key research questions for all those involved in the maritime, marine or coastal archaeology of England, from the academic, commercial and voluntary sectors. In the Netherlands, similar questions are raised in the National Research Agenda (NOaA) for many terrestrial areas and for several time periods. A view on submerged areas is currently being developed, building on the North Sea Prehistory Research and Management Framework (NSPRMF; Peeters et al., 2009) and experience in the context of Maasvlakte 2 (Manders et al., 2008).

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Likely 'threats' and key uncertainties

In order to consider the likely impacts from any proposed activities, it is of interest to all, but perhaps most especially to the regulator and developer, to establish where cultural heritage might exist and of what nature it might be. A clear understanding of the nature of the threat and its potential magnitude on the underwater cultural heritage is an essential pre-requisite to assessing the risks, as discussed elsewhere by Ward & Larcombe (2008). We have also noted above the need to adopt an ecosystem approach (as outlined by Atkins et al., 2011) and to develop predictive frameworks (Verhagen & Whitley, 2012) to develop thinking on such issues. Part of understanding the nature of the threat is to understand the uncertainties, and these are discussed by Roebroeks (2014) and Peeters & Momber (2014). In the interim, the increase in development in the waters around the UK has perhaps prompted the increase in the number of guidance and 'best-practice' documents for development-led archaeology in the marine and coastal environment. These documents relate specifically to port development, marine aggregate dredging and the offshore renewable energy sector (English Heritage 2006; BMAPA & English Heritage, 2003; COWRIE, 2007; Oxford Archaeology, 2008; Gribble et al., 2011) and up-to-date guidance documents could be developed for other development activities such as coastal defence or tourism.

Temporal and spatial scales

Indications are that the submerged North Sea basin represents one of the most extensive but well-preserved early Holocene (Mesolithic) landscapes in Europe (Gaffney et al., 2009), and the same may be true of the Pleistocene (Palaeolithic) landscape. On land, Lower Palaeolithic lithic and faunal material largely derive from fluvial floodplain sediments, and contextually similar deposits did (and may still) exist in the maritime zone (Hosfield, 2007; see also Tizzard, 2013; Tizzard et al., 2013). For Mesolithic archaeology, it is possibly coastal peat deposits that are of most interest, not only because they provide a datable proxy but also they contain or preserve beneath archaeological and palaeoenvironmental evidence (Mithen, 1994; Bailey & Flemming, 2008). Thus different archaeological periods may derive from different depositional contexts and these need to be better defined both temporally and spatially (Ward et al., 2006; Ward & Larcombe, 2008; Manders et al., 2010).

Within development-led archaeology, the focus is on small scales. However, individual environmental impact assessments do not necessarily present a good mechanism for identifying the regional picture, for which strategic environmental assessments seem to be more appropriate. A more regional view is presented through implementation of the Strategic Environmental Assessment Directive. A broadly comparable Regional Environmental Assessment process is being followed by the aggregate industry and a zone-based process by the offshore renewables industry (wind farms). At present, because of the unknowns, much of this work can only flag up deposits of possible interest and identify zones of possible archaeological potential. The still relatively rare discoveries of archaeological material may help to advance some working hypotheses about the presence and character of submerged prehistoric surfaces and deposits across wide areas of the North Sea. There is also some argument to draw upon and integrate with archaeological work being undertaken in coastal and estuarine areas (e.g. Deeben et al., 2002) as well as on land (e.g. Chapman & Lillie, 2004; Hosfield, 2007). Local knowledge only makes sense in its regional context; regional knowledge needs to be pinned down using local details. However, the absence of local detail should not prevent the development of specific science questions.

In this regard, recent work on the above-mentioned Area 240 and surroundings is particularly noteworthy. Here, a regional approach has been applied to develop specific scientific questions that can be tested by ground-truthing for artefactual evidence. As noted above, the initial discoveries from Area 240 were fortuitous, but they led to detailed geophysical, geotechnical and archaeological investigations that support elements of the Area 240 assemblage being in primary context in the floodplain deposits of a now submerged and buried channel of the River Yare. Following on from this, BMAPA took the initiative in carrying out a study of the entire palaeocatchment of the River Yare from its upper reaches that still form dry land to the lower reaches beneath the southern North Sea. This study, known as the Palaeo-Yare Catchment Assessment, used the intensive investigation of Area 240 to help interpret previous geophysical and geotechnical data across all the other licence areas in the vicinity (Tizzard et al., 2013). At the same time, sediment samples are being dredged in areas of interest to answer key questions about the presence, distribution and character of Palaeolithic remains in the region as well as the possible effects of natural processes and impacts of previous dredging on these. This innovative, industry-led approach provides an indication of how other regional-scale approaches could develop elsewhere, applying an explicit research focus that is concerned with answering archaeological questions as well as understanding geological context.

Archaeological value/significance

The question of significance as a means of selectivity for historic assets is a major area of debate (Darvill, 1995; Deeben et al., 1999). English Heritage's Conservation Principles (English Heritage, 2008) provide very useful guidance. These principles consider that the historic environment comprises places of different values (evidential, historic, aesthetic, communal) and significance; the latter is judged from these values as well as the contribution made by evolutional setting and context. However, these principles are perhaps less than easily applied to the marine environment

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and/or ancient land surfaces of which we have little evidential knowledge.

Recently, a system for selecting prehistoric land surfaces on the basis of their 'special interest' in marine aggregate areas has been proposed (Wessex Archaeology, 2008). Using this system, a prehistoric land surface or deposit will be of 'special interest' where it is considered capable of making a distinctive contribution in terms of narrative, associations, respect, aesthetics or current relevance. Consideration should also be given to rarity, representativeness, diversity, potential, survival, documentation, grouping, setting and context, associated collections, exceptional nature and age (Wessex Archaeology, 2008). However, for the North Sea, regardless of whether it is based on intrinsic (objectively measurable) or extrinsic (largely subjective) qualities, the determination of land surface or cultural heritage value remains contentious because it involves quantifying often poorly defined attributes of geomorphology or cultural land surface (see also Knight et al., 1999). Hence, the present focus on identifying prehistoric assets, and the means and techniques to detect them is well intentioned, but risks leaning too far towards dealing with the symptom (i.e. doing what we can do) rather than encouraging the development of a cure (doing what we should do). The latter begins by asking what is the *nature* of the deposit, and then from this, what is its *significance*.

New techniques and application

At present, there is some focus on the use of remote sensing and high-resolution geophysical techniques for the delineation of submerged and buried land surfaces, with highly visible results (e.g. Gupta et al., 2004; Gaffney et al., 2007, 2011; Dix & Sturt, 2011; van Heteren et al., 2014). These have rapidly increased our potential to interpret spatial context in buried and marine land surfaces. Should any submerged archaeological sites be discovered, the models produced from the application of these techniques will also be useful for yielding quantitative information with which to monitor and manage sites. Future archaeological surveys are likely to contain a similar range of remote geophysical technologies, and may include the use of remotely operated vehicles capable of sampling and excavating sediments around potential or known submerged sites (e.g. Webster, 2008). Use of such technologies, together with the more familiar direct sampling techniques of marine vibrocoring and drilling, will together assist ground-truthing of geophysical interpretations and predictive models (e.g. Gaffney et al., 2007; Dix & Lambkin, 2008; Dix et al., 2009; Dix & Sturt, 2011; van Os & Kosian, 2011; van den Brenk, 2012).

Geophysical data should, wherever possible, be augmented by geotechnical data such as sediment logs. Whilst each core samples a tiny part of the seafloor and sub-bottom sediments, skilful choice of sampling location using sub-bottom geophysics allows sampling of key strata and, critically, of the stratigraphic boundaries. Recent advances in dating of marine sediments using optically stimulated luminescence (OSL) dating (Stokes et al., 2003) and amino-acid racemisation (AAR) dating (Penkman et al., 2008) accompanied by intensive palaeoenvironmental analysis can provide the critical data on palaeoenvironmental character and archaeological meaning with which to test and supplement the geophysically derived models. A recent example is the work of Dix & Sturt (2011) in which extensive sampling and analysis of 30 long (< 6 m) vibrocores for palaeo-secular variation (PSV), electron spin resonance (ESR), AAR, OSL and radiocarbon dating was used to build up a chronological picture and long-term evolutionary development of the submerged landscapes of the Outer Thames Estuary back to the early Middle Pleistocene (> 420 ky BP).

OSL dating of the submerged Holocene seabed can also be a useful tool to investigate and monitor erosion and sedimentation, and to determine how much undisturbed original sediment is present (Manders et al., 2009b). With the further advent of new technologies applicable to marine sedimentary ecosystems, such as DNA analysis (e.g. Cooper et al., 2001; Willerslev et al., 2003), it would be sensible to consider the establishment of protocols for storing samples in a way that allows these techniques to be used in the future and/or making existing samples (e.g. commercial cores, records, etc.) available more easily and for a wider range of purposes.

Geophysical and geotechnical surveys tend to be very expensive and it has proved effective to use data that has already been acquired by industry. Mapping work in the southern North Sea (Gaffney et al., 2007) and the Irish Sea and Bristol Channel (Gaffney et al., 2011) demonstrate very successfully the use of oil-industry shallow-seismic data in mapping the Holocene and post-glacial deposits around the UK. The scope for re-using such industry data, for archaeological and other purposes, has been greatly aided in recent years by the acquisition of geophysical data in digital form, which is now industry standard. In the UK, there has been progress recently to achieve far greater integration of archaeological objectives within non-archaeological surveys, as encouraged by the Aggregate Levy Sustainability Fund (ALSF, see also Bicket, 2011) and as demonstrated by the Regional Environmental Characterisation programme outlined above. Furthermore, networks are being created to facilitate exchange of information about new survey results and planned surveys for the future. Again, in the UK, the Marine Data and Information Network (MEDIN, http://www.oceannet.org/) is acting as a focus for discussion about marine data exchange, and events such as the Conference on Shipping Hydrology (CoSH) are intended to encourage co-ordination and collaboration in directing survey effort. Similar discussion on data exchange and availability has developed in the Netherlands, largely due to the MACHU project.

Opportunities for collaboration

The wide range of interested parties noted above means that there is a wealth of opportunities for collaboration within the individual countries and also across national boundaries. On major schemes, the state may itself be a developer or at least a partner in the development. Just as for local developers, the obligation on the state to similarly consider the environmental consequences of its overarching decisions about development has been formalised in recent years through the Strategic Environmental Assessment (SEA) Directive. The mutual interests of the state, whole industries, individual developers, contractors and academics in addressing archaeological questions is resulting in considerable progress with respect to North Sea prehistory. The most visible vehicle for such advance has been the ALSF, which, from 2002 to 2011, saw the injection of millions of pounds into data acquisition and research relevant to prehistory in the North Sea.

The ALSF has built on a range of current investigations undertaken by the marine aggregate industry, and whilst there has no doubt been a great volume of new data, some would argue that this data acquisition is perhaps leading scientific thinking on the archaeological issues. There are ongoing opportunities to take stock here and develop an overarching strategy, such as that specifically addressing the Palaeolithic (Westley et al., 2013) and Mesolithic (Bell et al., 2013) (see also Bicket, 2011). Similarly, broad research themes have been outlined in the NSPRMF (Peeters et al., 2009).

In the UK, equally important archaeologically orientated work has been generated by other industry sectors: coastal erosion and flood risk have motivated extensive regional investigations of archaeological material, including early prehistoric sites, at the coast (http://www.english-heritage.org.uk/professional/advice/advice-by-topic/marine-planning/shoreline-management-plans/rapid-coastal-zone-assessments/), oil and gas licensing proposals have resulted in several reports on prehistoric archaeology in support of Strategic Environmental Assessments (SEAs) (e.g. Flemming, 2002; Wickham-Jones and Dawson, 2006), offshore windfarm proposals have prompted extensive reviews of geophysical datasets and their construction is being accompanied by geoarchaeological investigations of deeply buried sequences (see COWRIE, 2007; Oxford Archaeology, 2008; Gribble et al., 2011), port proposals and other coastal developments fringing the North Sea are also being accompanied by geophysical and geoarchaeological studies (Manders et al., 2008), and various research-driven projects are adding to this mix.

Similarly, there is a wide range of efforts currently underway to produce maps of the sea floor, primarily for marine management and conservation purposes (e.g. van den Brenk, 2012; see also www.machuproject.eu). Integration of geological, sediment dynamics and archaeological disciplines provides the best opportunity to develop tools, such as predictive maps of archaeological potential and risk, which serve the needs of managers of the marine archaeological heritage (Deeben et al., 2002; Ward & Larcombe, 2008; Deeben, 2009).

Overall it is clear that any regional archaeological framework can and must be undertaken in collaboration with other bodies, bearing in mind the need to balance the assessment of archaeological value and management with other contemporary management issues such as nature conservancy. As such, there is increasingly a need to take a broader, multi-disciplinary approach to deal with problems created by human activities and develop decision support systems to help manage these.

Conclusions and key thoughts

Knowledge underpins management. However, it is only once we have a focused and agreed set of questions that it will be possible to obtain and apply the scientific knowledge needed to effectively resolve these questions, and from this develop clear assessment methodology and practical options to support effective heritage management. Providing such questions is one of the purposes of the NSPRMF that papers in this volume support.

Addressing the key issues, it is clear that although positive steps are being made, we still do not know enough about natural and anthropogenic contexts, we have not identified the priorities, and the current approach to marine heritage management is not yet fit for purpose. We maintain that what is needed is to place the depositional, stratigraphic and chronostratigraphic context at the heart of any problem solving, with a suggestion to test the initial framework and palaeoenvironmental interpretations of Ward & Larcombe (2008), Gaffney et al. (2009) and any other geomorphic-based conceptual models or mitigation maps. Future work can also follow up on the work of MACHU and Area 240, with a set of focused archaeological questions to evaluate and test the procedures and management outcomes presented from these initial studies. These may hopefully address some of the priorities identified in the various research frameworks developed by English Heritage and their Netherlands equivalent. Finally, we argue that an ecosystems approach is essential to build collaboration and develop possible strategies to deal with the conflicts between different stakeholder and interest groups on the seabed resource.

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