Hornsea 4

Ørsted

Hornsea Project Four: Preliminary Environmental Information Report (PEIR)

Volume 5, Annex 10.1: Marine Archaeology Technical Report

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Glossary

Term	Definition
Archaeological Exclusion Zone (AEZ)	Areas where archaeological receptors are present and should be avoided during project works.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Hornsea Four	The proposed Hornsea Project Four offshore wind farm project; the term covers all elements within the Development Consent Order (i.e. both the offshore and onshore components).
Model Clauses	Guidance issued by The Crown Estate; Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects.
Written Scheme of Investigation (WSI)	Project specific document forming the agreement between the client, the appointed archaeologists, contractors and the relevant stakeholders. The document sets methods to mitigate the effects on all the known and potential archaeological receptors within the development area.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
AEZ	Archaeological Exclusion Zone
BC	Before Christ
BP	Before Present
CIfA	Chartered Institute for Archaeologists
COWRIE	Collaborative Offshore Wind Research into the Environment
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ECC	Export Cable Corridor
FISH	Forum on Information Standards in Heritage
HE	Historic England
HMD	His Majesty's Drifter
HMT	His Majesty's Trawler
JNAPC	Joint Nautical Archaeology Policy Committee
NRHE	National Record of the Historic Environment
NSIP	Nationally Significant Infrastructure Project
PEIR	Preliminary Environmental Information Report
PAD	Protocol for Archaeological Discoveries
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs

Acronym	Definition
NSPP	North Sea Palaeolandscapes Project
OD	Ordnance Datum
RCZA	Rapid Coastal Zone Assessment
REC	Regional Environmental Characterisation
RSL	Relative Sea Level
SMR	Sites and Monuments Record
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
WSI	Written Scheme of Investigation
WWI	World War One
WWII	World War Two

Units

Unit	Definition
GW	Gigawatt (power)
kV	Kilovolt (electrical potential)
kW	Kilowatt (power)
nT	Nanotesla (magnetic induction)

1 Introduction

1.1 Introduction

1.1.1 Project background

1.1.1.1 Ørsted Hornsea Project Four Limited (the Applicant) is proposing to develop the Hornsea Project Four Wind Farm (hereafter Hornsea Four). Hornsea Four will be located approximately 65 km offshore from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume 1, Chapter 1: Introduction** for further details on the Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network. The location of Hornsea Four is illustrated on **Figure 1**. The Preliminary Environmental Information Report (PEIR) boundary combines the search areas for the onshore and offshore infrastructure.

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 848 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project is currently giving due consideration to the size and location (within the existing AfL area) of the final project that will be taken forward to consent application (DCO). This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction. The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the AfL taken forward at the point of PEIR (see **Figure 1**). The evolution of the AfL is detailed in **Volume 1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume 4, Annex3.2: Selection and Refinement of the Offshore Infrastructure**. The final developable area taken forward to development consent application may differ from that presented in **Figure 1** due to the results of the EIA, technical considerations and stakeholder feedback.

1.1.1.3 Maritime Archaeology Ltd. was commissioned to undertake an archaeological impact assessment study of the Hornsea Four array area and surrounding area.

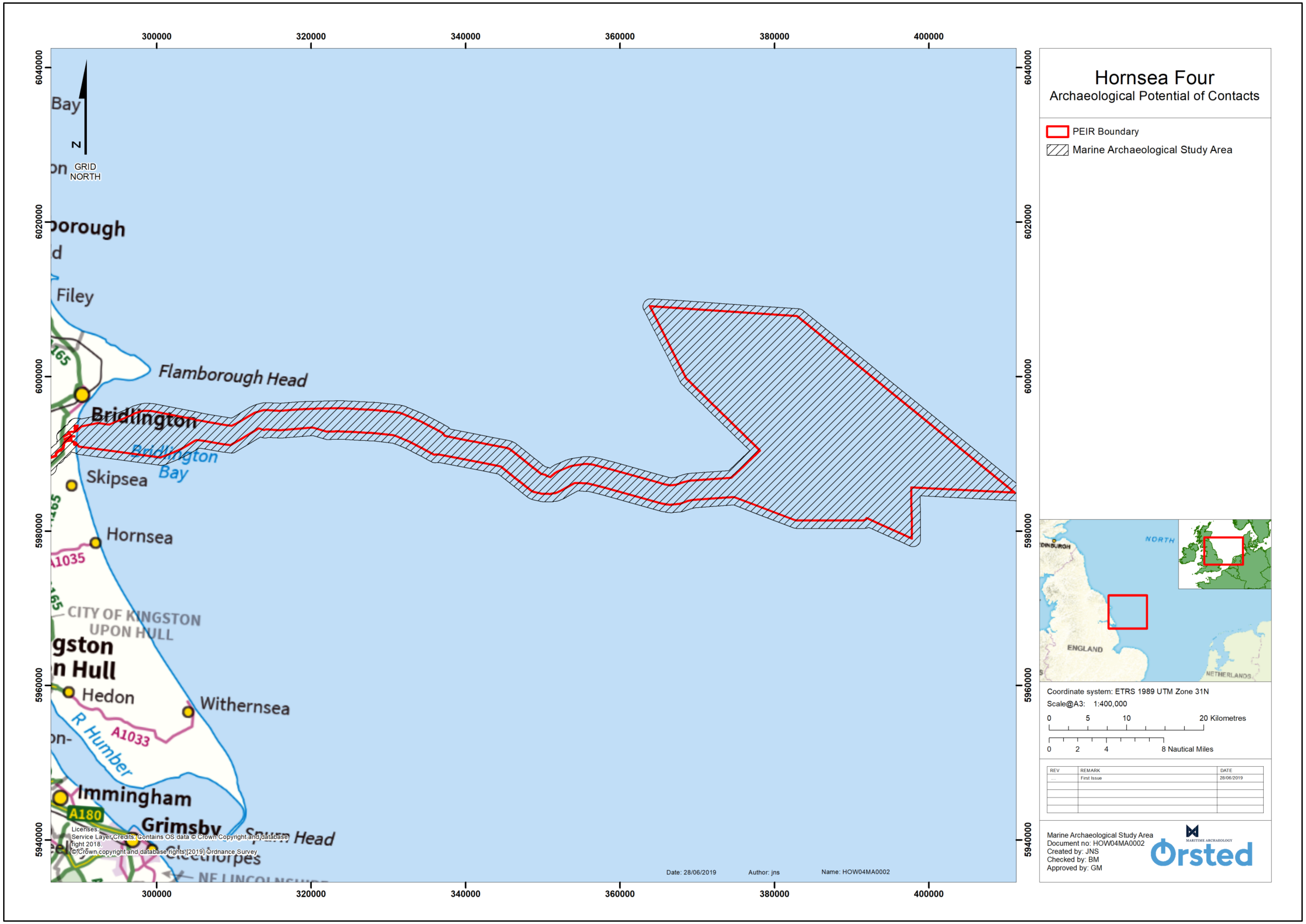

Figure 1: The location of Hornsea Four and the marine archaeology study area (not to scale).

1.1.2 Aims and objectives

1.1.2.1 The aim of this technical report is to identify known or potential marine archaeological resources within the PEIR boundary and wider marine archaeology study area and to provide an assessment of the potential effects on the resources likely to be impacted by the development of Hornsea Four.

1.1.2.2 The key objectives for the marine archaeological assessment process are to:

- Undertake ongoing consultation with Historic England (HE) and other key stakeholders, as required, in order to develop all aspects of the approach to identify receptors and mitigate impacts;
- Undertake a review of the known archaeological resources within the PEIR boundary and marine archaeology study area;
- Summarise the environmental context and archaeological potential;
- Asses geophysical and geotechnical data to identify previously unknown sites of archaeological potential;
- Provide an impact assessment and mitigation recommendations for all identified heritage receptors;
- Develop an agreed outline Written Scheme of Investigation (WSI) setting out the archaeological requirements pre- and post-application; and
- Provide a protocol and reporting chain to be utilised during the construction, operation and decommissioning phases in case of unexpected archaeological finds.

2 Methodology

2.1.1.1 Maritime Archaeology Ltd is a Registered Organisation with the Chartered Institute for Archaeologists (CIfA). Maritime Archaeology Ltd conducts all work in accordance with the guidance and principles established in the CIfA's *Code of Conduct* (2014) and *Code of Professional Conduct* (2019). The Hornsea Four marine archaeology baseline has been formulated according to the approach and best practice contained in:

- CIfA's Standard and Guidance for historic environment desk-based assessment (2017);
- Standard and guidance for the collection, documentation, conservation and research of archaeological materials (CIfA, 2014a);
- Standard and guidance for commissioning work on, or providing consultancy advice on, archaeology and the historic environment (CIfA, 2014b);
- Standard and guidance for archaeological field evaluation (CIfA, 2014c);
- Standard and guidance for nautical archaeological recording and reconstruction (CIfA, 2014d);
- Standard and guidance for an archaeological watching brief (CIfA, 2014e);
- Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects. Guidance issued by The Crown Estate (hereafter referred to as 'Model Clauses');
- Joint Nautical Archaeology Policy Committee (JNAPC) Code for Practice for Seabed Development 2006;

- Collaborative Offshore Wind Research into the Environment (COWRIE) Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy, 2008;
- Collaborative Offshore Wind Research into the Environment (COWRIE) Historic Environment Guidance for the Offshore Renewables Energy Sector, 2007; and
- The Protocol for Archaeological Discoveries: Offshore Renewables Projects (ORPAD) The Crown Estate, 2014.

2.1.1.2 The marine archaeology study area was established to encompass the Hornsea Four PEIR boundary plus a 1 km buffer defining the zone where any potential effects on marine archaeology receptors may occur. Following Hornsea Four's approach to proportionate Environmental Impact Assessment (EIA) as outlined in **Volume 1, Chapter 5: Environmental Impact Assessment Methodology**. Hornsea Four is currently giving due consideration to the size and location of the final project that will be taken forward to development consent application. The area which is currently being considered by the project is referred to as the PEIR boundary and for the purpose of this marine archaeology technical report both the marine archaeology study area and the PEIR boundary, as illustrated on **Figure 1** have been considered.

2.2 Baseline Assessment Methodology

2.2.1.1 A baseline review of the maritime archaeology of the marine archaeology study area is contained within **Section 3**. This begins with a review of the environmental context of the North Sea and continues with a baseline assessment of the maritime activity that has taken place within, or that may have affected, the marine archaeology study area.

2.2.1.2 Information sources used in the archaeological desk-based assessment are outlined in **Table 1**. Where there is a discrepancy between different sources' locational data, the location provided by the United Kingdom Hydrographic Office (UKHO) is used (as per Dellino-Musgrave & Heamagi, 2010). The vertical datum for depths listed in the gazetteer is the lowest astronomical tide (LAT).

Table 1: Information sources used in the archaeological desk-based assessment.

Database/ Source	Data type	Link
National Record of the Historic Environment (NRHE)	Spatial and descriptive; full coverage seaward and landward of MHWS.	https://archaeologydataservice.ac.uk/archives/view/398/
United Kingdom Hydrographic Office (UKHO)	Spatial; full coverage seaward of MHWS.	Via **https://www.oceanwise.eu/**
Humber Historic Environment Record	Spatial and descriptive; landward of MLWS only.	http://www.hull.gov.uk/resident/planning-and-building-control/humber-historic-environment-record
Rapid Coastal Zone Assessment: Yorkshire and Lincolnshire	Descriptive; landward of MLWS only.	https://archaeologydataservice.ac.uk/archives/view/yorksrcza_eh_2009
Yorkshire Archaeological Research Framework	Descriptive; landward of MLWS only.	https://historicengland.org.uk/images-books/publications/yorks-arch-res-framework-resource-assessment/
CITiZAN – Coastal and Intertidal Zone Archaeological Network	Descriptive; landward of MLWS only.	https://www.citizan.org.uk/

2.2.1.3 Within Historic Marine Protection Areas and on scheduled monuments, as well as the wrecks of all aircraft crashed in military service and designated vessels afforded statutory protection by the Ministry of Defence under the Protection of Military Remains Act 1986, additional restrictions apply. Although none of these have been identified within the marine archaeology study area to date, due to the great numbers of historic aviation losses across the UK, the possibility remains that previously unknown sites may be encountered.

2.2.1.4 Generally, known and identified features in the marine environment fall into two categories: wrecks and obstructions, the following definition of which is used by the UKHO:

- Obstruction: In marine navigation, anything that hinders or prevents movement, particularly anything that endangers or prevents passage of a vessel. The term is usually used to refer to an isolated danger to navigation. 'Fouls' (areas safe to navigate over but which should be avoided for anchoring, taking the ground, or ground fishing) listed by the UKHO are included within this category; and
- Wreck: The ruined remains of a stranded or sunken vessel which has been rendered useless.

2.2.1.5 Wrecks and obstructions are further classified in a number of ways by the UKHO:

- LIVE: Wreck considered to exist as a result of detection through survey;
- DEAD: Not detected over repeated surveys, therefore not considered to exist in that location;

- LIFT: Wreck has been salvaged; and
- ABEY: Existence of wreck in doubt and therefore not shown on charts.

2.2.1.6 It should be noted that classification as a DEAD wreck, simply indicates that no material has been located by the UKHO at that position. From an archaeological perspective, this may simply mean that the remains have become buried in sediment to a level where they are no longer visible, even though they are still present.

2.3 Geophysical data assessment methodology

2.3.1.1 The archaeological assessment of the geophysical data collected was undertaken by MSDS Marine Ltd. The full report including the methodology used is included asAppendix C: MSDS Archaeological Review of Geophysical and Hydrographic Data. This technical report summarises the results from the assessment in **Section 4.1**.

2.4 Mitigation methodology

2.4.1.1 Mitigation recommendations are formulated where archaeological features and anomalies are identified in the desk-based and/or geophysical assessments and follows the guidance set out in Historic Environment Guidance for the Offshore Renewables Energy Sector (Cowrie, 2007) and Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects (Crown Estate, 2010).

2.4.1.2 Hornsea Four has made several commitments as a part of the pre-application phase to avoid and reduce impact on marine archaeological receptors. The relevant commitments in relation to marine archaeology are presented in **Table 2** below. All commitments and their method of security are documented in **Volume 4, Annex 5.2: Commitments Register**.

Table 2: Marine archaeology commitments.

Commitment ID	Measure
Co46	Primary: The offshore export cable corridor and the array will be routed to avoid any identified archaeological receptors pre construction, with buffers as detailed in the Marine Written Scheme of Investigation WSI.
Co140	Primary: Archaeological exclusion zones (AEZs) will be established in the Marine WSI in accordance with the outline Marine WSI (document reference F2.4), to protect any known / identified marine archaeological receptors.
Co141	Tertiary: A Marine Written Scheme of Archaeological Investigation (WSI) will be developed in accordance with the Outline Marine WSI. The Marine WSI will include the implementation of a protocol for Archaeological Discoveries in accordance with 'Protocol for Archaeological Discoveries: Offshore Renewables Projects' (The Crown Estate, 2014).
Co166	Secondary: A geophysical survey (including a UXO survey) will be undertaken prior to construction and will be subject to a full archaeological review in consultation with Historic England.
Co167	Secondary: A geotechnical survey will be undertaken prior to construction, including a staged geoarchaeological assessment and analysis of geotechnical data inclusive of publication, in consultation with Historic England.

3 Baseline Review

3.1 Environmental Context

3.1.1 Sea Level Change

3.1.1.1 Sea level change in the southern North Sea is a key factor in determining the archaeological potential of the marine archaeology study area. During glacial periods, as a result of much lower sea levels, areas of the marine zone were exposed as land surfaces with opportunities for hominin habitation and exploitation. These same areas were inundated during inter-glacial periods when deglaciation caused relative sea level (RSL) to rise.

3.1.1.2 During the Quaternary period the last three glacial maximums—the Anglian, c.350,000-280,000 BP, the Wolstonian, c.250,000-150,000 BP and the Devensian, c.100,000-22,000 BP—were periods of low RSL, with RSL rising in the periods between glacial maximums. After the last (Devensian) glaciation, during the early Holocene, there was a RSL rise (of about 60 m globally) beginning at c.11,650-7000 cal. BP (c.9,650BC - c.5,000 BC) (Smith *et al* 2011). In North West Europe this caused considerable geographic change, including the development of the southern North Sea, an area that had previously been a relatively low-lying plain with an extensive river system (Sturt *et al.* 2013).

3.1.1.3 Like much of the offshore zone around the UK, the southern North Sea (including the marine archaeology study area) was inundated relatively late, between 10,000 and 7,500 years ago (8,000-5,500 BC) (Ward *et al* 2006; Gaffney *et al* 2007: 6; Sturt *et al* 2013). In some areas, high resolution, regional RSL curves offer a refinement to the UK scale model (Smith *et al.* 2012), since local factors impact on the rate of change. Notably, sea level rise in the marine archaeology study area is complicated by the isostatic effect of glacial rebound. Broadly, Scotland and Britain north of the Tyne has experienced post-glacial uplift and the south coast of England has experienced subsidence. North Yorkshire has experienced little change, whilst there is some evidence of land subsidence in South Yorkshire (Horton and Shennan 2009; Bradley *et al.* 2011). In addition, there was a meltwater pulse 8,450 years ago which would have impacted sea level change and the pattern of inundation in the vicinity of the marine archaeology study area (Bell *et al.* 30-34; Gornitz 2007).

3.1.1.4 Although there is a growing research focus on sea level change in the southern North Sea (e.g. Coles 1998; Gaffney *et al* 2009; Europe's Lost Frontiers 2017), there is no high resolution, local RSL curve for the marine archaeology study area. Notably, however, research into the palaeogeography of 'Doggerland' has identified Mesolithic shoreline data (as well as sedimentary deposits) that provide more accurate sea level data for the marine archaeology study area (with further refinement likely in the future as the coring programme of the Lost Frontiers project 2015-2020 offers potential localised sea-level index points) (Gaffney *et al.* 2007; Gaffney *et al* 2009; Europe's Lost Frontiers 2017).

3.1.1.5 In general UK sea levels stabilised to approximately their current level at c.4,000 BC. However, just to the south of the marine archaeology study area in the Humber Estuary, work using a range of local sea level index points suggests sea level was still rising until c.2,000 BC (Long *et al.* 1998), whilst in the Wirral, on the north-west coast of England, there were localised oscillations in sea level and a pattern of marine regression and transgression (including a marine regression at c.5,000-4,000 BC and at c.3,500-2,500 BC) (Cowell and Gonzalez 2007). These examples highlight the variation in sea level rise at local and regional scales and that it was not a steady change over the Holocene period (Sturt and Van de Noort 2013:53). More specifically, they reflect the varying impacts of inundation and land lost as sea level rose across different landscapes (see also Shennan and Horton 2002), which will be discussed further in the next section.

3.1.2 Geomorphological change

3.1.2.1 Since the Quaternary period, changing sea level has contributed to considerable geomorphological change across the marine archaeology study area. The last three glacial maximums—the Anglian, c.350,000-280,000 BP, the Wolstonian, c.250,000-150,000 BP and the Devensian, c.100,000-22,000 BP—were periods of low relative sea level, when areas of the marine zone were exposed as landsurfaces. Much of this geomorphology was reworked during subsequent inundations, as sea level rose during inter-glacial periods and by the effects of scour during each successive glaciation (Flemming 2002). As a result, though some sedimentary deposits from these earlier periods are found within the seabed, the current seabed and coastal geomorphology is largely the product of Holocene change.

3.1.2.2 The present coastline is very different to that of the early Holocene. About 8,000 years ago the coastline was 15-20 km offshore (Gaffney *et al.* 2007) and the current coastline would have been low-lying marshland. Key pioneering work on offshore landscape reconstruction demonstrates the survival of submerged Holocene landscape features in the marine archaeology study area, including the Mesolithic shoreline (*ibid.*; Gaffney and Fitch 2009). This shoreline is associated with the Outer Silver Pit, a vast sea inlet which existed to the south of the Dogger Bank from 8,000-7,500 years ago (Gaffney *et al.* 2007).

3.1.2.3 This work by Gaffney *et al* (2007) identifies the last marine transgression in the southern North Sea from c.10,000 years ago. From about 8,000 years ago this transgression dramatically altered the 15-20 km of coastal landscape between the Mesolithic shoreline in the marine archaeology study area and the current coast. Work by Sturt *et al* (2013) combines a newly refined glacial isostatic adjustment model (Bradley *et al* 2011) with recent relative sea level data to model paleogeographic change at 500-year intervals over the Holocene period. Though developed at a regional 'North Sea' scale, this is particularly useful for characterising geomorphological change through the prehistoric period (Sturt *et al* 2013). Change was not simply a question of inundation but also of varied rates of erosion and sedimentation which altered the morphology of both the seabed and land surfaces (*Op. Cit.,* 3968) and, in the southern North Sea Basin, marked changes in tidal ranges further impacted this geomorphological change (Cazenave, 2012).

3.1.2.4 As noted above (**Section 3.1.1**), though RSL had been broadly stabilised by the Neolithic (c.4,000 BC), evidence from localised studies in other areas suggests that there were still variations. In addition, there was a period of increased storm activity between 4,150-3,400 BC (6,150-5,400 years ago) (Tipping 2010) which would likely have had significant impact on coastal erosion, though as we have no local model for the Holderness coast the impact on geomorphological change in this area is not clear (Sturt and Van de Noort 2013:53-56).

3.1.2.5 Geomorphological change in the area since the Neolithic has been dominated by coastal erosion. Notably, the Holderness coastline is one of the fastest eroding coastlines in Europe. The coastline is characterised by soft, clay boulder cliffs (glacial till) deposited by retreating glaciers towards the end of the last glacial period from c.50,000 years ago (Evans and Thomson 2010; Boyes *et al.* 2016). The Bay of Bridlington, protected by the chalk cliffs of Flamborough head to the north, has been formed by coastal erosion as the dominant south-westerly North Sea waves create southbound longshore currents (Sistermans and Nieuwenhuis 2007). This pattern is developing a s-shaped coastline, with Bridlington Bay to the north and deposition of sediments at Spurn Point to the south. Bridlington bay is also therefore a historic anchorage site, sheltered by Flamborough Head, and a key focal point of maritime activity.

3.1.2.6 The Humber and fenland to the south of the marine archaeology study area are also worth noting, with their long history of occupation and maritime activity from early prehistory (Van de Noort 2004). During early prehistory, the current Holderness coast would have been part of the low-lying marsh lands of the Humber Estuary. The remnants of a number of post-glacial meres, or lakes, characterise the area with some fen and marsh still to the south. Although, only Hornsea Mere still survives with open water (Marsters 2011), the meres, including Barmston Mere and Skipsea Withow Mere located within the potential marine archaeology study area, have high potential for the preservation of geoarchaeologically significant deposits (Brigham and Jobling 2011: 40).

3.1.2.7 The Holderness coastline has long been known for 'the lost towns of Yorkshire' (settlements which have been 'lost' to the sea) (e.g. Sheppard 1912), reflecting both the degree and scale of coastal erosion and the persistence, nonetheless, of coastal settlement and maritime activity. Rates of erosion are high. Modelling of the Roman coastline, based largely upon proxy indicators, places it about 5.6 km seaward of the present coastline (Boyes *et al.* 2016). An average of 150 m of coast has been lost since the First Edition Ordnance Survey of the area in the 1850s, but biannual measurements at 116 points since 1951 suggest this process is accelerating, as well as uneven geographically and temporally (Brigham *et al.* 2008:18).

3.1.2.8 In addition, in the medieval period there was increased storm surge activity between 1300-1500 AD in the North Sea. Resulting rapid change has been documented in the Humber Estuary (Long *et al.* 1998) and the loss of medieval settlements such as Hornsea Beck reflects its likely impact on the Holderness coastline (see **Section 3.2.9** for further discussion). Thirty settlements are recorded lost to coastal erosion along this stretch of coast since the Medieval period (though numbers from previous periods are unquantifiable). These include Hornsea Beck, Great Cowden (lost since it was recorded in the first OS in the 1850s), and Ringborough (where first a medieval settlement and latterly WW2 artillery battery have been lost) (Brigham *et al.* 2008:19; Sistermans and Nieuwenhuis 2007). Brigham *et al.* note 'most villages [now] lie further back, the original row of medieval settlements bordering the sea and shore having been lost' (2008:19). This retreating coastline, with its lost coastal settlements, also suggests the potential for former coastal anchorages now located further out at sea.

3.2 Maritime Activity: baseline review

3.2.1 Introduction

3.2.1.1 The following sections provide a broad contextual overview of human activity in the region and of the archaeological site types that may be expected to occur within the marine archaeology study area. This overview aids the assessment of the archaeological potential of the marine archaeology study area and the assessment of significance of any sites contained within it.

3.2.1.2 The offshore marine archaeological resource can be described in three main classes of material and features:

- *Submerged prehistoric landscapes* caused by changes to sea level and eventual stabilisation of sea level at or near to the present position. Such landscapes may contain highly significant evidence of prehistoric human occupation and/or environmental change;
- *Archaeological remains of watercraft* deposited when vessels sank while at sea or became abandoned in an inter-tidal context which subsequently became inundated; and,
- *Remains of aircraft crash sites*, either coherent assemblages or scattered material usually the result of Second World War (WWII) military conflict, but also numerous passenger casualties, particularly during the peak of seaplane activity during the inter-war period. Also, includes aircraft, airships and other dirigibles dating to the First World War (WWI) although these rarely survive in the archaeological record.

3.2.1.3 In addition, structural remains other than watercraft, such as fish traps, abandoned quays, hards or defensive structures, may be found within the intertidal zone (between mean high water springs (MHWS) and mean low water springs (MLWS)). Only marine archaeology receptors located seaward of MHWS have been considered in this section. The offshore and onshore archaeological assessments overlap at the intertidal zone as outlined in this technical report and in **Volume 6, Annex 5.1: Historic Environment Desk Based Assessment**.

3.2.1.4 The chronology used below, including the 'overlaps' in later prehistory, is based on Historic England's *Protected Wreck Sites at Risk: A Risk Management Handbook* (Dunkley, 2008), MIDAS Data Standard *The UK Historic Environment Data Standard* (English Heritage, 2012), *People and the Sea: A Maritime Archaeological Research Agenda for England* (Ransley *et al*, 2013), FISH (Forum on Information Standards in Heritage) guides[1] and Historic England's 'Yorkshire Archaeological Research Framework: research agenda' (Roskams and Whyman, 2007). As noted in *People and the Sea,* these dates reflect cultural change, with, particularly in prehistoric periods, regional chronologies highlighting differences in the timing of these transitions, so they should be understood as 'indicative temporal horizons' (Ransley *et al* 2013) and a framework for interpretation.

[1] http://www.heritage-standards.org.uk/

3.2.2 Early Prehistory: Palaeolithic (c.800,000 – 10,000 BC)

3.2.2.1 Within the seabed of the southern North Sea there are submerged prehistoric landscape features and sediments from as early as 800,000 years ago. Although the marine archaeology study area is now a marine zone it constituted dry land, with associated opportunities for hominin habitation and exploitation, for considerable periods during the Palaeolithic when glaciations resulted in lower sea levels (as outlined above in **Section 3.1**).

3.2.2.2 Yorkshire and the exposed landsurfaces of the southern North Sea were repeatedly inhabited during the Palaeolithic as these lower sea levels connected the UK landmass to Europe and exposed rich wetlands (Roskams and Whyman 2007; Brigham *et al.* 2008:19, 171-2; Westley and Bailey 2013: 10-29). Hominin occupation in the vicinity of the marine archaeology study area during the Middle Palaeolithic is, for example, evidenced by a flint core eroded from Sewerby Cliff, just to the north of the current study area are near Bridlington (Brigham *et al* 2008:172, SMR ID MHU1893). This is likely to reflect 'inland' rather than coastal activity, because the predominantly lower Palaeolithic sea levels mean that Palaeolithic coastlines are now likely to be submerged offshore (Westley and Bailey 2013:11).

3.2.2.3 The archaeological and palaeoenvironmental potential of offshore prehistoric landscape deposits is attested by numerous artefacts, animal bone and peat finds from the Lower, Middle and Upper Palaeolithic from Brown Ridge, Eurogeul and Zeeland Ridges in the southern North Sea between UK and the Netherlands (Westley and Bailey 2013:14-16). In-situ offshore finds are rare as a result of collection factors (such as the complex logistics of offshore research investigations and the nature of marine industry activities). There are none in the vicinity of the marine archaeology study area, although the potential for the in-situ preservation in similar contexts is demonstrated by early Middle Palaeolithic flint tools, dated to 250-200,000 years ago, recovered from aggregate dredging Area 240 off the coast of Norfolk (Tizzard *et al.* 2014).Further to the south, there is a submerged late Middle Palaeolithic site at Fermanville on the French Channel coast, where 2,500 stone artefacts, dated to 40-50,000 years ago, were excavated from a peat deposit at -25 m (Scuvée and Verague 1988; Maritime Archaeology, 2007; Westley and Bailey 2013:15-16).

3.2.2.4 These two sites confirm the potential for in-situ deposits from earlier periods to survive multiple phases of glaciation and marine transgression. However, due to the high level of scour, erosion and reworking related to the actions of ice, marine and fluvial processes during successive glacial cycles; the potential for material from the Palaeolithic is highest within the last 100,000 years and increases significantly following the last glacial maximum, from about 20,000 years ago (Flemming 2002; Tappin *et al.* 2011: 126; Westley and Bailey 2013). Material from earlier periods is more likely to be derived from secondary contexts.

3.2.2.5 The survival of post-glacial and early Holocene deposits in this region is demonstrated by the North Sea Palaeolandscapes Project (NSPP) and the Europe's Lost Frontiers Project (see Gaffney *et al.* 2007; Gaffney *et al.* 2009; Europe's Lost Frontiers 2017). The NSPP has identified submerged Holocene landscape features within the marine archaeology study area, in the north of the Hornsea Four array area (**Figure 2**) Similarly, the Humber Regional Environmental Characterisation (REC) study covers an area immediately to the south and east of the marine archaeology study area and identifies numerous Holocene channels and landsurfaces (Tappin *et al.* 2011).

3.2.2.6 Despite the geographical gaps in the NSPP data (**Figure 2**) within the marine archaeology study area, it, along with the Humber REC study, suggests that Holocene sediments are likely to be present within other parts of the marine archaeology study area. In addition, sampling undertaken during the Humber REC study has shown that these deposits generally lie close to the surface of the seabed. Which of these Holocene deposits and features are Upper Palaeolithic is less clear from these studies, but given the timeframes and the nature of the cultural transition these periods mark, it is likely that both Upper Palaeolithic and Mesolithic deposits are present. Initial geoarchaeological studies undertaken by COARS and MSDS Marine Ltd support this view (see **Section 4.2**).

3.2.2.7 Any Upper Palaeolithic deposits would have high palaeoenvironmental and archaeological potential. During the Upper Palaeolithic this region, including the marine archaeology study area, would have been low-lying marshland and fens, populated with game herds and particularly favourable to hunter-gatherer lifeways – an attractive environment for human habitation. The Yorkshire Archaeological Research Framework identifies south-western Yorkshire and the Humber region as of high potential for Upper Palaeolithic research (Roskams and Whyman 2007: 20-21). There have been a number of Upper Palaeolithic finds identified in the coastal archaeological record along the Holderness coast. Notably, Late Upper Palaeolithic artefacts have been identified within the marine archaeology study area (though outside of the PEIR area) at Skipsea Withow Mere (artefacts and elk bones), along with a flint blade found in the area of the Withow Gap lake settlement (Murphy 2009:16; Brigham *et al.* 2008: 65-6) and at Gransmoor quarry, just 15 miles inland a bone harpoon point dated to c.11,500 years ago was recovered (Brigham *et al* 2003:172). To the south at Hornsea, a barbed bone point was found in lacustrine peat (SMR MHU3544), whilst a flint scraper was recovered south of Withernsea at Holmpton (*ibid.*). In addition, the post-glacial, infilled freshwater meres exposed along the coast are identified as having significant palaeogeoarchaeological potential (*Op. Cit.,* 195). This, along with the artefact finds they have yielded, means that as well as demonstrating the early prehistoric occupation of the area, they highlight the kinds of deposits and artefacts that may be present in Holocene fluvial and landsurface deposits within the seabed of the marine archaeology study area.

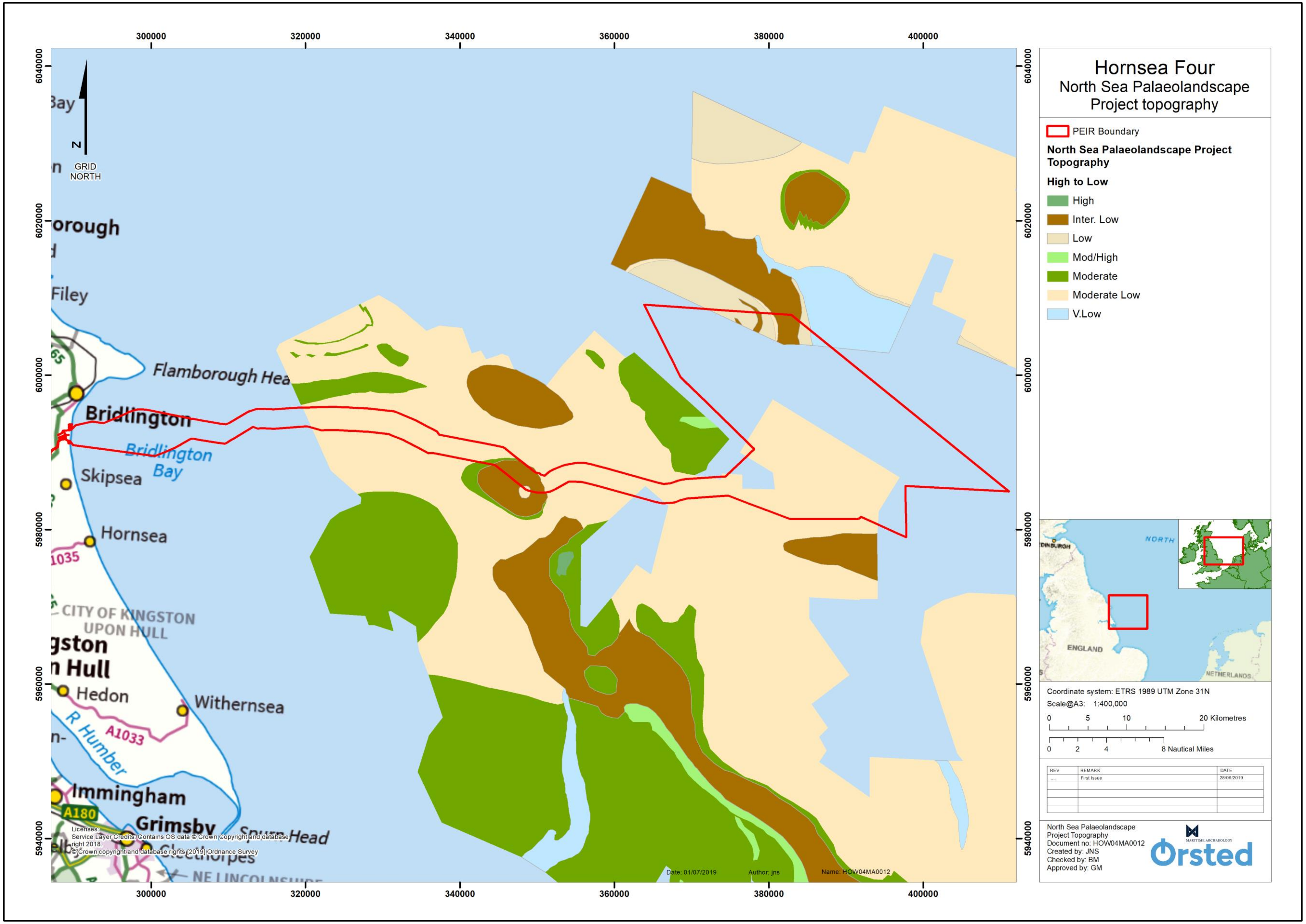

Figure 2: Identified submerged Holocene landscape features (North Sea Palaeolandscape Project) data (not to scale).

3.2.3 Early Prehistory: Mesolithic (10,000 - 4,000 BC)

3.2.3.1 Early Holocene landscape features and deposits are present within the seabed of the marine archaeology study area and in its vicinity (see Gaffney *et al.* 2007; Gaffney *et al* 2009; Tappin *et al.* 2011; Europe's Lost Frontiers 2017). These include a Mesolithic shoreline, in the northern part of the offshore array, along with fluvial deposits in other parts of the marine archaeology study area (Gaffney *et al.* 2007: 43ff).

3.2.3.2 This Mesolithic shoreline is located 15-20 km offshore from the present coastline, suggesting that most of the marine archaeology study area would have been part of a large tranche of low-lying, coastal wetland landscape during the Mesolithic. South-western Yorkshire and the Humber region were inhabited at this time and all evidence suggests this landscape would also have been 'a magnet for seasonal hunters' (Brigham *et al.* 2008:173; see also Van de Noort 2004; Roskams and Whyman 2007). This coastal wetland was, however, submerged during the last marine transgression from about 8,000 years ago. As a result, it would have been subject to dramatic geomorphological and environmental changes during the Mesolithic (relative sea level stabilised at approximately current levels at the end of this period; see **Section 3.1.2**: for further details). Any evidence of these events within the early Holocene deposits found in the marine archaeology study area, and particularly of human responses to that change, would be particularly significant.

3.2.3.3 Consequently, unlike later periods characterised by ship and boat remain deposits, submerged landscapes with coastal, fluvial and wetlands deposits of archaeological and paleoenvironmental potential characterise the archaeology of this period within the marine archaeology study area both offshore and in the intertidal.

3.2.3.4 Specifically, the highest known area of potential within the marine archaeology study area is the former Mesolithic shoreline in the northern part of the offshore array area identified by North Sea Palaeolandscapes Project (NSPP) (Gaffney *et al* 2007: 43ff) (**Figure 2**). It is associated with the Outer Silver Pit, a vast sea inlet which existed to the south of the Dogger Bank from 8,000- 7,500 years ago. The remainder of the array area and the offshore ECC crosses areas mapped as harder geology intersected by fluvial systems, which may also have provided a focus for human exploitation of natural resources. As noted above in **Section 3.2** *Early Prehistory: Palaeolithic*, there are some gaps in the NSPP data within the marine archaeology study area (**Figure 2**), but given the proximity of the Humber Regional Environmental Characterisation (REC) study to the south and east of the marine archaeology study area (Tappin *et al* 2011) and the NSPP results it is reasonable to extrapolate similar potential for these areas. In addition, the Humber REC identifies Mesolithic channel systems as of the highest 'archaeo-environmental potential' (*Op. Cit.*), and sampling undertaken during the study has shown that these deposits generally lie close to the surface of the seabed.

3.2.3.5 Human habitation of the region during the Mesolithic is demonstrated by the internationally important Mesolithic site of Star Carr north of marine archaeology study area, just south of Scarborough (see Milner *et al.* 2018a and 2018b). The Yorkshire Archaeological Research Framework identifies a number of Mesolithic production sites (Roskams and Whyman 2007: 21), including in the Humber wetlands (Van de Noort 2004).

There are also a number of finds and sites in Holderness' coastal archaeological record which highlight Mesolithic activity in the immediate area, including an elk antler and a harpoon head found at Fraisthorpe Sands inside the PEIR boundary (Brigham *et al.* 2008: 55, SMR ID MHU15036 and MHU344), evidence of exploitation of Skipsea Withow Mere by hunter-gatherers during the early Mesolithic (Sitch and Jacobi 1999; Brigham *et al.* 2008:65-6 & 173; Murphy 2009:16; Cadnam *et al.* 2018) and a collection of Mesolithic finds including flint cores, scrapers, a pebble macehead and tranchet axe were discovered at Bridlington, just to the north of the marine archaeology study area (NMN 910906).

3.2.3.6 In addition, there is a Mesolithic submerged forest at Withernsea, probably associated with the original Withernsea Mere (Brigham *et al.* 2008:110), and a number of post-glacial freshwater meres now eroding from the Holderness coastline. These have high palaeoenvironmental potential but are also likely foci for human activity (*Op. Cit.*, 19 and 173; Brigham and Jobling 2011:40). Within the marine archaeology study area Barmston Mere yielded peat and wood samples dated to the very early Mesolithic (Brigham and Jobling 2011) and Skipsea Withow Mere, mentioned above, is identified both as of palaeoenvironmental potential (Bell *et al.* 2013:38), with the earliest organic lake deposits dating to 9880BP (Brigham *et al.* 2008:66), and as a site of hunter-gatherer activity (Sitch and Jacobi 1999; Murphy 2009:16; Cadnam *et al.* 2018).

3.2.3.7 The kind of wetland landscape present within the marine archaeology study area during the Mesolithic would have supported a range of hunter-gatherer activity, including game-hunting, wildfowling, fishing and shellfish gathering, as well as exploitation of resources for temporary shelter, clothing, basketry etc (Brigham *et al.* 2008:173). Potential archaeological sites include walkways, platforms, shell middens, food-processing and tool-making sites, as well as seasonal shelters and more permanent settlements; fluvial/estuarine channels and remnant coastlines also have the potential for fish traps and other intertidal structures (Murphy 2009:47). It should also be noted that though rare, excavations of Mesolithic villages and burials at Tybrind Vig and Møllegebat in Denmark, as well as the Bouldnor Cliff site in the Solent, attest to the potential for extensive in-situ Mesolithic archaeological sites (including ship and boat remains) to survive (Andersen 2013; Skaarup and Gron 2004; Momber *et al.* 2011). There have even been Mesolithic footprints found in intertidal silts in the Severn Estuary (Bell *et al.* 2013:39). Many of the key research questions from *People and the Sea* (Maritime Archaeological Research Agenda for England) relate to human engagement with the sea and exploitation of marine, wetland and coastal resources, and reflect the small spatial samples of Mesolithic landscapes and sites in the current record (*Op. Cit.*, 44-45), and, therefore, the potential importance of any Mesolithic in-situ deposits or archaeological finds.

3.2.3.8 Finally, it should be noted that there is potential for archaeological remains of boats, or associated artefacts such as paddles or fishing equipment, to be found from this period (McGrail 2001: 176). These would likely be either logboats, skin/hide boats (Bell *et al.* 2013:48) or possibly birch bark canoes (as discussed in relation to Star Carr (Rowly-Conwy 2017). There are no secure examples of log, skin or bark boats of Mesolithic date from the UK, although logboats are found in Mesolithic contexts in Denmark (Pedersen *et al.* 1997) and Netherlands (Louwe Kooijmans 2001). These boats would have been utilised within inshore waters, estuaries and rivers, such as the environment present within the marine archaeology study area at the time. There is also indirect evidence for Mesolithic seafaring from island colonisation and the dispersal of raw materials (Warren 2005; Wickham-Jones

2005). Any Mesolithic boat remains or associated artefacts would be highly significant/important.

3.2.4 Later Prehistory: Neolithic (4,000 – 2,200 BC)

3.2.4.1 By the Neolithic, sea level had risen to levels approximate to today, and the potential for extensive submerged landscape deposits from this period in the marine archaeology study area is therefore reduced. However, as noted in **Section 3.1.1**, this broad model is not always consistent at local scales. Consequently, there remains potential for in-situ Neolithic material, including remains of intertidal structures and watercraft as well as of Neolithic occupation, in intertidal and inshore sediments. There is also potential for eroded Neolithic deposits and finds to be found in secondary contexts in the intertidal and inshore of the marine archaeology study area.

3.2.4.2 Notably, the Neolithic occupation site on the foreshore at Easington, on the Holderness coast to the south of the marine archaeology study area, attests to this potential (Brigham *et al.* 2008:19; 122; Brigham and Jobling 2011:69, 96). There are also Neolithic submerged forests eroding from the intertidal zone at Hornsea as well as at Easington (Murphy 2009:31). The survival of Neolithic fishtraps within such contexts is evidenced by a fishtrap preserved in a stretch of submerged forest off Hartlepool (Tolan-Smith 2008:65; Sturt and Van de Noort 2013:59).

3.2.4.3 More broadly, the coastal archaeological record of Holderness and the Humber highlights Neolithic activity in the area including evidence of agriculture alongside coastal and maritime resource exploitation (Van de Noort and Ellis 1997; Brigham *et al.* 2008). There is evidence of a substantial Neolithic industry exploiting material extracted from the local till, along with occupation sites, at Flamborough Head to the north of the marine archaeology study area, likely associated with the scheduled monument Danes Dyke (Brigham *et al.* 2008:174). There are a number of assemblages and find spots along the Holderness coast between this site and the one at Easington to the south. These include small assemblages and finds around Bridlington (including the Mesolithic to Late Bronze Age flint industry at Sewerby golf course) (*Op. Cit.*, 43), an assemblage of late Neolithic / early Bronze Age flints at Newbegin, Hornsea (*Op. Cit.*, 75), a possible long barrow and pit at Roos (*Op. Cit.*, 96) and likely Neolithic occupation deposits eroding from Cliff at Withernsea (*Op. Cit.*, 106). Notably, there are plough stones among these finds indicating agricultural activity (*Op. Cit.*, 175) and reflecting the arrival in the Neolithic of more sedentary, agricultural lifeways alongside the mobile hunter-gather wetland exploitation evident in the Mesolithic. Finally, the occupation site at Easington spans c4,000-2,500 BC, with a henge monument of late Neolithic/Early Bronze Age date nearby (Brigham *et al.* 2008:122, 175; Selkirk 2006:530). Along with the hearths, pits and postholes, over 650 pottery sherds and 750 worked flints were recovered during excavations (Selkirk 2006:530) and there is a palaeochannel exposed on the foreshore (Brigham and Jobling 2011:69, 96).

3.2.4.4 Within the marine archaeology study area at Barmston there is a concentric ditched enclosure of late Neolithic or early Bronze Age date (NMN 1445312, shown on Figure 3). The site is not securely dated to the Neolithic, but there are also polished axe finds at Fraisethorpe (Brigham *et al.* 2008:55, SMR MHU8970), along with ploughed-out burial mounds at Watermill (now likely lost to erosion (Brigham and Jobling 2011:40)), which together suggests Neolithic activity within the coastal strip. In addition, there is evidence of continuity of activity into the Neolithic at Withow Mere, Skipsea (Brigham *et al.* 2008:67). Withow Gap has evidence interpreted as a Neolithic lake village, perhaps as early as 4,770 BP, including remains of trackways, stakes and worked timbers of early Neolithic date 3,771-3,370 BC (though more recent work has complicated this interpretation) (Murphy 2009:32; NMN 910838).

3.2.4.5 Together, this evidence indicates potential for both in-situ Neolithic remains and Neolithic material in secondary contexts within the intertidal and inshore waters of the marine archaeology study area.

3.2.4.6 As mentioned above, there is also potential for archaeological remains of boats, or associated artefacts such as paddles or fishing equipment, within the marine archaeology study area. Current consensus suggests that Neolithic watercraft are likely to have been skin/hide boats or logboats (McGrail 2001: 172-183; c.f. Mallon, 2005: 17-19) or possibly sewn plank boats (Sturt and Van de Noort 2013:71), though there are no securely dated Neolithic boats from UK contexts (*Op. Cit.*, 69). These boats would have operated within inland, estuarine and sheltered inshore waters. There is also compelling indirect evidence of open water seafaring in the Neolithic (*Op. Cit.*, 71-73; Murphy 2009: 59; Garrow and Sturt 2011). Consequently, there is potential, although unlikely, for surviving remains further offshore, as the Neolithic logboat recovered 1 km offshore from Gormanstown, County Meath, Ireland during pipeline trenching attests (Brady 2002; Mallon 2005: 19). Any Neolithic boat remains or associated artefacts, such as the examples found from Jaywick in Essex (Wilkinson and Murphy 1995:100-104), would be highly significant/important.

3.2.4.7 Finally, it is worth noting that the Maritime Archaeological Research Agenda for England, *People and the Sea*, suggests that evidence for Neolithic (and Early Bronze Age) activity in the north-east tends to be inland at elevations near 100 m OD, reflecting early twentieth century interests and patterns of investigation, and that consequently the relative evidential value of coastal, intertidal or inshore finds 'to a picture which is potentially flawed and imbalanced' is high (Sturt and Van de Noort 2013:59).

3.2.5 Later Prehistory: Bronze Age (2,600 – 700 BC)

3.2.5.1 The potential for extensive submerged landscape deposits in the marine archaeology study area is further diminished by the Bronze Age. Instead, there is potential for in-situ archaeological remains of occupation, farming and coastal, wetland and maritime activities, as well as for secondary deposits and finds eroded from deposits landward of MHWS, in the inshore and intertidal of the marine archaeology study area. There are also a number of notable Bronze Age boat finds in the area which demonstrate the potential preservation of boat remains and associated artefacts in intertidal and inshore sediments.

3.2.5.2 Specifically, there are Bronze Age deposits landward of MHWS (including an occupation site at Barmston), but also Bronze Age material eroding out seaward of MHWS to the south of the marine archaeology study area, most notably at Easington and Kilnsea Beach, which attest to this potential. At Kilnsea, about 30 miles south of the marine archaeology study area, the remains of a Bronze Age boat dated to 1870-1670 BC were found (Van de Noort *et al.* 1999). Therefore, the Humber wetlands have yielded extensive evidence of Bronze Age occupation and activity (Van de Noort and Davies 1993; Van de Noort 2003; Sturt and Van de Noort 2013:59), including the oldest sewn plank boats in Britain, amongst the oldest seagoing vessels in Europe, found at Ferriby in a Bronze Age 'boatyard' (Wright 1990:1-54; Van de Noort 2004:81; Coates 2005:38; Van de Noort 2006).

3.2.5.3 More broadly, the coastal archaeological record confirms Bronze Age activity along the Holderness coast. A key material and cultural shift occurs in the Bronze Age around 1,500 BC. Before this point there are continuities with the Neolithic, and afterwards a commonality until the Roman influence begins to develop in the late Iron Age and early Romano-British period (Ransley *et al.* 2013). Evidence for occupation and activity in the vicinity of the marine archaeology study area falls either side of this change and shows, in particular, a continuity of occupation and activity from the Neolithic into the Bronze Age and beyond at Flamborough Head to the north of the marine archaeology study area and at Easington to the south (Brigham *et al* 2008:35, 122-123).

3.2.5.4 At Flamborough Head, there are a number of Bronze Age monuments including several barrows (one with a beaker burial), as well as a Neolithic-Bronze Age occupation site and an assemblage of Late Bronze Age pottery found (*Op. Cit.*, 40). At Easington, there are Bronze Age barrows (one with a beaker burial), pits and a henge, as well as a Neolithic-Early Bronze Age occupation site on the foreshore (Selkirk 2006:530) and a Late Bronze Age-Iron Age occupation site at Easington Cliff (Brigham *et al* 2008:122-123). Together with further barrows and pits in the vicinity as well as the prehistoric field system which is likely associated and the Kilnsea boat, the evidence attests to Bronze Age exploitation of the wetland habitat (*Op. Cit.*, 124). Between Flamborough and Easington there are a number of Bronze Age monuments, findspots and small assemblages along the coast, including barrows, a bronze bracelet and axes found at Bridlington, finds at Atwick and evidence of activity at Aldborough and Roos (*Op. Cit.*, 43; NMNs 1510522 (shown on Figure 3), 81091, 80999, 81183).

3.2.5.5 Importantly, within the marine archaeology study area at Barmston there is a Middle Bronze Age occupation site constructed on the edge of a mere with a later second phase of Late Bronze Age-Iron Age activity (Van de Noort *et al.* 1995:226–7, 349–52, NMN 80760, shown on Figure 3). The site included timber structures, hearths, ovens, pits, postholes and a cobbled surface (Brigham *et al.* 2008:56). In addition, there are a number of Bronze Age findspots and monuments nearby, including a palstave, Late Bronze Age potsherds (from the cliff face) and a Bronze Age flint assemblage (*Op. Cit.*, 43; NMN 910907, 1551072, 1551027, all shown on Figure 3). There is also a barrow eroding from the cliff (Brigham and Jobling 2011:40) and a number of assemblages interpreted as a Middle Bronze Age-Iron Age occupation site just inland at the mouth of the Earl's Dike (Brigham *et al.* 2008:61).

3.2.5.6 Just to the south, still within the marine archaeology study area, at Ulrome there is a Bronze Age pit containing pottery, bones and flints along with number of casual finds (NMN 910759) and also a possible Middle Bronze Age-Iron Age 'lake dwelling' at Round Hill just inland (*Op. Cit.*, 62-63). At Skipsea a Bronze Age beaker was recovered from near Withow Mere, auroch horns have eroded from the cliff and traces of a possible Bronze Age/Iron Age settlement were found at the mere (*Op. Cit.*, 67; NMNs 80921, 1546041). In addition, Withow Mere has yielded a Bronze Age peat layer (Marsters 2011).

3.2.5.7 Together this evidence suggests significant potential for Bronze Age archaeology in the intertidal section of the marine archaeology study area.

3.2.5.8 There is also potential for the archaeological remains of boats and associated artefacts (such as paddles or fishing equipment) within the marine archaeology study area. Bronze Age logboats and plank boats have been preserved in a number of archaeological contexts around the UK and consensus suggests skin/hide boats would also have been in use (though no archaeological examples survive in the UK) (Sturt and Van de Noort 2013; Hill and Willis 2013; McGrail 2001:174-5; Clark 2002). These boats would have been used in inland, estuarine and sheltered inshore waters. The Ferriby plank boats, for example, likely used in the Humber Estuary itself, as well as in coastal and inshore waters (Van de Noort 2003; Chapman and Chapman 2005; Van de Noort 2006). In addition, the Bronze Age cargo wrecks discovered off the Devon coast (Fenwick and Gale 1998:28-31; Murphy 2009:60) illustrate the ability of mariners to operate offshore and, along with indirect artefactual evidence, suggest Bronze Age maritime trading networks that stretched over substantial areas of open-sea (Cunliffe 2001:255-260; Murphy 2009:60-61).

3.2.5.9 Of the 23 Bronze Age boat finds from England, nine are the remains of plank boats and fourteen of logboats with two additional offshore cargo wrecks (Sturt and Van de Noort 2013; Hill and Willis 2013; Fenwick and Gale 1998; Murrell 2012). Notably, four of the nine plank boat finds have been within the vicinity of the marine archaeology study area (the Kilnsea Beach and Ferriby finds;)and the Kilnsea plank boat remains were discovered eroding from peat deposits in the foreshore (Van de Noort *et al* 1999). In addition, two Bronze Age logboats were reported as discovered in the former mere basin at Withernsea during the eighteenth century (Brigham *et al.* 2008:106).

3.2.5.10 These finds attest to the potential for archaeological remains of boats, and associated artefacts, in the intertidal of the marine archaeology study area, whilst the Bronze Age cargo finds off Devon demonstrate the possibility of boat remains and/or cargo assemblages in marine sediments. Any Bronze Age boat remains or associated artefacts would be highly significant/important.

3.2.6 Later Prehistory: Iron Age (800 BC – AD 43)

3.2.6.1 By the Iron Age sea level change no longer had a significant impact on the geomorphology of the marine archaeology study area, instead coastal erosion was the key driver. The Iron Age coastline would likely have been more than 6 km offshore (based upon the Roman coastlines modelled through proxy indicators as 5.6 km offshore (Boyes *et al.* 2016). The Rapid Coastal Zone Assessment identifies 'extensive traces of Iron Age/Romano-British agricultural settlements, with a highly developed pattern of fields, trackways, drainage ditches and enclosures' along the Holderness coast (Brigham *et al.* 2008:19). Any Iron Age archaeological deposits in the marine archaeology study area are therefore likely to represent the remains of agricultural settlements and activity sites, particularly those drawing on wetland resources. This, together with a number of occupation sites identified landward of MHWS within the marine archaeology study area itself, indicate the potential for secondary Iron Age deposits below MHWS in the marine archaeology study area, as well as the potential for the remains of watercraft and associated artefacts in the marine zone.

3.2.6.2 The coastal archaeological record includes a number of occupation sites along the current coast, along with agricultural features and field systems, but this is complicated by a considerable number of undated prehistoric field systems, enclosures, pits etc are interpreted as Iron Age/Romano-British but are un-investigated. The Yorkshire Archaeological Research Framework suggests low-lying areas are under-represented in the Iron Age archaeological record (Roskams and Whyman 2007:28). This together with the number of casual beach finds eroded from Iron Age deposits in the cliffs, (such as a carved chalk figurine found at Withernsea (*Op. Cit.*, 106) and staters (coins) at Hollym (*Op. Cit.*, 113) highlight the potential for unidentified Iron Age sites along the coast (although any Iron Age remains within the intertidal of the marine archaeology study area are likely to be in secondary contexts).

3.2.6.3 With this in mind, the number of occupation sites identified along the current coast is notable. Broadly, the coastal archaeological record suggests Bridlington became a focus for settlement and a port during this period (*Op. Cit.*, 44-45), whilst a number of features suggest continued activity through the Iron Age and into the Romano-British period at Flamborough Head (*Op. Cit.*, 35-36). Just to the south of the marine archaeology study area at Atwick there is another Iron Age occupation site, a ditched enclosures and gold staters found on the beach (*Op. Cit.*, 72). At Rolston, there is a pit dwelling with assemblage of flint, bones, pottery (*Op. Cit.*, 83) and there is also evidence of continuity of occupation at Easington beach, further south, with traces of Iron Age settlement extending into the Romano-British period (though the sites themselves are now likely eroded) (*Op. Cit.*, 124 -125).

3.2.6.4 More specifically, within the marine archaeology study area, there is continuity of occupation from the Bronze Age through the Iron Age into the Romano-British period at Barmston. The Middle Bronze Age occupation site on the edge of a mere has a later phase of Late Bronze Age-Iron Age activity (Van de Noort *et al* 1995: 226–7, 349–52) and several associated ditch features with Iron Age pottery eroding from the cliff face, along with a significant number of square barrows and probable Late Iron Age enclosures, boundaries, pits and trackways (Brigham *et al.* 2008: 56; NMNs 1546593; 1551059; 1551075, as shown on Figure 3).

3.2.6.5 In addition, just inland at the mouth of the Earl's Dike a number of assemblages are interpreted as a Middle Bronze Age-Iron Age occupation site (*Op. Cit.*, 61) and to the south at Watermill Grounds, are several centres of activity and a considerable number of features, enclosures, ditches and even possible buildings representing an extensive former Iron Age/Romano-British landscape (*Op. Cit.*, 57). Whilst just inland at Ulrome there is a probably Middle Bronze Age-Iron Age 'lake dwelling' at Round Hill (*Op. Cit.*, 62-63) and on the coast at Ulrome there are a number of ditches and enclosures which, along with finds including pits and ditches with coins, pottery and bone assemblages and a gold stater recovered from the cliff, suggest Iron Age settlement continuing into Romano-British period (*Op. Cit.*, 62-63; NMNs 1546940; 1551022; 1546627- shown on Figure 3).

3.2.6.6 The likely scale of activity in this Iron Age landscape, and therefore the level of potential for Iron Age archaeology in the marine archaeology study area, is difficult to determine because many of the features are undated and denoted simply as 'prehistoric', but given the Yorkshire Archaeological Research Framework identifies low-lying areas as under-represented in the archaeological record (Roskams and Whyman 2007:28), the relative evidential value of Iron Age finds is high.

3.2.6.7 There is also potential for the archaeological remains of ships or boats, and their associated artefacts, to be found within the marine archaeology study area. Seafaring and maritime connections with Europe became more prominent through this period. During the early Iron Age, the exchange of metals and resources as well as objects around the coast and across the Channel and southern North Sea reflects Bronze Age trading patterns. By the Late Iron Age this exchange and interconnectedness becomes more prominent, reflecting the material and cultural shift that takes place from the Middle Iron Age including increasing Roman influences (Hill and Willis 2013:87). Evidence, such as the adoption of coinage in North Europe and the UK at similar times (Haselgrove 1993), is interpreted as reflecting commercially, politically and culturally interdependent communities (Willis 1994; Hill and Willis 2013:89). There is even evidence of developing cosmological connections to the sea with the development of coastal shrines (Hill and Willis 2013:91). Notably, only about 25 miles south of the marine archaeology study area just north of Withernsea, the Roos Carr figures and boat model (c.600 BC) were found (Coles 1990). This nationally-important maritime find is interpreted as a votive offering and reflects the importance of boats and water to the early Iron Age communities of Holderness.

3.2.6.8 There is significant indirect evidence for seaborne trade and travel, as noted above, but there is virtually no primary evidence of seagoing boats or ships in the UK from the period (Hill and Willis 2013:83). Primary evidence of Iron Age boats come from inland, riverine or estuarine contexts, including a number of logboats and some sewn boat fragments, including the Hasholme logboat (Millet and McGrail 1987) and Iron Age sewn boat fragments found at Ferriby both in the vicinity of the marine archaeology study area (Hill and Willis 2013:83-85). The sparse primary evidence available has in the past been interpreted as suggesting the sewn-plank boats of Bronze Age were replaced at some point during the Iron Age with the hull-first vessels with fixed iron nails of the Romano-Celtic tradition which are in evidence at the end of the Iron Age and into the Romano-British period (Hill and Willis 2013:87). More recently, consensus suggests a plurality of watercraft were likely present, including logboats, skin/hide boats, sewn boats and the heavier Romano-Celtic iron-nailed boats (*ibid.*), and potentially even visiting Greco-Roman vessels from the Mediterranean (see Boon 1977; Cowell 2007: 382). Given the rarity of Iron Age boat or ship finds from the Iron Age, any boat remains or associated artefacts found within the marine archaeology study area would be high importance/significance.

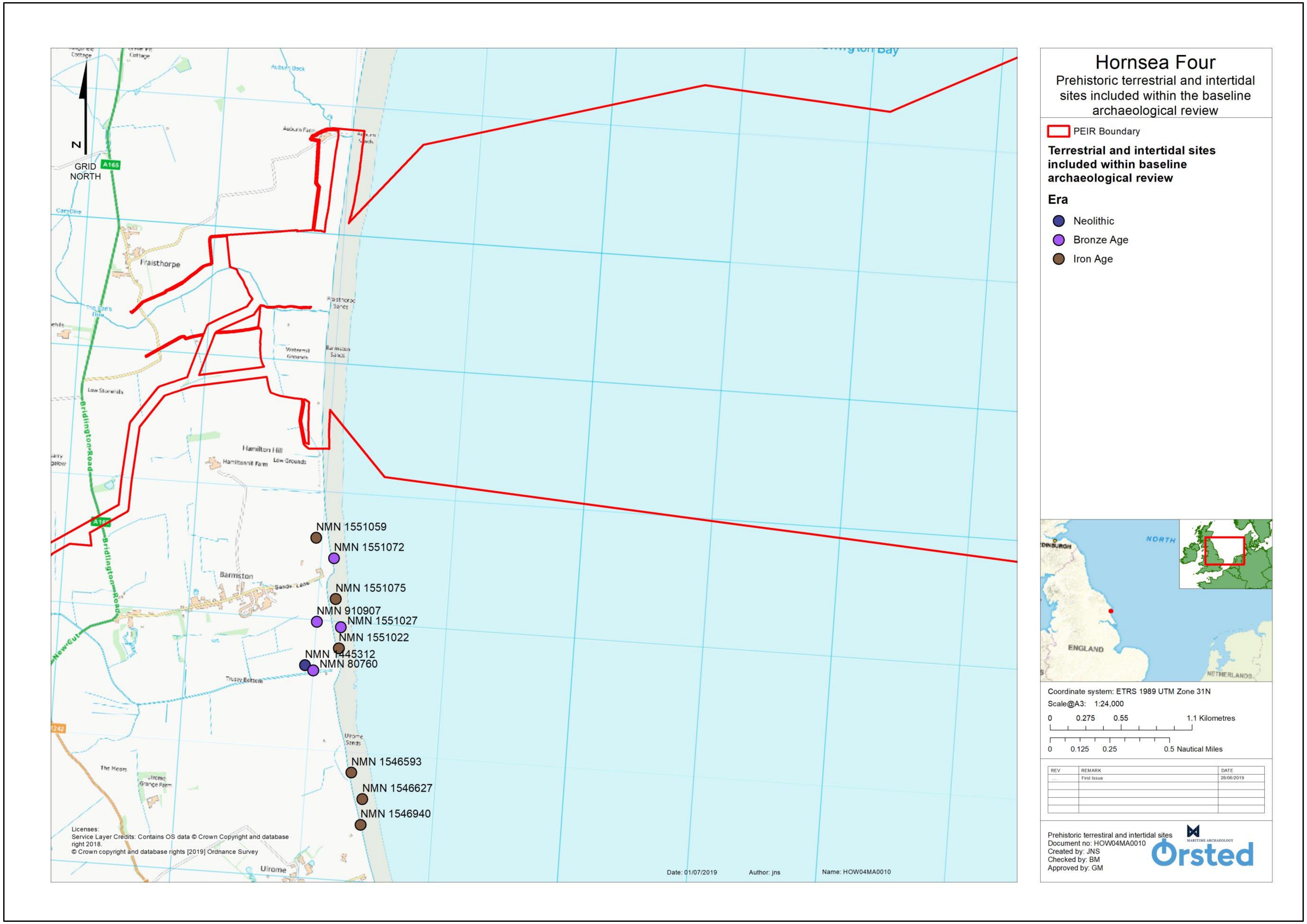

Figure 3: Terrestrial and intertidal Neolithic, Bronze Age and Iron Age sites included within the baseline archaeological review (not to scale).

3.2.7 Romano-British (AD 43 – AD 400)

3.2.7.1 The Roman coastline has been modelled by a number of scholars using proxy indicators as about 5.6 km offshore from the current coastline (Boyes *et al.* 2016) and evidence suggests there was, broadly, continuity of settlement and activity in the Holderness area from the Iron age into the Romano-British period. The Rapid Coastal Zone Assessment (RCZA) characterises the Iron Age archaeology of the Holderness coast as 'extensive traces of Iron Age/Romano-British agricultural settlements, with a highly developed pattern of fields, trackways, drainage ditches and enclosures' (Brigham *et al.* 2008:19). Due to the level of activity in this area during this period, and because of the extensive erosion since later prehistory through to the modern day, secondary deposits of Romano-British material seaward of MHWS in the marine archaeology study area are possible. These are likely to be small, casual finds such as coins. There is also a potential for the remains of watercraft and associated artefacts in the marine zone as the port of Bridlington continued to be used. A Roman road, running from York to Bridlington, suggests that the port and surrounding area may have seen the shipping of people and supplies, as well as being integrated with military and political activity in the region.

3.2.7.2 The broad pattern of maritime activity reflects the AD 43 Roman conquest on the south coast, but also marks the beginning of a period when the burgeoning Roman influence on indigenous Iron Age culture increases, creating a blend between evidence of Iron Age settlement and activity and the remains of Roman military and political infrastructure. As the period progresses, a distinctive Romano-British signature, the result of these two cultures interacting, appears, and is marked in increased urbanisation, changing religious practices and mortuary behaviours, and changing hinterland relations, particularly from AD 200 onwards (Roskams 1999). To the north of the marine archaeology study area, an extensive series of signal stations was built along the coast in the 4th century, at a time when the north of England was being invaded by Saxons from across the sea, and Pictish tribes from the north (Hornsby and Laverick 1932). These stations are evidence of a tumultuous time, when the coast became a defensive line.

3.2.7.3 Due to erosion, the coastal archaeological record represents mostly terrestrial remains, and shows a number of undated prehistoric field systems, enclosures, and other features which are likely attributed to the Iron Age or Romano-British period, but are as of yet uninvestigated. These include a significant number at Barnaby, just north of the marine archaeology study area; this area includes features eroding from the cliff edge which could reflect a later Roman settlement, and a 4th century 'signal station type' pottery find on the beach (Brigham *et al.* 2003:51-52). In addition, there have been several beach finds of Roman coins which have likely also eroded out from the cliffs.

3.2.7.4 Bridlington was the main focus for Romano-British settlement in the area, with the port servicing the town likely to be 1-2 km east of the present harbour given the dramatic level of coastal change. In the town itself, there are traces of occupation including an urn and a female skeleton with a bronze armlet. A possible Roman camp was previously noted to the north in the Sewerby area, on the edge of a cliff, though this has since been lost to erosion. A number of finds, pits, and features suggesting small-scale industry have been discovered between the village and Danes Dyke.

3.2.7.5 Moving south, into the marine archaeology study area, there are a considerable number of features – enclosures, ditches, and cropmarks possibly relating to buildings – which are likely to be late Iron Age or Romano-British. To the south of The Earl's Dike at Watermill Grounds, there are several areas of activity which represent an extensive landscape of enclosures, pits, ditches, and trackways (NMN 1446482, shown on Figure 4). To the north of Barmston Beach Caravan Park there is also a substantial trackway cropmark of approximately 100 m in length (SMR MHU334, also shown on Figure 4), and a little further south and extending to the cliff edge, there is a possible settlement site. Small finds from the Barmston parish include Roman coins, the 4th century Signal Station type pottery (SMR MHU3141, marked on Figure 4), and other pottery fragments. A coin hoard was discovered in Auburn in 1571, with coins dating between AD 69 and AD 161 (NMN 81268, also on **Figure 4**).

3.2.7.6 Continuing south along the coast to Ulrome, there appears to be a continuation of activity from the late Iron Age, with a probable pit and contemporary pottery at the Seaside Caravan Park (SMR MHU15809 and EHU269, as shown on **Figure 4**), and a bronze pin find from the beach in the same area (SMR MHU17703, also on **Figure 4**). Three more coin hoards were discovered in this area: one to the south-east of the caravan park, and two unprovenanced finds from the early 20th century and also 1969, dating from AD 293 – AD 408 and AD 69 – AD 180 respectively (SMRs MHU4523 (shown on **Figure 4**), MHU18616, MHU18617). To the north of Ulrome, a ditch and Romano-British pottery were recorded on the cliff (NMN 1444940).

3.2.7.7 To the south of the marine archaeology study area, the next evidence for Romano-British activity is at Atwick, where a likely Iron Age occupation site extends into the Romano-British era, with more traces of a late Roman settlement in Hornsea (Brigham *et al.* 2008). Other centres of activity to the south have been found at Rolston Cliff, Aldrough, Withernsea, and Easington, which generally constitute collections of small finds. There may be a higher likelihood of small finds to the south of the marine archaeology study area as much of the eroding material is ultimately carried south by wave and tidal action (East Riding of Yorkshire Council, 2006).

3.2.7.8 The archaeological remains of ships or boats, and their associated artefacts, are possible within the marine archaeology study area, especially given the proximity to the port at Bridlington. The presence of Mediterranean goods (pottery and coins in particular) and the local ports indicate maritime activity was occurring, although no Roman ships or boats have thus far been found in the region, or indeed the UK (barring three abandoned hulks in London, Wales, and Ireland). Despite this lack of shipwreck evidence, maritime activity during the Romano-British period is otherwise clearly documented and extensive, and a range of vessel types would have been used to facilitate activity, from ocean-going merchant craft to estuarine and riverine craft (McGrail 2001). Later, documented sea-borne raids by the Saxons towards the end of the Romano-British period, as well as the 4th century signal stations in the area, indicate continued frequency of maritime activity, all of which raises the possibility of watercraft within the marine archaeology study area. Any such discovery would be of high significance / importance.

3.2.8 Early Medieval / Anglo-Saxon (AD 400 – 1000)

3.2.8.1 With relative sea levels stable during this period, there is no likelihood of extensive submerged landscapes. Instead there is potential for archaeological remains of watercraft in the seabed or intertidal zone, and archaeological remains of early medieval occupation and coastal activity in the intertidal and near shore, though the latter is likely to be eroding or found in secondary contexts seaward of MHWS.

3.2.8.2 Notably, throughout the early medieval period the marine archaeology study area was within a key sphere of maritime activity within the wider northern European region. The broad pattern of maritime activity shifted during the period to a focus on connections across the southern North Sea and eastern Channel towards the Nordic world and northern Europe (Ransley *et al.* 2013). The Holderness coast was part of the Anglo-Saxon kingdom of Northumbria from the seventh century (c. 600) (Murphy 2009) and was positioned within this focus of maritime activity. In addition, it would have experienced pressure from Viking raiders from the late eighth century (c.790) and from the mid-ninth to mid-tenth century (c.857-964) from the northern Viking kingdom or 'Danelaw' area just to the north. To the south of the marine archaeology study area, there are the important late sixth-early seventh century Sutton Hoo and Snape ship burials in Suffolk, which reflect the maritime focus of communities during this period.

3.2.8.3 More specifically, Holderness's coastal archaeological record indicates coastal settlement and maritime activity throughout the period. Recent work in the region suggests that maritime connections and trading between the seventh and tenth century was not limited to the well-known wics (ports or trading sites often riverine), as previously thought, but was also part of coastal life (Loveluck 2012; Loveluck *et al.* 2013: 116-122). Loveluck references the Holderness sites of Flamborough, Sewerby, Bridlington, Aldbrough and Easington in this work (Loveluck *et al.* 2013:117-119) and highlights the potential for landing places, beach markets and interactions with traders moored along the coast or in the Humber Estuary. However, the Rapid Coastal Zone Assessment identifies Early Medieval archaeology is under-represented due to a combination of continued development on sites during later periods and the impacts of coastal erosion (Brigham *et al.* 2008:45; see also the Yorkshire Archaeological Research Framework, Roskams and Whyman 2007:32). So, despite this activity the coastal archaeological record for the period is sparse.

3.2.8.4 Just to the north of the marine archaeology study area, Bridlington continued to be a focus of settlement and port activity during the period, though the Early Medieval quay is largely lost and archaeology of the period is poorly represented (Brigham *et al.* 2008:45). A fifth to early seventh century inhumation cemetery still survives, although the Anglo-Saxon 'satellite' villages of Hilderthorpe and Wilsthorpe have been lost to coastal erosion (*Op. Cit.*). Hornsea, just to the south of the marine archaeology study area, was an important market centre originally located some distance from the sea. Its coastal partners, Hornsea Beck and Hornsea Burton, are now lost to coastal erosion (*Op. Cit.*, 76). The sixth century Anglo-Saxon cemetery at Hornsea (Head 1997), along with a handful of casual finds, suggest a substantial presence in the eastern part of the present town (*Op. Cit.*, 77). Further south there is an Anglo-Saxon burial at Aldbrough, which along with Withernsea and Easington has Early Medieval origins, though much of present Withernsea is nineteenth century with the original lost to coastal erosion (*Op. Cit.*, 89, 106, 125).

3.2.8.5 Within the marine archaeology study area itself, Barmston, Fraisthorpe and Ulrome appear in the Domesday book and were certainly Early Medieval settlements, along with the lost villages of Hartburn and Auburn, but the only known archaeological remains in the area is an Anglo-Saxon burial (*Op. Cit.*, 57-58, NMN 1189332).

3.2.8.6 Therefore, although evidence suggests potential for agricultural settlement in the coastal strip and a variety of maritime activity, coastal erosion means that *in-situ* evidence of settlements, landing places or beach markets, etc, is very unlikely, with some potential for secondary contexts eroding from deposits landwards of MHWS remaining. Similarly, *in-situ* evidence for coastal maritime activity common to the period and region (such as sea fisheries, iron-smithing and wildfowling (Crowson *et al.* 2005) is unlikely seaward of MHWS.

3.2.8.7 There remains potential for the archaeological remains of ships or boats, and their associated artefacts, to be found within the marine archaeology study area. The discovery of the ship or boat remains from this period has been exceptionally rare (Loveluck *et al.* 2013:125), with no identified remains from maritime contexts. However, finds from riverine, estuarine and burial deposits are useful in characterising the potential archaeological resource. The Welham Bridge logboat, dated to sixth century and found at a riverine landing place excavated at Welham Bridge, East Riding (Allen and Dean 2005:91-3), along with other UK examples including the Langstone and Hamble River logboats, dated sixth and seventh century respectively (Loveluck *et al* 2013:126; Whitewright 2010), reflect the kinds of small craft which would have likely been involved in coastal and riverine dispersal of goods. Seagoing, merchant vessels were likely clench-nailed, clinker-built vessels of the Nordic tradition (McGrail 2001:207-223). The late sixth-early seventh century ship and boat burials at Sutton Hoo and Snape in Suffolk reflect this construction (Carver 2005; Filmer-Sankey and Pestell 2001), as does the mid-tenth century Graveney boat, found in Kent (Fenwick 1978). Given the rarity of such finds, the remains of any vessels, or associated artefacts, found within the marine archaeology study area would be significant/important.

3.2.9 Medieval (1000 – 1550)

3.2.9.1 As in other periods since late prehistory, erosion is a key factor in this area. Assuming a rate of erosion equivalent to that of today (1.5 m – 2.5 m a year), the coastline during this period could be between approximately 2.5 km and 1.5 km offshore from the current coastline (East Riding of Yorkshire Council 2019). While there is no likelihood of extensive submerged landscapes, there is a high potential for archaeological remains of occupation, coastal activity, and watercraft within the marine archaeology study area.

3.2.9.2 During the 'high' medieval period (lasting from approximately 1000 AD to 1250 AD) there is a shift in the broad pattern of maritime activity from the Nordic world and northern Europe to a focus on relations within the British Isles, in addition to the urbanisation and development of ports. The evolution of nation states across Europe during this time is reflected in a more European maritime outlook (Ransley et al. 2013). Maritime trade and warfare were supported by considerable fleets, from small vessels to large war galleys. There is more surviving evidence from this period, including documentary evidence and physical remains; known wrecks, however, date from 1400s onwards (Historic England 2016a).

3.2.9.3 It is during this period that we also see fledgling global connections – in this area, twice-yearly visits from 'esterlings' (or easterners) trading pepper from Indonesia and the

Malabar coast (Keay 2006:108). Towards the end of the early Medieval period, from the 10th century, there is a shift from wics (a network of maritime trading centres) and local, coastal landing places, to a focus of maritime connections and trade in major port towns (Loveluck *et al.* 2013:120).

3.2.9.4 The coastal archaeological record within the marine archaeology study area has been impacted by the rapid erosion of the coastline and a notable increase in storm surges between c.1300-1500 AD in the North Sea region; the nature of coastal and maritime activity would have adapted in response (Long *et al*. 1998). As with the Early Medieval period, the high Medieval period has been identified in the Rapid Coastal Zone Assessment as under-represented due to the impact of coastal erosion and later development.

3.2.9.5 To the north of the marine archaeology study area, Bridlington continued to be a centre of settlement and maritime activity; the port and harbour were granted to the Augustinian Bridlington Priory by King Stephen in 1135, which then became Bridlington Quay, a separate entity from the main town. A road, since lost, ran between Bridlington and Auburn (SMR MHU14857, shown on Figure 3). Wilsthorpe, with a number of sunken trackways, fields, earthworks and ditches, marks the western and southern limits of a more extensive settlement which has now also been lost to the sea.

3.2.9.6 Within the marine archaeology study area, remains of ridge and furrow ploughing systems are visible landward of MHWS at Barmston, Ulrome and Skipsea, but these have not been specifically dated to this era (NHRE monument numbers 1446399; 1445415; 1445422). Casual finds include: a spindle whorl found on the beach south of Bridlington; a coin, wall, and pottery from near Auburn village. Of the village itself, most remains have been destroyed by erosion, but as of 2009, the remains of St Nicholas Chapel are still visible as an earthwork (NMN 81264, shown on **Figure 4**). These remains are the second iteration of the church, the first having been taken down in 1590 due to its proximity to the sea, and rebuilt inland (Allison, 1974). South of Auburn is the deserted medieval village of Hartburn, which was likely abandoned in the 15th century, but nothing of it now remains.

3.2.9.7 In the south of the marine archaeology study area, Cleeton was the main settlement of significance up until the 11th or 12th century. Shortly after the Norman Conquest, a motte-and-bailey castle was built near the village of Skipsea, which in turn encouraged a town to develop nearby. Cleeton became less important after this development; it is supposed to have stood approximately a mile south east of Skipsea village, but has been lost to the sea (Allison 1974). Skipsea castle was demolished in the 14th century, though a large mound over an infilled mere is still extant (Brigham *et al.* 2008).

3.2.9.8 To the south of the marine archaeology study area, the hamlet of Hornsea Beck to the east of Hornsea was recorded as early as 1367, but was completely taken by coastal erosion by 1747.

3.2.9.9 There is potential for archaeological remains of ships or boats, and associated remains from this period, to be found within the marine archaeology study area. Though no known wrecks exist in this period until the 14th century, extensive documentary evidence and isolated vessel-related finds (e.g. a 13th century steerboard from Rye Bay, and hull planks from a 13th century vessel from Parliament Square, London) indicate the types of vessels operating during the era. They would have been primarily clinker-built, but there was a larger variance in the type of vessels than in earlier periods; the establishment of the mercantile Hanseatic League in 1158 necessitated bigger ships as trade expanded, and very large vessels were built in the keel technique. Cog, hulk, and keel-type ships were also evident, though the distinctions between them were becoming blurred by the 14th century (Historic England 2016a). From the late 13th century, carvel-built vessels began to appear in southern Europe; in northern England, ports would have seen regular visits from Mediterranean merchants with these types of vessels. It is not until the latter half of the 15th century that carvel-built vessels were constructed in England. Wreck and hulk evidence for vessels from this period is still very rare, so any discoveries of vessels or associated artefacts within the marine archaeology study area would be important and significant.

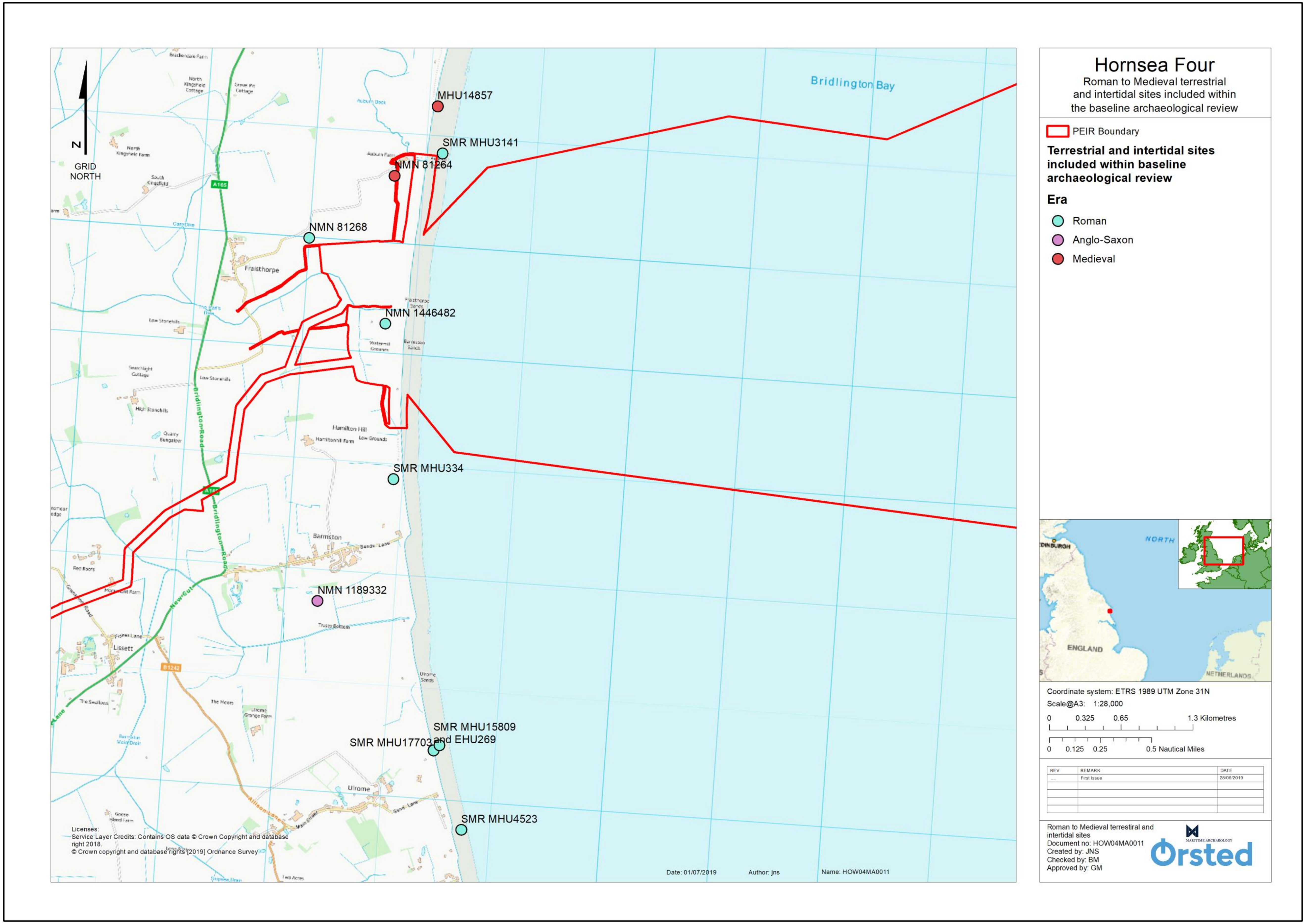

Figure 4: Terrestrial and intertidal Roman, Anglo Saxon and Medieval sites included within the bassline archaeological review (not to scale).

3.2.10 Post Medieval (1550-1900): Tudor (1485 – 1603), Stuart (1603 – 1714), Hanover (1714 – 1837), Victorian (1837 – 1901)

3.2.10.1 During the Post Medieval to Victorian periods, the character of the wider East Riding region changes to an emphasis on industry. This had a significant impact on the nature and scale of maritime activity at sea and in the intertidal zone of the county; on the Holderness coast, this involved a diversion from agriculture and a change to coastal resorts and commuter towns serving the area's larger settlements (Allison *et al.* 2002). As in previous periods, potential nearshore remains are likely to be found in eroding or secondary contexts due to the continued heavy coastal erosion, while potential for remains of watercraft in the offshore zone is increased above earlier periods.

3.2.10.2 The broad pattern of maritime activity sees two key shifts within this period. By the time of the Tudors, the idea of 'maritime England' has symbolic, mercantile, and military importance, and then from the mid-seventeenth century this grows into a global and colonial maritime enterprise. There was a huge expansion in trans-oceanic voyaging, in the number of merchant vessels in operation, and in the size of the navy. In the 1500s, there were numerous vessels setting out to explore the world; some of these voyages resulted in the creation of trading companies such as the Muscovy company, and the Honourable East India Company, whose trade still leaves a legacy today.

3.2.10.3 The second key shift begins in the mid-nineteenth century with a gradual move from sailing to steam ships. The first successful steamship ran trials in 1801;by the 1870s, the tripled expansion engine had been introduced, which meant steam-powered vessels became suitable for long-distance routes (Royal Museums Greenwich 2019). By the end of the 19th century, steam-powered vessels had overtaken sail, though sailing ships were still employed in many instances, particularly coastal trade and pleasure trips (Historic England 2016b).

3.2.10.4 The coastal archaeological record for this period is dominated by patterns of enclosures and ridge and furrow systems across the whole marine archaeology study area; these were associated with the villages both extant and since lost to erosion.

3.2.10.5 To the north of the marine archaeology study area, Bridlington Quay expanded during the post-medieval period, and there are numerous post-medieval buildings in Bridlington and Sewerby. At the Quay, two stone-filled timber piers were built by 1560, and though they were rebuilt several times, nothing now survives of these or any other harbour installations from this era. Similarly, to the north of the harbour, an artillery fort was built in the mid-17th century, but this was demolished by 1748 with no visible remains left today.

3.2.10.6 Erosion remained a problem for coastal communities here during this period: the chapel at Auburn, already in its second iteration after being moved inland in the 16th century, was finally dismantled in 1731 before it shared the same fate as the rest of the village (Sheehan and Whellan 1856). In the south of the marine archaeology study area, Withow Mere was also a victim of erosion, likely having become little more than a seasonally flooded hollow by the 16th century before being entirely breached by the sea in the late 17th century (Brigham *et al.* 2008).

3.2.10.7 In Ulrome there are a few extant buildings from the 19th century: at the end of Sand Lane, there are coastguard houses, built in 1890 to replace an earlier one to the east which has been built in 1829, and a possible 19th century farmhouse at Cliff Top Farm. The area of the farm is on the cliff edge and in imminent danger of collapse (Brigham *et al.* 2008). To the south of the marine archaeology study area, there were several more villages lost to erosion: Ringborough, of which by the 19th century only a farm remains; Great Colden (Cowden), which lay between Hornsea and Mappleton, was mapped in c.1850 but lost by the mid-20th century.

3.2.10.8 There is a high probability for archaeological remains of ships or boats from this period within the marine archaeology study area. Five post-medieval wrecks, though located outside the PEIR boundary, are within the marine archaeology study area. These are summarised in **Table 3** and illustrated on **Figure 6**.There are also several wrecks of unknown name and date, both dead and live – these are discussed further in **Section 3.3**.

Table 3: Post-medieval wrecks within the marine archaeology study area.

Name	Year of Loss	UKHO Status
Little Nell	1872	Live
Salacia	1897	Live
Flirt	1897	Live
Cumberland	1890	Dead
Adventure	1882	Dead

3.2.10.9 To the north of the marine archaeology study area, there is a protected wreck site at Filey Bay. This is likely to be the wreck of the Bonhomme Richard, an American privateer which foundered after a gun battle with HMS *Serapis* in 1779 (Wessex Archaeology 2007). Vessels from this period vary greatly in type, construction and use. Any discoveries of vessels or associated artefacts, particularly from the earlier half of this period would be significant because of their rarity.

3.2.11 Modern (1900-Present)

3.2.11.1 Coastal erosion still impacts the Holderness coast during the modern era; many sites, particularly from the World Wars, are in the process of being lost to the sea. Intertidal remains are present and likely, though may occur in secondary contexts due to the effects of sedimentary erosion. There is a high potential for archaeological remains of watercraft on the seabed and in the intertidal area.

3.2.11.2 The broad pattern of maritime activity since the beginning of the 20th century has been deeply impacted by technological development. Both World Wars drove development at a rapid pace: sonar, radio, and weaponry, and new types of vessels such as submarines and battlecruisers all grew from wartime necessity. These, along with innovation in energy technologies and the opening up of overseas labour markets, have led to increasing globalisation and containerisation of maritime trade, and a transformation of port and coastal infrastructure to support it. Smaller ports have gone into decline or changed focus to serve the leisure industry while trade focuses in on larger regional centres which have become progressively more industrialised (Corbett and Winebrake 2008).

3.2.11.3 With the development of large passenger aircraft in the mid-1900s, the primary method of intercontinental travel switched from ships to planes. The ocean liners of the previous century were phased out in favour of cruise ships. The size of vessels is ever increasing: one of the largest modern cruise ships, the *Symphony of the Seas*, has a gross tonnage of over 4.5 times more than its ancestor the *Titanic,* itself one of the largest ships of the modern period.

3.2.11.4 The coastal archaeological record for this period is dominated by World War defences. To the north of the PEIR boundary, Bridlington underwent extensive urbanisation during the 20th century; the harbour was also substantially rebuilt at this time. Immediately after the Second World War, many defences were removed in order to restore the local holiday trade which greatly reduced the present extent of such material. There are, however, a cluster of surviving features to the south-east of Carnaby and running down the coast towards Barmston, including a series of trenches, possible buildings, a barbed wire compound and several pillboxes on top of Wilsthorpe Cliff (NMN 1446409). There are also several anti-tank cubes, though these have often been moved or slipped from their primary context as the cliff has eroded. These features are show on **Figure 5**.

3.2.11.5 Just to the north of the PEIR boundary, the area of Auburn Sands was strategically important to Bridlington's Second World War defences: there are concentrations of features here. These include: a pillbox and heavy machine gun emplacement (NMN 1418845); two pillboxes at 100 m intervals to the north and 3 similarly spaced to the south (SMRs MHU9986, MHU9985, MHU9983, MHU9982, MHU9981).

3.2.11.6 Within the PEIR boundary, below (or very close to) MHWS, there are numerous features stretching from the beach below Aurbun Farm to the north edge of Ulrome Sands, though many of these are no longer in-situ due to coastal erosion. These all date to the Second World War, and are also shown on **Figure 5**. From north to south:

- An anti-tank wall and twin machine gun emplacements (NMN 1429775);
- Two possible beach defence lights (NMN 1418860 and 1446436);
- Anti-tank defences and a minefield extending along the beach (NMN 1446399);
- A pillbox designed to house a 6-pounder quick-firing gun (RCZA BA119);
- Anti-tank cubes (RCZA BA 183);
- A pillbox (RCZA BA186);
- A pillbox (NMN 1446479);
- Searchlight battery and associated buildings (NMN 1446447);
- Weapons pits (NMN 1446451);
- Military buildings (NMN 1446454);
- Beach defence light (RCZA BA193);
- Pillbox and surrounding barbed wire obstructions (NMN 1446456);
- Pillbox (RCZA BA187);
- Barbed wire obstructions and trackways (NMN 1445152);
- Anti-tank cubes (NMN 1445209);
- Anti-tank cubes (NMN 1445214);
- Pillbox (SMR MHU9988); and
- Anti-tank cubes (NMN 1445233).

3.2.11.7 To the south of PEIR boundary, but within the marine archaeology study area, there is a similar distribution pattern. At Spurn Head, there is a Second World War observation post (NMN 1429773).

3.2.11.8 There are known archaeological remains of ships or boats within the marine archaeology study area for this era, and the potential for more yet to be found. Vessels from this period range hugely in type, size, and use, though there is a bias towards vessels lost in the World Wars due to the sheer number of losses resulting from these conflicts. Any discoveries of vessels or associated artefacts may be of archaeological significance.

3.2.11.9 There are a total of 25 known wrecks or obstructions within the PEIR boundary recorded by the UKHO (**Figure 6**).

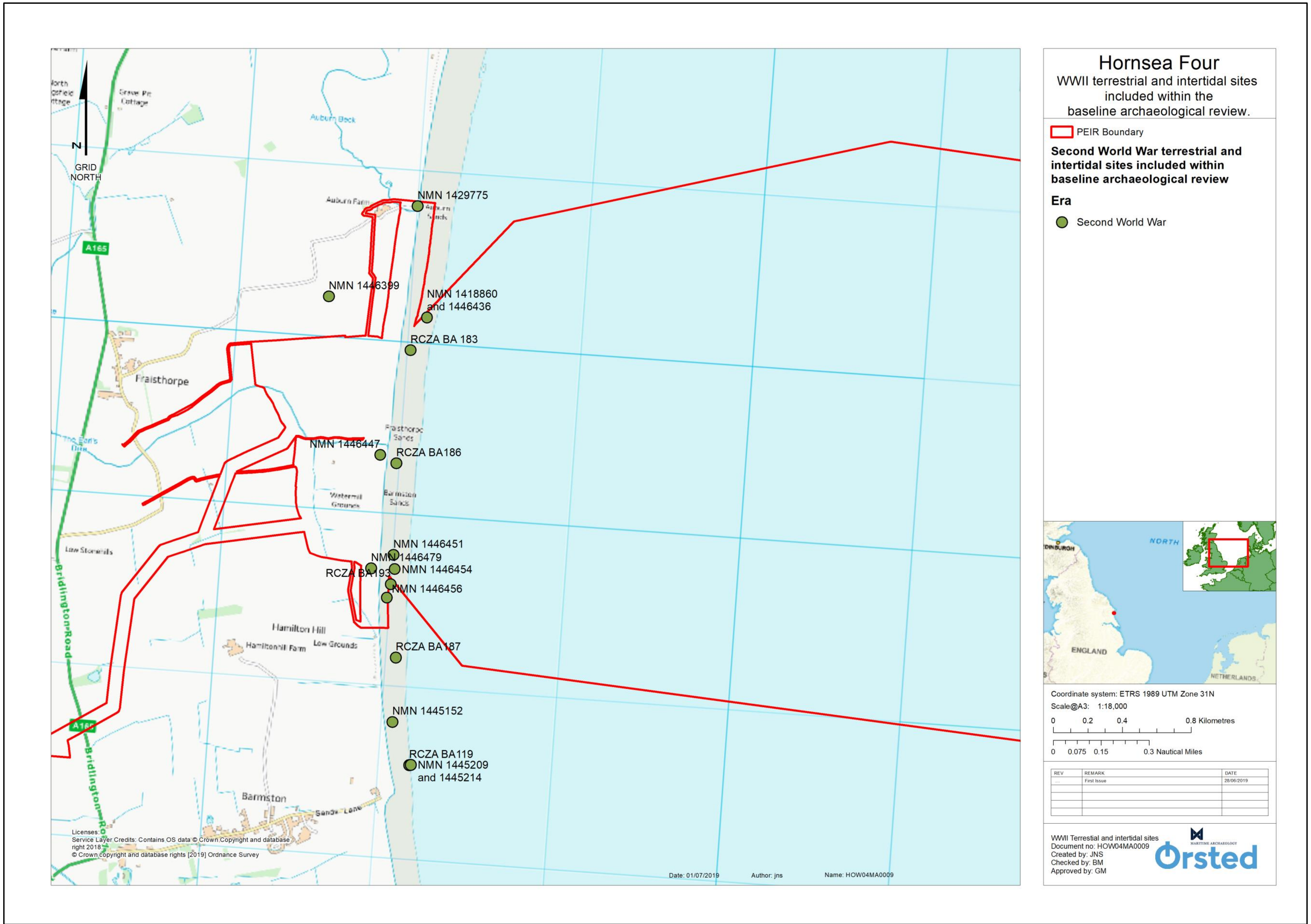

Figure 5: Second World War terrestrial and intertidal sites (not to scale).

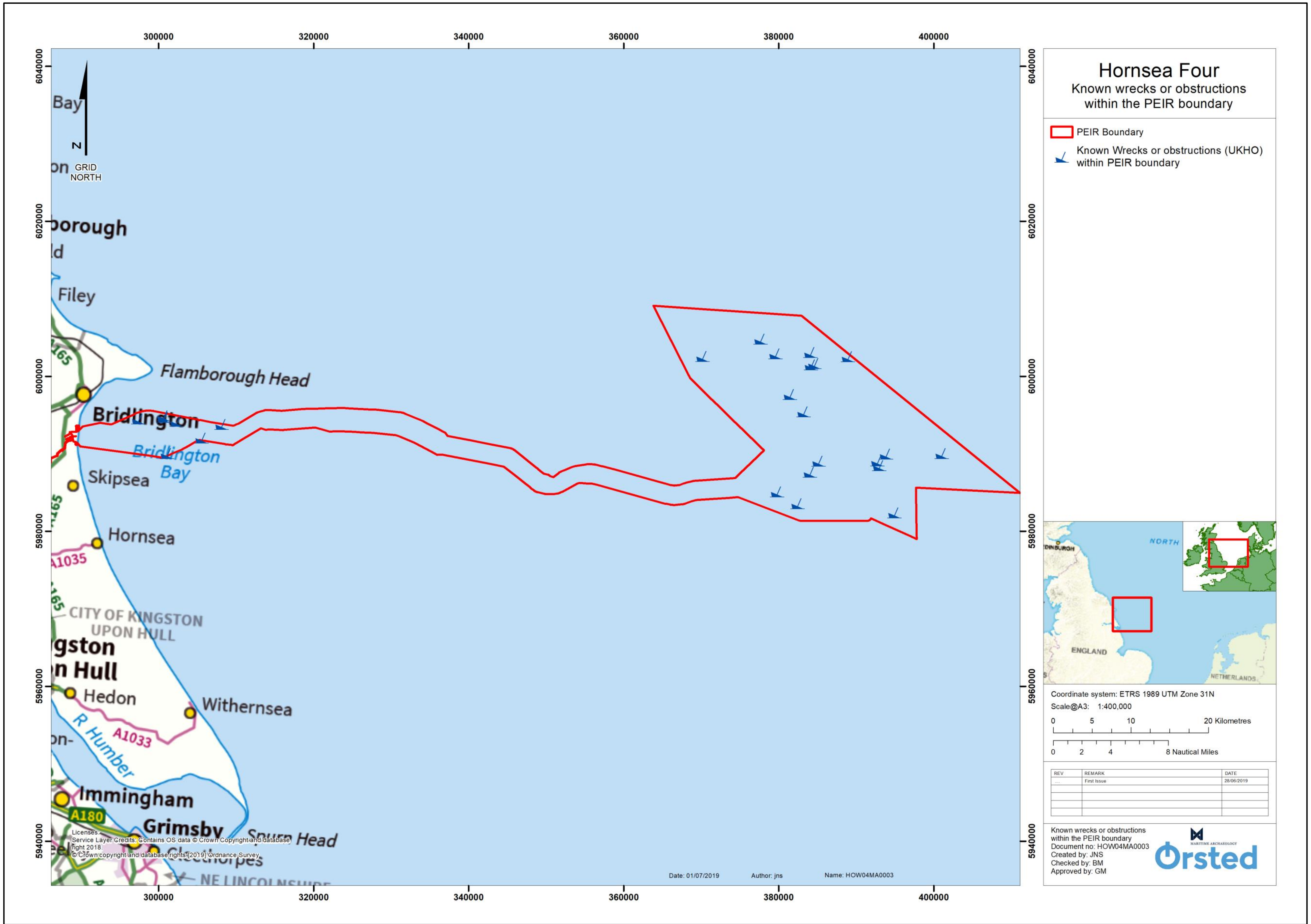

Figure 6: Locations of known wrecks or obstructions within the PEIR boundary (not to scale).

3.2.11.10 There is one known vessel within the PEIR boundary with a UKHO record and corresponding geophysical contact (MSDS_HOW04_2019_ARCH_0224): the 1940 wreck of the *Lapwing*. A British steam-powered trawler, the *Lapwing* measured 35.1 x 6.1 m and was built in 1904. The vessel struck a mine on 6th June 1940 and sank with no lives lost. The geophysical contact for this vessel is discussed in **Section 4.1.5.5,** and its significance in **Section 3.3.8**.

3.2.11.11 Within the marine archaeology study area, there are several known wrecks beyond that discussed above which have not been covered by geophysical survey. As shown on **Figure 7**, these are:

- *Brabant* (UKHO 5807): A Norwegian steam ship sunk in 1917 after a collision with a mine. This wreck was last located with ~3 m accuracy in 2011 as lying at 096/276 degrees and measuring 58 m long, 19 m wide, and 5 m tall. At this time, only the stern section and two boilers show;
- *Nitedal* (UKHO 6493): A Norwegian cargo vessel torpedoed by a German submarine in 1917. Surveyed in 2016, the site measured 85.4 x 30.8 x 5.7 m (length, width, height), lying at a depth of 43 m and with a strong magnetic anomaly. Initially misidentified, the wreck was positively identified by the discovery of a bell with its previous name, *Hero*;
- *Biesbosch* (UKHO 5808): A Belgian steamship lost in 1923 after foundering due to a leak. Surveyed to within 40 m-100 m accuracy in 1980 and showing a site 57 m x 16 m, and 4.9 m tall, looking to be somewhat broken but generally intact;
- *Feltre* (UKHO 6470): An Italian steamer lost in 1917. Originally built in Germany as the *Rhenania*, this vessel was torpedoed by a German submarine. Last examined in 2016, with a location accuracy of 40 m-100 m, this wreck was associated with a strong magnetic anomaly. The site was measured at 135.4 m x 34.2 m, and 11.3 m high;
- *Resercho* (UKHO 6586): A British fishing trawler lost in 1939 after collision with a mine. The reported location of this wreck is unreliable, so it may fall outside of the marine archaeology study area. This wreck is currently listed as dead; and
- *Syrian* (UKHO 6741): A British steam trawler lost in 1915 by shelling from a German submarine. Last surveyed in 1986 with location accuracy of up 40 m-100 m, the site was measured at 42 m x 11 m, with a height of 2.7 m. At this time, it is reported to have been intact but lying at the foot of a sand wave.

3.2.11.12 Outside of the PEIR boundary, but within the geophysical dataset there are two known wrecks, also shown on **Figure 7**:

- *Tors* (UKHO 9363): A British fishing trawler sunk in 1915 after collision with a mine. Last surveyed in 1986 with a location accuracy of 40 m-100 m, the site was measured to be 5 m x 4 m, with a height of 1.2 m. It should be noted that this vessel's reported location is approximately 620 m from geophysical contact; and
- MSDS_HOW04_2019_ARCH_0096/UKHO record 9403 of unknown identity.

3.3 Known Wrecks – Archaeological Significance

3.3.1.1 The known wrecks described in the following sections are illustrated in **Figure 7**.

3.3.2 Brabant

3.3.2.1 The wreck of the *Brabant* is listed as LIVE by the UKHO. Built by Fredikstad Mekansike Verksted in 1907 in Norway, the ship was owned at the time of sinking by Olsen Fred – Ganger Rolf A/S of Oslo. A steel steam-powered transport ship with a triple expansion engine and a gross tonnage of 1492, the vessel measured 73.6 x 10.7 x 6.2 m. On 15 November 1917, *Brabant* was sailing from Christiania, Denmark, to London with general cargo when it struck a German-laid mine and sank with the loss of 3 lives.

3.3.2.2 *Baseline Archaeological Significance:* while itself not well documented, *Brabant* represents a type of vessel common throughout the early 20th century: a steel-built steamship employed in trade and transport. This vessel type is well served by other sources, both documentary evidence and in other surviving examples. As a reasonable amount of the wreck survives, it is deemed to be of medium archaeological significance.

Table 4: Significance assessment matrix for the wreck of the *Brabant*.

Criteria (DCMS, 2011)	Archaeological Significance
Period	*Medium*
Rarity	*Low*
Documentation	*High*
Group Value	*Medium*
Survival/Condition	*Unknown*
Fragility/Vulnerability	*Unknown*
Diversity	*Medium*
Potential	*Medium*
Overall	***MEDIUM***

3.3.3 Nitedal

3.3.3.1 The *Nitedal* is recorded as LIVE by the UKHO. Originally built in 1903 as the *Hero* by Laxevaags Maskin & Jernskibsbyggeri, Bergen, the vessel was owned at the time of loss by Ostlandet D/S A/S of Oslo. A steam collier with a triple expansion engine and two boilers, the vessel measured 81.7 x 11.8 x 5.3 m and had a gross tonnage of 1,714. While on passage from Jarrow to Rouen, the *Nitedal* was torpedoed on 10 October 1917 by *UB-57*. Twelve of the twenty-one crew were lost as the vessel sank within three minutes. The wreck was positively identified by the discovery of a bell inscribed 'HERO'.

3.3.3.2 *Baseline Archaeological Significance*: the *Nitedal* is described as of 2016 as being mostly intact, so may represent a good condition example of a common vessel type of the early late 19th and early 20th century. Colliers were vital to the war effort, as coal was needed to power the vast number of steam ships at sea by this time. Other examples of this type of vessel exists, and the type and activities of such vessels are well documented, but because of the potential completeness of the wreck, the remains here hold good potential for adding to the archaeological record.

Table 5: Significance assessment matrix for the wreck of the *Nitedal*

Criteria (DCMS, 2011)	Archaeological Significance
Period	*Medium*
Rarity	*Low*
Documentation	*High*
Group Value	*Medium*
Survival/Condition	*Medium (potentially)*
Fragility/Vulnerability	*Unknown*
Diversity	*Medium*
Potential	*Medium*
Overall	***MEDIUM***

3.3.4 Biesbosch

3.3.4.1 *Biesbosch* is listed as LIVE by the UKHO. Built in 1916 by Wilmink J. Thomas & Co., France, the vessel was owned at the time of loss by the Belgian Corneillie'S Shipping Co. of Antwerpen. A steel coastal cargo steamship with a triple expansion engine and two boilers, the *Biesbosch* measured 48.8 x 7.71 x 3.51 m and had a gross tonnage of 492.

3.3.4.2 The vessel was seized by the U.S. Government towards the end of the First World War and converted to a salvage ship by November 1918. By May 1919, *Biesbosch* was decommissioned from the U.S. Navy and returned to its owners where it resumed its commercial career under Dutch and Belgian flags.

3.3.4.3 In 1923, on December 29, *Biesbosch* developed a leak while on passage from Antwerp to Middlesbrough with a general cargo. Though repairs were attempted, it was soon deemed a lost cause and the crew abandoned ship and made their way to safety before their vessel foundered and sank later that night.

3.3.4.4 *Baseline Archaeological Significance:* The *Biesbosch* is a well-documented vessel: its operational history has been recorded and it is not unusual for a wartime vessel. Many thousands of merchant ships were pressed into service to fill a variety of roles and the majority, if not lost, were returned to their owners in peacetime. As a peacetime loss, the *Biesbosch* was covered in the local news (Northern Daily Mail, 1923), and so perhaps has more information available on it than similar ships lost in wartime. The vessel construction is of no particular note, and the wreck itself is somewhat broken up, but the site has some archaeological significance in part due to the historical background available as well as its group value.

Table 6: Significance assessment matrix for the wreck of *Biesbosch*.

Criteria (DCMS, 2011)	Archaeological Significance
Period	*Medium*
Rarity	*Low*
Documentation	*High*
Group Value	*Medium*
Survival/Condition	*Medium*
Fragility/Vulnerability	*Unknown*
Diversity	*Medium*
Potential	*Medium*
Overall	***MEDIUM***

3.3.5 Feltre

3.3.5.1 This vessel is listed as LIVE by the UKHO. Another wartime wreck, it was built in 1904 as the *Rhenania* by the German Bremer Vulkan (Vegesack), it was owned at the time of loss by Ferrovie Dello Stato - Italian Railways. It was a steel steamship with a quadruple expansion steam engine, two boilers, dual shaft and two screws. It measured 124.7 m x 16.15 m x 8.53 m and had a gross tonnage of 6,455. It was designed to carry over 260 passengers.

3.3.5.2 At the outbreak of the First World War, *Rhenania* was in Naples, requisitioned by the Italian Government, renamed *Feltre*, and put to use as a cargo ship. On 26 August 1917, it was travelling to Tyne with a cargo of iron ore when it was torpedoed and sunk by UB-32. The wreck was positively identified by the discovery of a bell with its original name by divers.

3.3.5.3 *Baseline Archaeological Significance:* The *Feltre*'s story is similar to many other vessels operating in the First World War: built as a merchant vessel and requisitioned for a wartime role. Similar to the other vessels previously mentioned, this vessel type is well represented and documented across the World War eras, with the notable exception of its quadruple-expansion engine, which is relatively unusual. The wreck itself is fairly broken up, but still represents substantial archaeological remains.

Table 7: Significance assessment matrix for the wreck of *Feltre*.

Criteria (DCMS, 2011)	Archaeological Significance
Period	*Medium*
Rarity	*Medium*
Documentation	*High*
Group Value	*Medium*
Survival/Condition	*Unknown*
Fragility/Vulnerability	*Unknown*
Diversity	*Medium*

Criteria (DCMS, 2011)	Archaeological Significance
Potential	*Medium*
Overall	***MEDIUM***

3.3.6 Resercho

3.3.6.1 This vessel is listed as DEAD by the UKHO. Built in 1917 by Cook, Welton & Gemmell Ltd. in Hull as a fishing trawler, it was requisitioned as a minesweeper by the Royal Navy during the First World War, before being sold to Sleight & Humphey of Grimsby in 1933. The vessel measured 36.9 x 6.7 x 3.4 m, had a gross tonnage of 258, and a triple expansion engine and one boiler. On 28 November 1939, the *Reserсho* was sunk by a mine laid by *U-15*, but all ten crew were rescued.

3.3.6.2 *Baseline Archaeological Significance:* The *Reserсho* is another common type of wartime vessel. Despite its unreliable position and status as a DEAD, the wreck could still represent substantial archaeological material if located. However, it is likely to be less intact than other notable examples of the type and service such as HMD *John Mitchell* (1917) and the Protected Wreck HMT *Arfon* (1918), both located on the south-coast.

Table 8: Significance assessment matrix for the wreck of *Reserсho*.

Criteria (DCMS, 2011)	Archaeological Significance
Period	*Medium*
Rarity	*Low*
Documentation	*Medium*
Group Value	*Medium*
Survival/Condition	*Low*
Fragility/Vulnerability	*Unknown*
Diversity	*Medium*
Potential	*Low*
Overall	***LOW***

3.3.7 Syrian

3.3.7.1 The *Syrian* is listed as LIVE by the UKHO. A British fishing trawler build in 1904 by Cook, Welton & Gemmell Ltd. of Hull, it was owned at the time of loss by Robinson F. W. of Grimsby. A small steel fishing trawler, the vessel measured 42.1 x 6.4 x 3.4 m with a gross tonnage of 176 and a single boiler and triple expansion engine. The *Syrian* was shelled by the German submarine *U-25* on 11 July 1915. There were no casualties.

3.3.7.2 *Baseline Archaeological Significance:* A fairly intact wreck, the *Syrian* is of a vessel type that is well served by other sources, both documentary evidence and in other surviving examples. As a reasonable amount of the wreck survives, it is deemed to be of medium archaeological significance.

Table 9: Significance assessment matrix for the wreck of *Syrian*.

Criteria (DCMS, 2011)	Archaeological Significance
Period	*Medium*
Rarity	*Low*
Documentation	*High*
Group Value	*Medium*
Survival/Condition	*Unknown*
Fragility/Vulnerability	*Unknown*
Diversity	*Medium*
Potential	*Medium*
Overall	***MEDIUM***

3.3.8 Lapwing

3.3.8.1 The *Lapwing* is listed as LIVE by the UKHO and was a British fishing trawler that sank after hitting a sea mine on the 6th of June 1940. Lapwing was built in 1904 in Selby and had during its career been requisitioned by the Admiralty during both the world wars.

3.3.8.2 *Baseline Archaeological Significance:* The *Lapwing* is of a vessel type that is well served by other sources, both documentary evidence and in other surviving examples. As a reasonable amount of the wreck survives, it is deemed to be of medium archaeological significance.

Table 10: Significance assessment matrix for the wreck of Lapwing.

Criteria (DCMS, 2011)	Archaeological Significance
Period	*Medium*
Rarity	*Low*
Documentation	*High*
Group Value	*Medium*
Survival/Condition	*Unknown*
Fragility/Vulnerability	*Unknown*
Diversity	*Medium*
Potential	*Medium*
Overall	***MEDIUM***

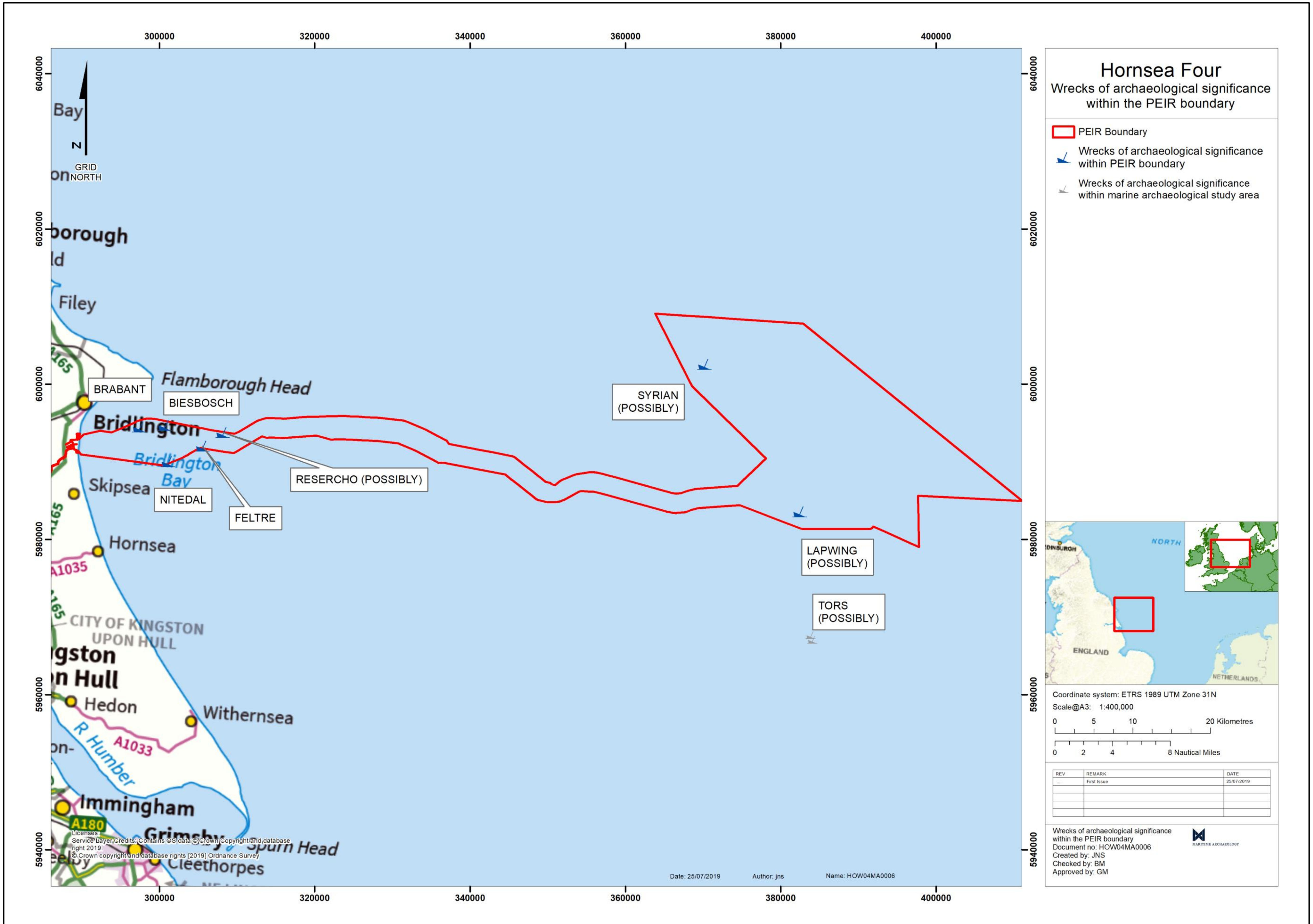

Figure 7: Wrecks of archaeological significance within the PEIR boundary (not to scale).

4 Geophysical Assessment

4.1 Geophysical Assessment

4.1.1.1 The geophysical assessment was undertaken by MSDS Marine and is summarised here; further information can be found inAppendix C: MSDS Archaeological Review of Geophysical and Hydrographic Data. The archaeological potential of the contacts was determined following the criteria as stated in **Table 11**.

Table 11: Criteria for assessment of archaeological potential.

Potential	Criteria
Low	A contact potentially of anthropogenic origin but that is unlikely to be of archaeological significance – examples may include; discarded modern debris such as rope, cable, chain or fishing gear, small isolated contacts with no wider context or small boulder-like features with associated magnetometer readings.
Medium	A contact believed to be of anthropogenic origin but that would require further investigation to establish its archaeological significance – examples may include; larger unidentifiable debris or clusters of debris, unidentifiable structures or significant magnetic anomalies.
High	A contact almost certainly of anthropogenic origin and with a high potential of being of archaeological significance – high potential contacts tend to be the remains of wrecks, the suspected remains of wrecks or known structures of archaeological significance.

4.1.1.2 The assessment identified 222 contacts of potential anthropogenic origin within the project data; 129 of these are located within the PEIR boundary as summarised in **Table 12**, with a further 93 within the data extents (i.e. within the AfL). All contacts are shown on **Figure 8.**

Table 12: Summary of anomalies with archaeological potential.

Potential	Within PEIR Boundary	Within AfL	Total
Low	123	84	207
Medium	3	2	6
High	2	7	9
Total	**129**	**93**	**222**

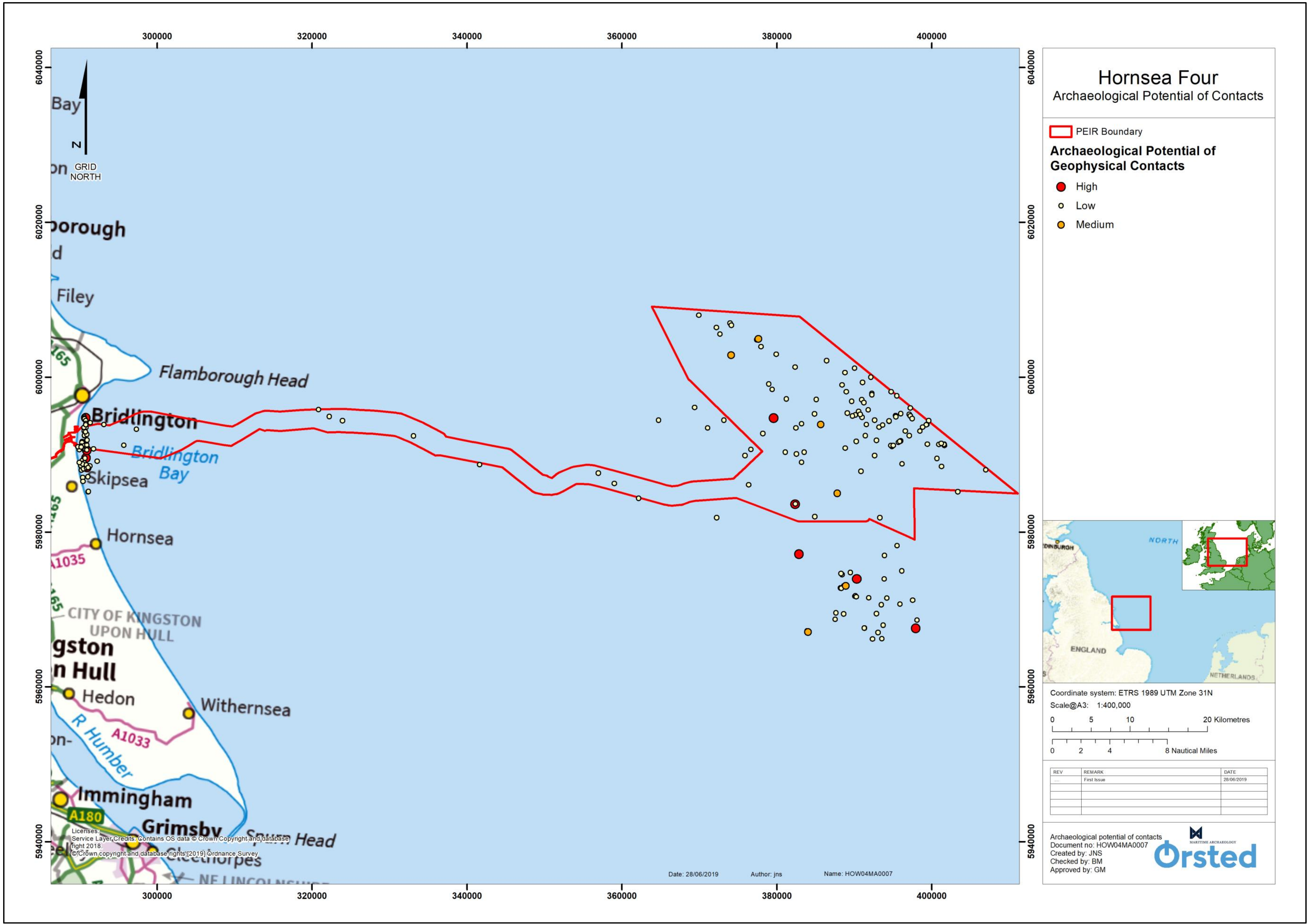

Figure 8: Archaeological potential of geophysical contacts (not to scale).

4.1.2 Data Limitations

4.1.2.1 The key data limitations with the baseline data and their ability to materially influence the outcome of the EIA are the current absence of full coverage geophysical survey and the ongoing geoarchaeological programme prior to application.

4.1.2.2 However, the proportional approach to impact assessment has been presented and clarified for Historic England; Hornsea Four has ensured that future commitments to mitigate the impact of the development on known and unknown archaeological receptors are clearly stated in **Volume 4, Annex 5.2: Commitments Register** and these commitments will be delivered through the mechanism of the resulting DCO and associated dML(s).

4.1.2.3 Impact on all known and identified archaeological receptors outlined in the existing baseline assessment as outlined here and in **Section 3** will be mitigated by utilising the imbedded mitigation methodology as outlined in **Section 5**.

4.1.3 Low potential contacts

4.1.3.1 Of the 208 contacts identified as of low archaeological potential, 124 are located within the PEIR boundary. The low potential contacts have been characterized as a mixture of small features, often boulder like, or isolated linear features and modern debris such as rope, chain, fishing gear or lost equipment, or seabed contacts with associated magnetic anomalies. A further 65 magnetic anomalies over 100 nT but with no corresponding seabed contacts have been identified within the data extents, of which 24 are located within the PEIR boundary.

4.1.4 Medium potential contacts within the PEIR boundary

4.1.4.1 MSDS_HOW04_2019_ARCH_0079: A square feature measuring 4.1 m x 4.7 m, with a height of 0.3 m. It has raised edges with a depression in the middle which corresponds to the surrounding seabed. There is no associated magnetic anomaly, but as above, this could be due to its distance from the magnetometer track.

4.1.4.2 MSDS_HOW04_2019_ARCH_0088: A dense cluster of boulder-like features over an area of 22.0 x 12.3 m. Though this could represent a boulder field, this contact is associated with a magnetic anomaly and could represent a ballast mound from a wreck vessel.

4.1.4.3 MSDS_HOW04_2019_ARCH_0235: A cluster of features over an area of 16.6 x 7.7 m associated with a strong magnetic anomaly. Though the origin is unclear, the significant quantity of ferrous material is suggestive of anthropogenic origin.

4.1.5 Medium potential contacts within the data extent (AfL) but outside of the PEIR boundary

4.1.5.1 MSDS_HOW04_2019_ARCH_0072: A prominent mound which may represent anthropogenic material. The mound measures 12.3 x 5.8 m, with a maximum height of 0.9

m. There is no associated magnetic anomaly, though this may be due to the distance from the closest magnetometer survey line.

4.1.5.2 MSDS_HOW04_2019_ARCH_0096: A spread of features over an area of 70.2 x 16.8 m with a height of 0.2 m. This feature corresponds with UKHO record 9403 and has an associated magnetic anomaly, which suggests a broken-up wreck but with no known identity.

4.1.5.3 **High potential contacts within the PEIR boundary**

4.1.5.4 MSDS_HOW04_2019_ARCH_0086: A spread of potential debris and an associated magnetic anomaly. The debris covers an area of 34.1 x 15.7 m, with a maximum height of 0.3 m. In the multibeam survey dataset, the feature appears as an area of disturbed seabed; within the sidescan data it is characterised as a rectangular feature with associated features to the north and south. Though not associated with a UKHO record, it does have a significant magnetic anomaly.

4.1.5.5 MSDS_HOW04_2019_ARCH_0224: The semi-coherent remains of a wreck with a significant associated magnetic contact. This feature corresponds with UKHO record 9400, the possible wreck of the *Lapwing*. A British fishing trawler sunk after collision with a mine in 1940, the *Lapwing* was requisitioned by the admiralty for periods during both world wars before being returned to its owners. This vessel is further described in **Section 3.3.8**.

4.1.6 High potential contacts within the data extent (AfL) but outside of the PEIR boundary

4.1.6.1 MSDS_HOW04_2019_ARCH_0015: The semi-coherent remains of a wrecked vessel measuring 21.1 x 7.9 m and with a height of 3.1 m. The outline of the vessel is clear but there is potential for further material to be buried in the immediate area. This contact corresponds to UKHO record 9410, an unknown wreck located in 1986. The UKHO measurements for this vessel do not match the survey measurements, but this could be due to further degradation or burial of the site in the intervening period.

4.1.6.2 MSDS_HOW04_2019_ARCH_0073: The coherent remains of a wreck lying towards the outer extents of the survey data and so partially ensonified. The remains measure 32.4 x 9.6 m, with a height of 2.8 m. There is no associated magnetic anomaly, likely due to the distance of the feature from the closest magnetometer track. This contact is associated with UKHO record 9377, likely to be the wreck of the *Flirt*, a British ketch which sank in 1897 after a collision with the Swedish steamship *Talis*.

4.1.6.3 MSDS_HOW04_2019_ARCH_0113: The coherent remains of a wreck associated with a magnetic anomaly and UKHO record 9410, which was identified in 1985 but has no known identity. The vessel measures 21.1 x 7.7 m with a height of 1.8 m.

4.1.6.4 MSDS_HOW04_2019_ARCH_0171: A likely wreck measuring 12.4 m x 4.1 m but with no corresponding magnetic anomaly. It measures 13.4 x 4.1 m and 0.4 m in height, but lies outside the bounds of the available multibeam data and does not have an associated UKHO record.

4.1.6.5 MSDS_HOW04_2019_ARCH_0173: A probable wreck measuring 15.5 x 4.2 m with a height of 0.1 m. Though partially ensonified within the multibeam data, the wreck is clearly defined in the sidescan imagery, and is characterised by regular features forming the outside of the vessel which may potentially be internal frames of a wooden vessel.

4.1.6.6 MSDS_HOW04_2019_ARCH_0178: The remains of a wrecked vessel covering an area of 77.3 x 33.8 m with a height of 0.1 m. It has an associated magnetic anomaly and UKHO record (5805) which notes the aft section of the *Sote*. *Sote* was a Swedish steamship built in 1883 and sunk by torpedo in 1918 which was on tow when the aft-section broke off and was later dispersed with explosives. Other magnetic anomalies within 100 m of the centre may be related to this vessel, but these do not correspond with any visible seabed features.

4.1.6.7 MSDS_HOW04_2019_ARCH_0187: A prominent mound measuring 16 m x 10 m with a height of 1.3 m. The surface is irregular and likely to be made up of individual features, similar to a mound of boulders. The origin is uncertain, but the large magnetic contact indicated some material of anthropogenic origin in the vicinity of the mound which could be related to a vessel, such as a ballast mound.

4.2 Palaeogeographic Review of Geophysical Survey Data

4.2.1.1 This summary work relating to the development of the ground model and input into geotechnical investigations to-date is based on the assessments undertaken by MSDS Marine Ltd (**Appendix D: MSDS Palaeogeographic Review of Geophysical Survey Data**). These investigations took place in the southern part of the AfL the interpretations within this summary are based primarily on seismic data, supported by knowledge gained from other Hornsea project areas and previous geotechnical work.

4.2.1.2 As with the broader region, the marine archaeology study area has been subject to cold cycles and warmer interludes associated with the Devensian, Wolstonian, and Anglian glaciations and interglacial periods.

4.2.1.3 These changeable environmental conditions have left a sequence of deposits within the site of varying levels of palaeoenvironmental and archaeological potential. A summary of the sedimentary sequence of the site is provided in **Table 13**.

4.2.1.4 Entries of particular archaeological and paleoenvironmental interest have been highlighted as bold. The Yarmouth Roads deposits in particular have been equated with onshore Cromer Forest Beds, which have produced in situ archaeological and paleoenvironmental remains dating to the Lower Palaeolithic.

4.2.1.5 Along the ECC, the sedimentary sequence is characterised as dating from the Holocene, with deposits including mobile sands with channels or depressions at the base. These undulations may represent corresponding undulations in underlying moraines which can be a focus for the accumulation of sediment.

4.2.1.6 Basal deposits, lying on top of the bedrock, include Boulders bank, Swarte bank, and Yarmouth Roads. Units which underlie the Holocene deposits but overlie the basal deposits have been identified in some areas; interpretations of this are still ongoing.

4.2.1.7 Quaternary deposits are thin in the western and northern parts of the array area, but thicker to the southern part of the site; archaeological potential is highest in this area. The potential of Holocene deposits is highest within the palaeochannels and depressions where organic sediment has accumulated.

4.2.1.8 These channels were mapped by the North Sea Palaeolandscape project. Yarmouth Roads deposits are particularly extensive and thick within the array area, with multiple internal reflectors indicating different phases. These deposits may help provide a more detailed understanding of their correlation with the terrestrial Cromer Forest Beds sequence.

Table 13: Deposits identified during the phase one ground model developed by MSDS.

Deposit	Description
Holocene	During the Holocene period the site was characterised by terrestrial, intertidal and then fully marine conditions. A Holocene shoreline is likely to have run along the north-eastern edge of the array area and studies show palaeochannels dating to this period may be present within the array area. Marine sands are underlain by early Holocene channels cut into the earlier glacial channels (Botney Cut). Depressions in possible morraines and other glacial features along the export cable route may hold organic deposits of Holocene date.
HTG20	Glaciotectonite
Botney Cut	Related to the Late Devensian and Early Holocene period. Predominantly glacio-fluvial features and till. Some of the botney cut features may be re-interpreted as Bolders bank.
Boulders Bank	Related to the Devensian period. Diamicton probably formed by an ice lobe, with probable internal sub-glacial channels. Different phases of Bolders Bank glacial activity within the area. Present as a blanket deposit in the southern part of the array area, with more erosive properties to the north.
HGT30	Glaciotectonite
Eem Formation	Related to the Ipswichian interglacial. Fine to medium grained shelly marine sands, or intertidal/sub-tidal deposits.
HTG40	Glaciotectonite
Egmond Ground	Fine grained marine sands interbedded with clays.
HTG52	Glaciotectonite
Swarte Bank	Related to the Anglian glaciation. Primarily characterised by sub glacial valleys incised into the Yarmouth Roads formation and underlying deposits (where present).
Yarmouth Roads	Related to the Cromerian Period. Fluvial or deltaic deposits with sands, silts, clays and reworked peat. Partially equated with the onshore Cromer Forest Beds which are associated with in situ archaeological material at Happisburgh and Pakefield. Multiple phases of

Deposit	Description
	Yarmouth Roads Formation have been identified within the site. Internal Yarmouth Road reflectors are clearly visible within seismic data.
Chalk	Bedrock
Pre Chalk	Bedrock

5 Mitigation

5.1 Introduction

5.1.1.1 Analysis of the baseline data and the geophysical surveys undertaken to-date have enabled the following mitigation commitments to be put forward to avoid and reduce impact on marine archaeological receptors as outlined in **Table 2**.

5.1.1.2 These recommendations have been designed to reduce or eliminate direct impacts on heritage receptors within the PEIR boundary. This approach is further detailed in the project Outline Marine WSI document (**F2.4: Outline Marine Written Scheme of Invesitgation**) and follows the methodology detailed in *Model Clauses for Archaeological Written Schemes of Investigation – Offshore Renewables Projects* (The Crown Estate, 2010).

5.2 Mitigation for Known wrecks and obstructions

5.2.1.1 Eighteen known wrecks identified in the data provided by UKHO are located within the PEIR boundary. Of the 18 wrecks, 13 are classed as LIVE. In addition, there are seven foul and seabed obstructions within the PEIR boundary. Of the 25 known heritage receptors, only two wrecks correlate with the geophysical data assessed for archaeological potential as detailed below.

5.2.1.2 As per commitments Co46 and Co140 in **Table 2**, precautionary AEZ's of 50 m are recommended for all 25 known heritage receptors, full details of which are provided in **Appendix A** of this document..

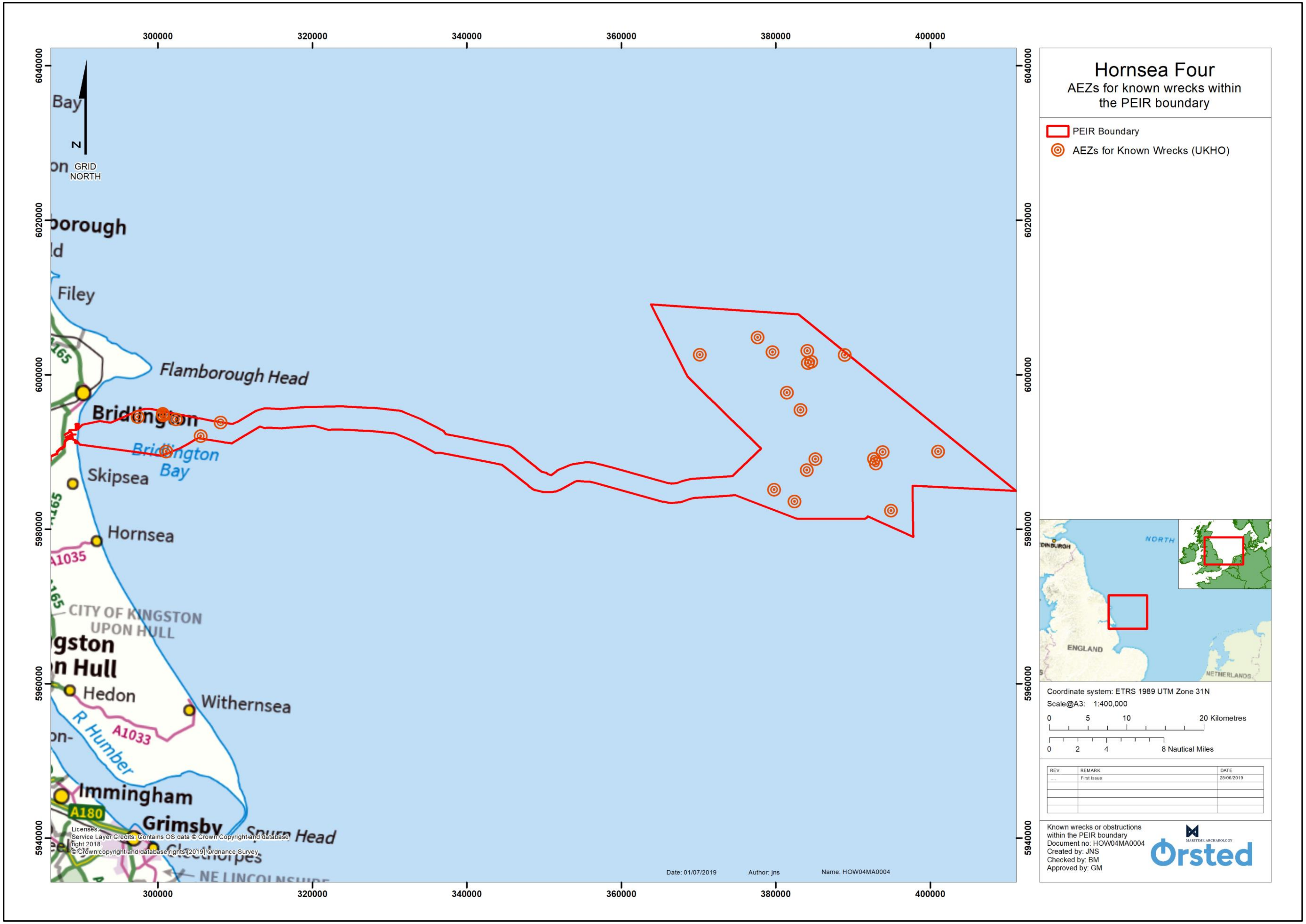

Figure 9: Centerpoint locations of precautionary AEZs assigned to known wrecks and obstructions (not to scale).

5.3 Mitigation for geophysical contacts of archaeological potential

5.3.1.1 The combined geophysical data assessment undertaken to identify material of anthropogenic potential identified 129 features within the PEIR boundary as outlined in **Table 14**.

Table 14: Features with archaeological potential identified in the geophysical survey data.

Potential	Contacts
Low	124
Medium	3
High	2
Total	**129**

5.3.1.2 Contacts of low archaeological potential and magnetic anomalies > 100 nT without correlating seabed feature are detailed in **Appendix C: MSDS Archaeological Review of Geophysical and Hydrographic Data**. Due to the uncertainty of their archaeological significance, the 124 low potential contacts and the 24 magnetic anomalies have not been assigned AEZ's.

5.3.1.3 As per commitment Co141 in **Table 2**, if any works during the construction, operational and decommissioning phases of the project is taking place on any of the locations the project specific protocol for archaeological discoveries (**Appendix A of F2.4: Outline Marine Written Scheme of Invesitgation**) should be observed and any objects of archaeological potential should be reported as outlined in **F2.4: Outline Marine Written Scheme of Invesitgation**.

5.3.1.4 As per commitments Co46 and Co140 in **Table 2,** features assigned medium and high archaeological potential are likely to be of anthropogenic origin and of archaeological significance and have therefore been assigned AEZs based on a radius from the centre point of the feature, as detailed below and in **Appendix C: MSDS Archaeological Review of Geophysical and Hydrographic Data**. In total five AEZs have been assigned within the PEIR boundary, for two high potential and three medium potential contacts as per **Table 15**.

Table 15: Archaeological Exclusion Zones assigned to medium and high potential features.

MSDS ID	Potential	Basic Description	Easting	Northing	AEZ Radius (m)
MSDS_HOW04_2019_ARCH_0086	High	Potential wreck	379559.3	5994689.6	75
MSDS_HOW04_2019_ARCH_0224	High	Wreck	382353.2	5983573.2	100
MSDS_HOW04_2019_ARCH_0079	Medium	Potential anthropogenic debris	374099.1	6002824.4	15
MSDS_HOW04_2019_ARCH_0088	Medium	Potential ballast mound	387801.1	5984995.7	30
MSDS_HOW04_2019_ARCH_0234	Medium	Potential anthropogenic debris with large magnetic anomaly	385666.0	5993861.0	25

5.4 Mitigation for deposits of palaeographic potential

5.4.1.1 The baseline study, supported by the geophysical survey data, has provided some information about potential Holocene sediments and palaeolandscapes within the PEIR boundary. Although the impact to sediments will be restricted to the required burial and penetration depths, it is recognised that all phases of the development may cause direct impact to deposits which have the potential to be of geoarchaeological interest.

5.4.1.2 As per commitment Co167 in **Table 2**, mitigation for deposits of palaeographic and/or archaeological potential will be further developed and delivered through the completion of future staged geoarchaeological studies and may comprise archaeological exclusion zones and/or the recommendation to undertake further assessments and analyses of the material as outlined in **F2.4: Outline Marine Written Scheme of Invesitgation**.

5.5 Mitigation for unexpected archaeological discoveries

5.5.1.1 As per commitment Co141 in **Table 2**, it is proposed that any finds believed to be of archaeological potential recovered by any operating vessels during construction, operation or decommissioning should be reported using the methodology outlined in the project-specific Protocol for Archaeological discoveries (PAD) (**Appendix A** of **F2.4: Outline Marine Written Scheme of Invesitgation**).

5.5.1.2 The project-specific PAD aims to mitigate the effect on the historic environment by enabling people working offshore to report their finds in an effective and convenient manner.

5.5.1.3 Any finds discovered should be safeguarded i.e. kept in water in a clean, covered container. It is not recommended to remove concretions, clean the finds, or in any other way interfere with them.

5.5.1.4 Crew on board the vessels and onshore staff should familiarise themselves with the Protocol and the reporting procedures it describes, which is further detailed in **F2.4: Outline Marine Written Scheme of Invesitgation**.

6 References

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Appendix A: Known shipwrecks, fouls, and obstructions within the PEIR boundary

Table A.1: Shipwrecks.

Name	MSDS ID	UKHO ID	Latitude	Longitude	Status	Location accuracy	Year Lost
Brabant		5807	+54.058917	-0.09695	Live	~3 m	1917
Biesbosch		5808	+54.062183	-0.046733	Live	~25 m	1923
Feltre		6470	+54.039967	+0.029083	Live	~25 m	1917
Lapwing	0224	9400	+53.987217	+1.205633	Live	~13 m	1940
Linda Louise		6845	+54.038883	+1.360883	Live	~13 m	1983
Nitedal/Leka		6493	+54.02025	-0.037283	Live	~13 m	1917
Resercho (possibly)		6586	+54.056633	+0.067417	Dead	Unreliable	1939
Syrian		6741	+54.154967	+1.010633	Live	~4 m	1915
Unknown		6163	+54.06385	-0.047283	Dead	Unreliable	Unknown
Unknown		6165	+54.0583	-0.0209	Live	Unreliable	Unknown
Unknown		6721	+54.000267	+1.164767	Dead	Unreliable	Unknown
Unknown		6728	+54.047217	+1.37755	Live	~13 m	Unknown
Unknown	0233	6830	+54.176917	+1.124233	Live	~13 m	Unknown
Unknown		6846	+54.16025	+1.154783	Dead	Approximate	Unknown
Unknown		6833	+54.16275	+1.223383	Live	~13 m	Unknown
Unknown		6735	+54.148583	+1.225333	Live	~13 m	Unknown
Unknown		6736	+54.158867	+1.2981	Live	~13 m	Unknown
Zephr		6725	+54.0336	+1.364767	Dead	Unreliable	1960

Table A.2: Fouls and other obstructions.

UKHO ID	Latitude	Longitude	Status	Location Accuracy
6863	+54.049167	+1.486983	Live	~13 m
9387	+53.979167	+1.486983	Dead	~13 m
6859	+54.024167	+1.228683	Live	~13 m
66240	+54.036933	+1.244767	Dead	Unreliable
6858	+54.093867	+1.213117	Live	~13 m
6862	+54.1136	+1.185333	Live	~13 m
6860	+54.149983	+1.231717	Live	~13 m

Appendix B: Intertidal and terrestrial sites within the baseline archaeological review

Table B.1: Intertidal and terrestrial sites within the baseline archaeological review.

NMR or SMR record number	Era	Description	Latitude	Longitude
SMR MHU1893	Palaeolithic	Flint core	+53.927724	-0.170355
NMN 910838	Palaeolithic	Flint blade	+53.973916	-0.196311
SMR MHU3544	Palaeolithic	Barbed point	Unknown	Unknown
SMR MHU344	Palaeolithic	Harpoon head	Unknown	Unknown
NMN 910906	Palaeolithic	A collection of finds including flint cores, scrapers, a pebble macehead, and tranchet axe.	+54.076415	-0.197984
NMN 1445312	Neolithic	Concentric ditched enclosure	+54.010694	-0.217110
SMR MHU8970	Neolithic	Polished axes	Unknown	Unknown
NMN 910838	Neolithic	Lake village	+53.973916	-0.196311
NMN 1510522	Bronze Age	Small flanged axe	+54.081018	-0.191456
NMN 81091	Bronze Age	Halberd	+54.076415	-0.197984
NMN 80999	Bronze Age	Bracelet	+54.076415	-0.197984
NMN 81183	Bronze Age	Inurned cremation	+54.076415	-0.197984
NMN 80760	Bronze Age	Occupation site	+54.010347	-0.216102
NMN 910907,	Bronze Age	Palstave	+54.013761	-0.215956
NMN 1551072,	Bronze Age	Potsherds	+54.018230	-0.214238
NMN 1551027	Bronze Age	Flint assemblage	+54.013448	-0.213069
NMN 910759	Bronze Age	Possible occupation site	+53.986811	-0.217108
NMN 80921	Bronze Age	Beaker	+53.968617	-0.202639
NMN 1546041	Bronze Age	Auroch horns	+53.979220	-0.199361
NMN 1546593	Iron Age	Ditch and pottery	+54.003350	-0.211061
NMN 1551059	Iron Age	Flint assemblage alongside mixed age pottery, including Iron Age	+54.019611	-0.216469
NMN 1551075	Iron Age	Ditch containing pottery	+54.015392	-0.213826
NMN 1546940	Iron Age	Double ditch or two pits with coin and pottery	+53.999734	-0.209690
NMN 1551022	Iron Age	Ditch containing pottery	+54.011967	-0.213209
NMN 1546627	Iron Age	Box drain, ditch, pottery and animal bone	+54.001531	-0.209613
NMN 1446482	Roman	An area of activity with extensive landscape of enclosures, pits, and ditches and trackways.	+54.034247	-0.219003

NMR or SMR record number	Era	Description	Latitude	Longitude
SMR MHU334	Roman	A substantial trackway cropmark of approx. 100 m in length.	+54.021640	-0.216916
SMR MHU3141	Roman	Roman coins and 4th Century Signal Station type pottery	+54.048312	-0.212185
NMN 81268	Roman	Coin hoard	+54.040936	-0.230065
SMR MHU15809 and EHU269	Roman	Probable pit and pottery	+53.999734	-0.209690
SMR MHU17703	Roman	Bronze pin	+54.000172	-0.208908
SMR MHU4523	Roman	Coin hoard	+53.993378	-0.205386
SMR MHU18616	Roman	Coin hoard	Unknown	Unknown
SMR MHU18617	Roman	Coin hoard	Unknown	Unknown
NMN 1189332	Anglo-Saxon	Burial	+54.011456	-0.226646
SMR MHU14857	Medieval	Road	+54.052129	-0.213167
NMN 81264	Medieval	Remains of St Nicholas' church	+54.046314	-0.218686
NMN 1429775	Second World War	An anti-tank wall and twin machine gun emplacements	+54.047897	-0.214494
NMN 1418860 and 1446436	Second World War	Two possible beach defence lights	+54.042125	-0.213214
NMN 1446399	Second World War	Anti-tank defences and a minefield extending along the beach	+54.042983	-0.221974
RCZA BA119	Second World War	A pillbox designed to house a 6-pounder quick-firing gun	+54.018750	-0.212995
RCZA BA 183	Second World War	Anti-tank cubes	+54.040374	-0.214541
RCZA BA186	Second World War	A pillbox	+54.034444	-0.215345
NMN 1446479	Second World War	Pillbox	+54.028916	-0.217139
NMN 1446447	Second World War	Searchlight battery and associated buildings	+54.034843	-0.216794
NMN 1446451	Second World War	Weapons pits	+54.029669	-0.215214
NMN 1446454	Second World War	Military buildings	+54.028929	-0.215047
RCZA BA193	Second World War	Beach defence light	+54.028134	-0.215341
NMN 1446456	Second World War	Pillbox and surrounding barbed wire obstructions	+54.027419	-0.215631

NMR or SMR record number	Era	Description	Latitude	Longitude
RCZA BA187	Second World War	Pillbox	+54.024329	-0.214603
NMN 1445152	Second World War	Barbed wire obstructions and trackways	+54.020959	-0.214640
NMN 1445209 And 1445214	Second World War	Anti-tank cubes	+54.018766	-0.212841
SMR MHU9988	Second World War	Pillbox	+54.008740	-0.210829
NMN 1445233	Second World War	Anti-tank cubes	+54.008443	-0.210781
NMN 1429773	Second World War	Observation post	+53.979351	-0.199127

Appendix C: MSDS Archaeological Review of Geophysical and Hydrographic Data

Hornsea Project Four Offshore Wind Farm

Archaeological Review of Geophysical and Hydrographic Data

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Author.: [Mark James – MSDS Marine]

Table of Contents

Non-Technical Summary

MSDS Marine Ltd (MSDS Marine) have been commissioned by Ørsted Hornsea Project Four (UK) Limited, to undertake an archaeological review of the geophysical and hydrographic data collected along the Export Cable Corridor (ECC) and Array of Hornsea Project Four Offshore Wind Farm (Hornsea Project Four) in 2018 as part of the pre-application works. The archaeological review is to establish the archaeological potential of the area and identify known and unknown contacts of archaeological potential within the dataset. The data has been reviewed to identify contacts of potential archaeological significance, to characterise potential for material of archaeological significance and to recommend appropriate mitigation strategies.

The survey was divided into two lots, the Export Cable Corridor (ECC) and the Array with two survey companies commissioned to undertake each area, Bibby Hydromap over the ECC and Gardline over the Array. Data were collected by Bibby Hydromap between 17th October and 5th December 2018 and by Gardline between 16th August and 18th September 2018. The survey data extends to the scoping boundary, however the area taken forward at the PEIR stage is much reduced. The full extents of the data have been interpreted and reported as part of this assessment, however mitigation strategies relate to the revised PEIR boundary.

The data were processed and interpreted to identify contacts of potential archaeological significance which were graded according to their potential to be of archaeological significance. The grading structure follows a low, medium and high rating, with low being assessed as unlikely to be of archaeological significance and high being assessed as likely to be of archaeological significance.

222 contacts of potential archaeological significance were identified within the geophysical data extents, these can be broken down as 207 low potential, six medium potential and nine high potential. 129 of the contacts lie within the PEIR boundary, broken down as 123 low potential, four medium potential and two high potential. The contacts are derived primarily from sidescan sonar and multibeam bathymetry data and correlated with magnetometer and sub-bottom data. Analysis of United Kingdom Hydrographic Office data within the survey data extents was also undertaken to correlate with contacts identified on the seabed.

The recommended mitigation strategy for the medium and high potential contacts is in the form of archaeological exclusion zones. The low potential contacts have been interpreted as being unlikely to be of archaeological significance, therefore no specific mitigation strategy has been recommended other than reporting any finds of potential archaeological significance through an appropriate protocol for reporting archaeological discoveries. Five archaeological exclusion zones have been recommended for contacts identified as of medium or high archaeological potential. Twenty-four magnetic anomalies with no significant correlating seabed contacts have been identified and noted as areas of archaeological potential. Areas of archaeological potential are where magnetic anomalies are known to exist but the positioning is not accurate enough to recommend exclusion zones

Recommendations have been made for future work, this includes the archaeological review of all new geophysical data, survey specifications and the implementation of an appropriate protocol for reporting archaeological discoveries.

Should archaeological exclusion zones impact on the proposed development works it is recommended that a program of ground truthing is undertaken to establish the identity of the contacts so that further archaeological assessment can be undertaken and interpretations revised as appropriate.

1. Introduction

MSDS Marine Ltd (MSDS Marine) have been commissioned by Ørsted Hornsea Project Four (UK) Limited, to undertake an archaeological review of the geophysical and hydrographic data collected along the Export Cable Corridor (ECC) and Array of Hornsea Project Four Offshore Wind Farm (Hornsea Project Four) in 2018 as part of the pre-application works. The archaeological review is to establish the archaeological potential of the area and identify known and unknown contacts of archaeological potential within the dataset. The data has been reviewed to identify contacts of potential archaeological significance, to characterise potential for material of archaeological significance and to recommend appropriate mitigation strategies.

2. Introduction to MSDS Marine Ltd

MSDS Marine are a marine and coastal archaeological contractor specialising in the management and support of archaeological projects. MSDS Marine offer a full range of archaeological services including, but not limited to consultancy, research, desk-based services, remote sensing, conservation, ground-truthing, and diving services.

MSDS Marine are the retained archaeological consultants for the Ørsted Walney Extension, Hornsea Project Two and Project Three Offshore Wind Farms and the archaeological geophysical and geotechnical consultants for Hornsea Project Four. It is of note that Walney Extension is currently the world's largest Offshore Wind Farm and on completion Hornsea Project Two will be the world's largest following commissioning. MSDS Marine have undertaken the archaeological review of geophysical data across Walney Extension, Hornsea Project Two, Hornsea Project Three, Rampion and Navitus Bay as well as across a significant number of aggregate extraction areas and other developments.

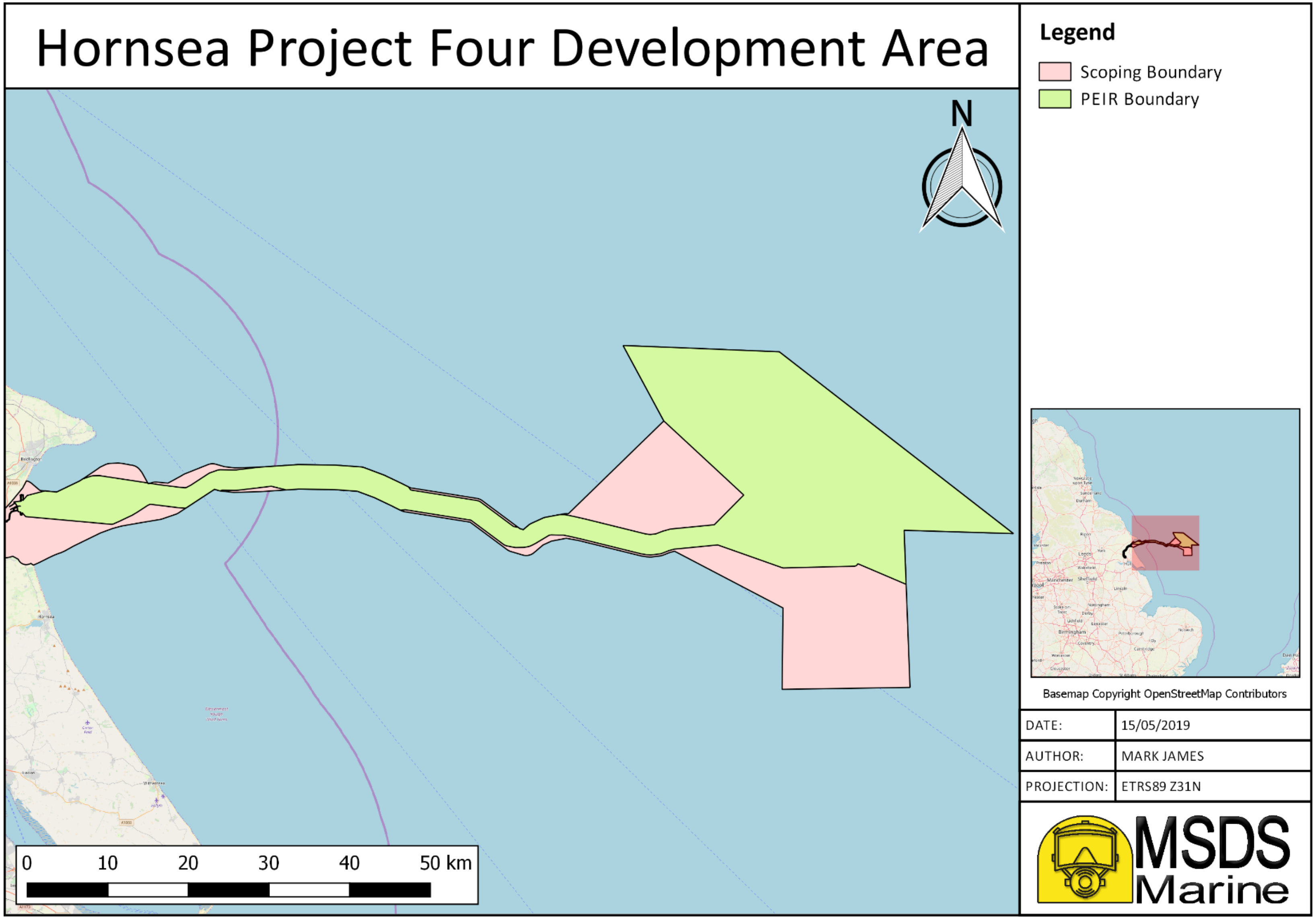
MSDS Marine has been established since April 2011 and are a well-known and trusted contractor with clients including A2Sea Solutions Ltd, ADUS DeepOcean, APEM Ltd, Bibby Hydromap, Carcinus Ltd, Cotswold Archaeology, The Dutch Cultural Heritage Agency (RCE), EGS International, EMU Ltd, E.ON, Historic England, Isles of Scilly IFCA, MarineSpace, Ørsted, Pascoe Archaeology Services, PMSS/Navitus Bay, Sea Change Ltd, Southampton University, Swathe Services and Trendarch.

3. Project Location and Status

Ørsted Hornsea Project Four (UK) Limited (hereafter referred to as Hornsea Project Four) is proposing to develop the Hornsea Project Four Wind Farm (hereafter Hornsea Project Four). Hornsea Project Four is located approximately 65 km offshore from the coastline of the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. The location of Hornsea Project Four is illustrated in Figure 1. Of the other Hornsea projects, Hornsea Project Two lies in closest proximity, and is expected to commence offshore construction works in 2020. Hornsea Project Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network at Creyke Beck. The Preliminary Environmental Information Report (PEIR) Study Area combines the search areas for the onshore and offshore infrastructure.

The Hornsea Four Agreement for Lease (AfL) area was 848 km2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate EIA, the project is currently giving due consideration to the size and location (within the existing AfL area) of the final project that will be taken forward to consent application (DCO). This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction. The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the AfL taken forward at the point of PEIR (see Figure 1). The evolution of the AfL is detailed in the Site Selection and Consideration of Alternatives Chapter (A1.3.) and its associated Annex: Selection and Refinement of the Offshore Infrastructure (A4.3.2). The final developable area taken forward to consent may differ from that presented in Figure 1 due to the results of the EIA, technical considerations and stakeholder feedback.

Figure 1. Hornsea Project Four Development Area and Location



4. Previous Archaeological Works

Hornsea Project Four is currently in the early stages of the application process and is engaged in the production of the Preliminary Environment Information Report, the Written Scheme of Investigation (WSI), the Protocol for Archaeological Discoveries (PAD), Environmental Statement (ES) and marine archaeological technical report which this report will inform.

In addition, MSDS Marine are contracted to provide ongoing consultancy in relation to archaeological input into the production of the ground model.

An Environmental Impact Assessment, Scoping Report was produced in 2018 (Ørsted 2018) which aimed to establish relevant cultural heritage assets and the potential impacts from construction, operation and decommissioning of Hornsea Project Four.

A significant amount of archaeological work has been undertaken in the adjacent Hornsea Zones (One, Two and Three) which serve as an indication as to the archaeological potential of the wider area, despite not being undertaken directly within the development area.

5. Aims and Objectives

5.1 Archaeological Review of Geophysical and Hydrographic Data

The principle aim of the archaeological review of geophysical and hydrographic data is to establish the presence of potentially significant archaeological material on the seabed. The identification of material allows for strategies to be recommended to mitigate against any negative effects that may be caused by the development process.

The objectives of the archaeological interpretation can be summarised as follows;

1. To establish the presence of anthropogenic material of archaeological potential
2. To interpret the identified contacts as to their potential to be of archaeological significance
3. To recommend mitigation strategies for the contacts appropriate to their archaeological potential
4. To recommend further works that may be required and their specifications

The limited survey coverage means that a comprehensive review of potential archaeological features across the development cannot be made. However, the results will serve as an indication as to the wider potential of the area to inform preliminary characterisation assessments.

6. Methodology – Archaeological Review of Data

6.1 Data Collection

All data collected as part of the pre-application survey were collected to a specification that fulfils the requirements of Section 5 of Model Clauses for Archaeological WSIs (Wessex Archaeology 2010).

The survey was divided into two lots, the Export Cable Corridor (ECC) and the Array with two survey companies commissioned to undertake each area, Bibby Hydromap over the ECC and Gardline over the Array. Data were collected by Bibby Hydromap between 17th October and 5th December 2018 and by Gardline between 16th August and 18th September 2018.

The data collected varied in specification across the two lots, however the data from each lot is considered comparable and appropriate to characterise the marine archaeological potential of the Hornsea Project Four development site. Mobilised sensors are detailed in Table 1 and Table 2.

Line spacing varied across the area, from c.50m close inshore (c.1.5km out) to c.500m (c.3.75km out) with c.2.0km cross lines, where data was collected along the ECC, c.50km, line spacing was c.0.5km. Line spacing increased within the array area to between c.0.75-3.0km with c.3.0km cross lines. Coverage is presented in Figure 2.

Table 1. Survey Specification - Export Cable Corridor (Bibby Hydromap)

Vessel / Sensor	Sidescan Sonar	Multibeam	Magnetometer	Sub-bottom
Bibby Tethra	Edgetech 4200 (300/600 kHz)	Kongsberg 2040 Dual head (400 kHz)	Geometrics G-882	Innomar SES-2000 Medium

Table 2. Survey Specification - Array (Gardline)

Vessel / Sensor	Sidescan Sonar	Multibeam	Magnetometer	Sub-bottom
MV Ocean Endeavour	Edgetech 4200 (300/600/900 kHz)	Kongsberg 2040 (400 kHz)	Geometrics G-882	Innomar SES-2000 Medium

The data were collected to a specification appropriate to achieve the following interpretation requirements;

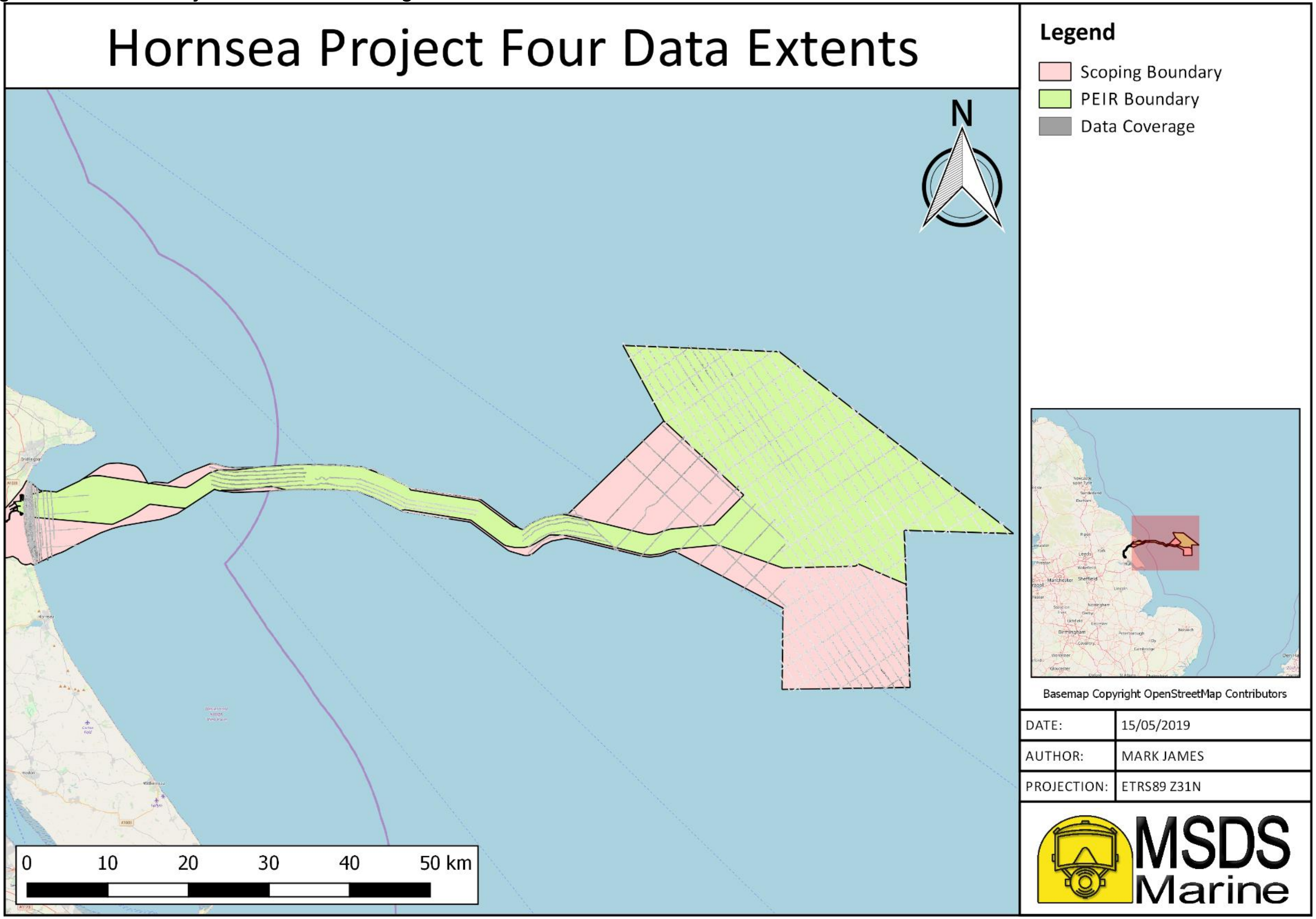
- **Magnetometer**: identification of contacts >5nT
- **Sidescan sonar**: ensonification of contacts >0.5m
- **Sub-bottom profiler**: penetration >10m
- **Multibeam bathymetry**: BIN size of <0.5

All data were collected and referenced relative to the ETRS89 datum and UTM31N projection.

The towed sensors, Sidescan Sonar and Magnetometer, used an Ultra Short Baseline (USBL) positioning system to ensure positional accuracy of the sensors throughout the survey. USBL ensures the actual position of the sensor is recorded, as opposed to when the position is estimated based upon the direction of the vessel and the amount of cable out (layback). Although the accuracy of the USBL system is dependent on the angle, and the distance, of the beacon from the transceiver tolerances of between 0.5m and 2.0m can be achieved.

Positional accuracy is further increased through the correlation of Sidescan Sonar and Magnetometer datasets with the Multibeam Echo-Sounder dataset.

Figure 2. Hornsea Project Four Data Coverage



6.2 Data Processing

Data collected during the 2018 survey campaign were processed by Bibby Hydromap and Gardline. Whilst the specifics and the software may vary between contractors the general methodologies, including the deliverables, remain the same. The methodologies presented below follow those detailed by Bibby Hydromap (Bibby Hydromap 2018).

6.3 GNSS Data

The logged GNSS observations were processed using the Precise Point Positioning (PPP) module inside Novatel's Waypoint post processing software. GNSS data (1Hz) was converted to the software format and merged with freely available precise ephemeris and precise clocks data. The software then combined, and smoothed the trajectories computed forwards and backwards in time, which resulted in an improvement in the position, velocity and accuracy to 10cm (1 sigma).

Logged Inertial Navigation System (INS) observations were processed using the Applanix SmartBase™ module, which is a feature of Applanix POSPac MMS software. SmartBase™ uses a Post Processed Virtual Reference Station (PPVRS) technique to provide a positioning solution that yields accuracies better than 0.05m. The Virtual Reference Stations (VRS) enabled a positioning solution that eliminated the effects of the atmospheric (ionosphere and troposphere) and satellite clock inaccuracies that can cause systematic errors in the observations.

IMU data (200Hz) and position data (25Hz) was imported into POSPac and merged with freely available precise ephemeris and precise clocks data. Nearby base station observations were acquired from the Leica Spiderweb website and imported into the software to create the SmartBase™ network. The Applanix IN-Fusion processing technology, which employs a "tightly-coupled" integration approach and then an Inertially Aided Kinematic Ambiguity Resolution (IAKAR) technique to resolve integer ambiguities, was used to provide centimetre level positioning. The software finally combined and smoothed the computed forwards and backwards trajectories in time to create a Smoothed Best Estimated Trajectory (SBET) solution, which resulted in an improvement in the position velocity and accuracy to typically less than 0.05m, depending on baseline lengths.

6.4 Vertical Reduction Methodology

The vertical datum used for all measurements was Lowest Astronomical Tide (LAT), as defined in the Project Scope, using the UKHO VORF model.

The reduction of data to the defined vertical datum used a GNSS height measurement-based approach. The observed heights from the C-Nav 3050 GNSS system were reduced using the VORF LAT geoid/ellipsoid separation model. The post processed solution of the C-Nav 3050 GNSS system observations were reduced using the VORF LAT geoid/ellipsoid separation model. The post processed SBET solution was reduced using the VORF LAT geoid/ellipsoid separation model.

The ellipsoidal heights from the computed solution were exported to a text file and the heights were reduced to the survey vertical datum with the same VORF LAT separation model used during acquisition.

QINSy was setup to apply the VORF LAT separation model to reduce the height observations of the C-Nav 3050 GNSS, which are accurate to +/-10cm utilising the C-Nav C2 correction service. This reduced LAT height, was applied to multibeam soundings to calculate the reduced depth.

6.5 Multibeam Bathymetry

The processed data files were gridded and reviewed in Qimera. The gridded surface was checked for data quality and accurate reduction in line with Bibby HydroMap data standards, and to ensure all ancillary data was applied correctly Qimera was used to correct and filter bathymetric data. Sound velocity corrections and post-processed heave were applied to data displaying issues.

Data editing was completed using a combination of tools provided by Qimera software including CUBE (Combined Uncertainty and Bathymetry Estimator) algorithms and manual editing, alterations being applied directly to the database. This allows the bathymetry surface to update immediate with the changes made by the processor, enabling real-time validation of the data editing.

CUBE processing involved the creation of a surface of hypotheses based on standardised CUBE algorithms. These hypotheses are then validated to remove the effects of spurious data and the bathymetry data filtered using the CUBE surface.

Predefined spline and IHO filters can also be used to de-spike the dataset. When using the predefined filters, the operator can adjust parameters of the filter to suit the dataset in terms of variation in the seabed or end use of data. One or more of these predefined filters can be applied to partial or entire data sets.

The bathymetry data surface is then validated, and any remaining noise or spurious data is manually filtered.

Once cleaned, a combined surface of the multibeam data was generated at 0.25m, 0.5m and 1m bin resolutions and used for the creation of seabed imagery and exports of XYZ files.

6.5.1 Bathymetric Quality Assurance

All bathymetry processing followed a structured workflow with clearly defined QC checkpoints. All filtering, corrections and comments were recorded in a detailed processing log prior to a full QC check. Each data output from the approved bathymetry surface was documented and checked before being added to the project charting.

Before the processed bathymetry surface was approved, the standard deviation and sounding density of the gridded surface were checked.

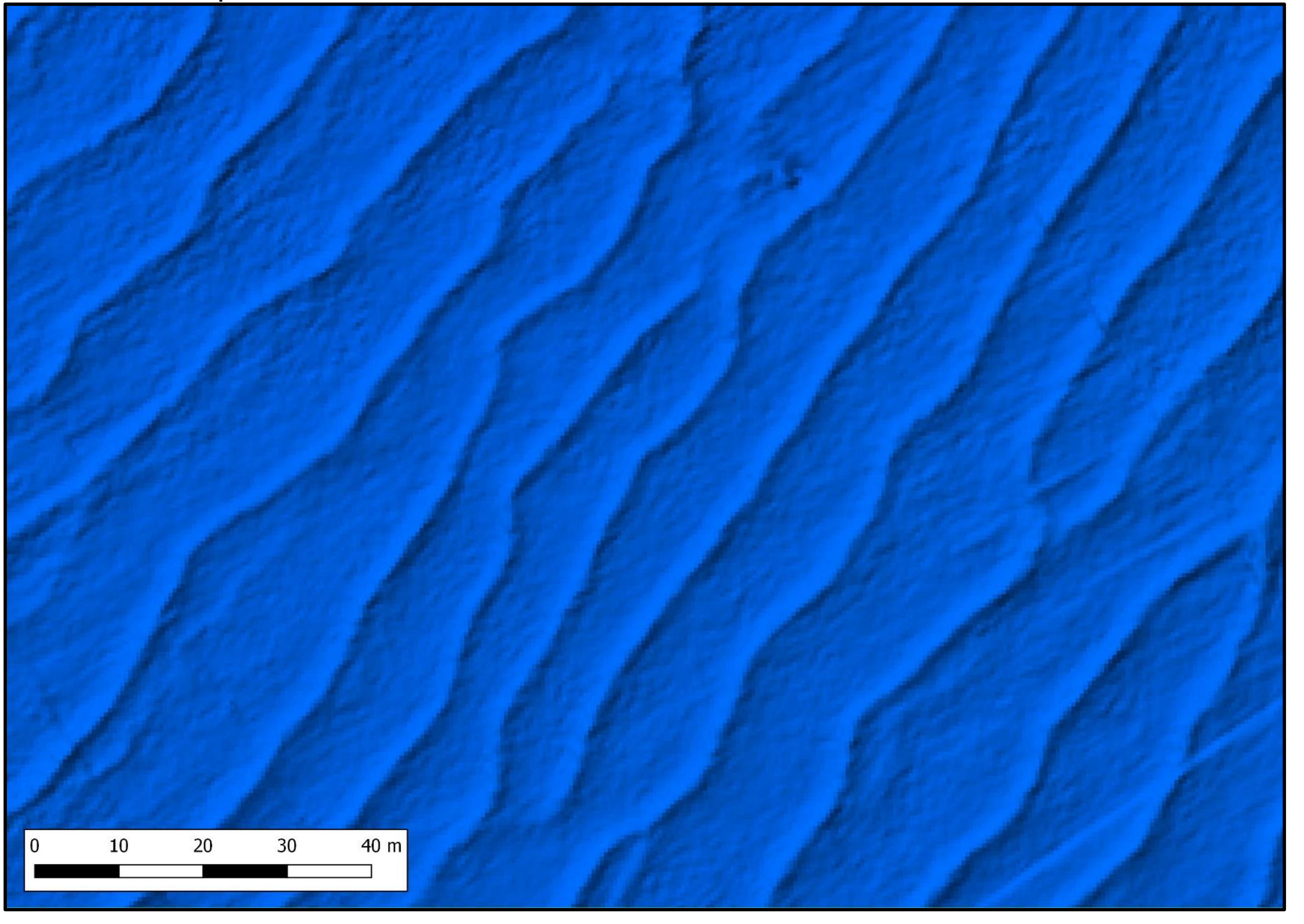
The computed standard deviation surface was used during processing to assess the quality of neighbouring swaths. Uniformly high standard deviation values on overlapping swaths indicate poor data correlation, relating to problems with the application of peripheral data and/or tidal reduction.

Standard deviation also highlights the roughness of the seabed surface. Flat and featureless seabed has low standard deviation, whereas a seabed with features such as exposed bedrock, mega-ripples, steep slopes and prominent wrecks usually have high standard deviation values. The average standard deviation of this survey is 0.05m, which was considered an acceptable level for this survey.

The sounding density surface assesses whether the processed bathymetry met the feature detection and data coverage requirements of the project. The scope of work for this project specified 40 soundings per gridded cell to provide an acceptable surface. The average sounding density across the survey area was calculated as 100 soundings within a 1m x 1m cell.

Full coverage was achieved, meeting project requirements for full seafloor search. The striping in the figure represents the overlap in multibeam swaths required to achieve complete ensonification. The feature detection criteria for the project have been achieved. The final gridded surface is binned at 0.5m, exceeding the minimum size of detectable features for the water depth. This bin size provided a sounding density exceeding the minimum of 9 soundings per cell assumed necessary for accurate feature detection.

Figure 3. MBES Data Example



6.6 Sidescan Sonar

Side scan sonar data were imported into, and processed in, Chesapeake Technology SonarWiz 7.3 software, allowing accurate picking of the seabed before applying a slant range correction before forming in to a mosaic.

The navigation data recorded in the side scan data during acquisition were filtered to remove any bad position fixes and create a smooth position interpolated for each sonar ping. The position of the side scan data were compared to the bathymetry to check that the position of significant seabed features match between the two datasets, within the specified tolerances. Adjustments were made if required. The data were enhanced in the mosaic window by applying an EGN (Empirical Gain Normalisation) and layering the data accordingly to create a final image of the seabed. Both high frequency (HF) and low frequency (LF) mosaics were produced and exported as Geotiff images at a resolution of 10 pixels per metre and 1 pixel per metre (ppm). These were then normalised and merged in Global Mapper, to then export 2km x 2km, and 10km x 10km (10ppm and 1ppm, respectively) tiled deliverables.

Targets were picked in SonarWiz on the waterfall display. In SonarWiz any target tags picked on overlapping lines were shown up on adjacent lines in the waterfall so that the same target was not picked and reported multiple times; this also allowed positional data to be verified. The dimensions of any relevant targets / debris, or those identified greater than 0.5m were measured.

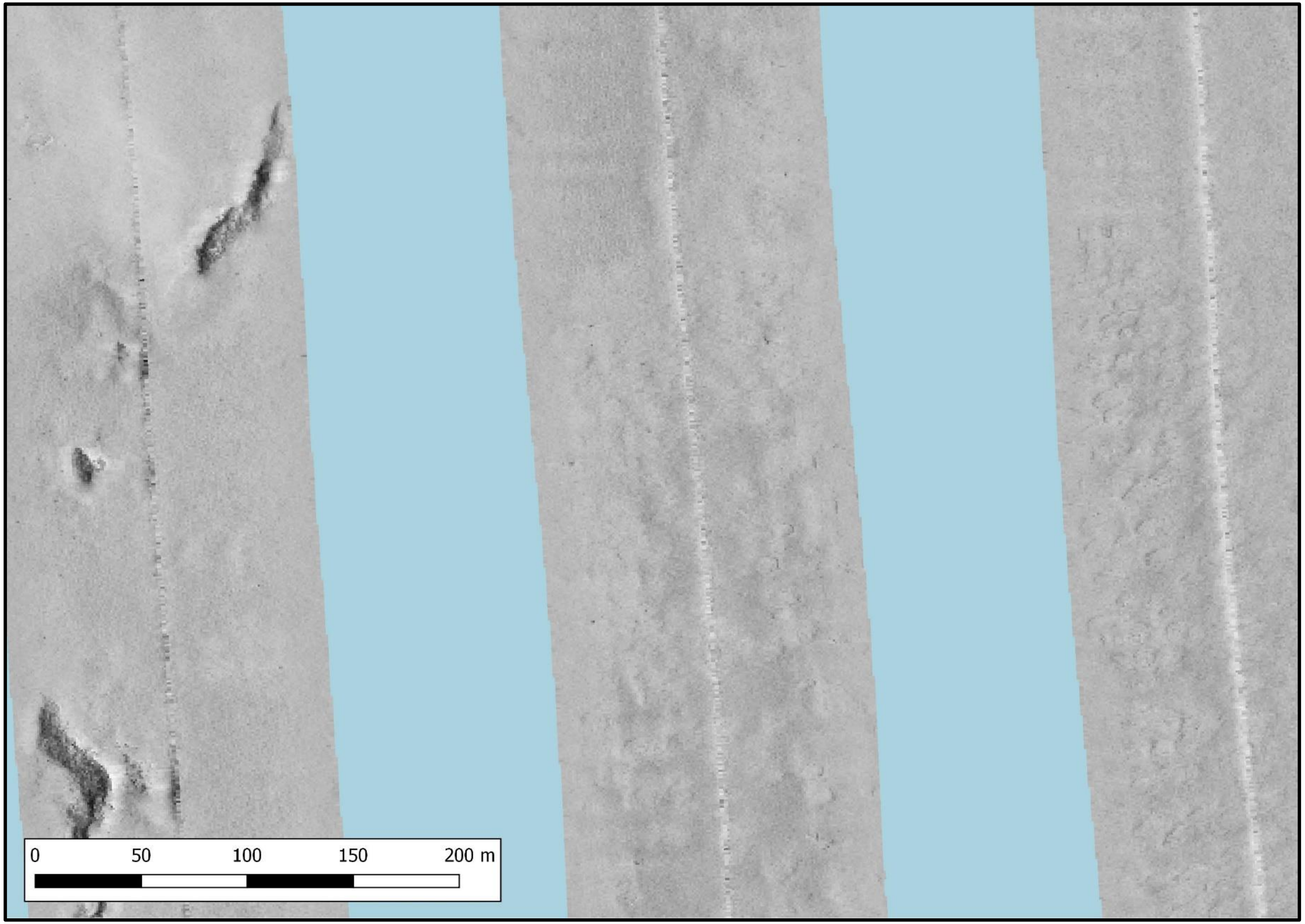
The GIS in SonarWiz window allows other datasets to be imported (e.g. bathymetry, magnetometer grids, etc.) and shows how they compare against the side scan sonar data. During processing, reference was made to magnetometer, bathymetry and seismic data to ensure integration with these datasets.

Confidence intervals were assigned to the buried contacts as follows:

1. Identified on one data file from one sensor only;
2. Identified on multiple data files from the same sensor (where there are overlapping files); however, contacts are too dense to reconcile individual objects;
3. Identified on multiple data files from one sensor only – position reconciled between files;
4. Identified on data files from multiple sensors – position reconciled between files; and
5. Position and interpretation verified with background information (wreck site, etc.).

The mosaic Geotiff and targets were exported from SonarWiz and imported into ArcGIS for QC, further integration with final datasets, and reporting.

Figure 4. SSS Data Example



6.7 Magnetometer

All magnetometer data were processed in Oasis Montaj allowing filtering to remove any long wavelength magnetic signals caused by diurnal variation and/or regional geology. The software was also used for gridding and interpretation of large magnetometer datasets to produce a target listing.

To begin this process, the navigation was de-spiked and smoothed by applying a non-linear filter. The altitude data was put through the same process.

Any spikes were removed from the total field data. Any resultant gaps in the total field data were not interpolated. Then a long wavelength approximation of the magnetometer data was undertaken, using a non-linear filter with a wavelength of 50 fiducials and a tolerance of 0.0001. This effectively used a sliding window to average the data set; the number of samples or window over which this averaging was performed was manipulated on individual lines by the interpreting geophysicist to correctly resolve relevant features. These averaged values were then subtracted from the de-spiked total field to produce a residual value.

Once a residual value was calculated, the data was gridded to a cell size of 0.5m with a blanking distance of 20m to help visualise the data and to produce plots of the residual values. This grid showed any trends in the data that can help identify cables, pipelines, potential UXO targets and geology.

The data was then interpreted, and anomalies were picked with a criterion of 5nT peak-to-peak and subsequently measured before a listing was exported and reported.

6.8 Sub Bottom Profiler

The heave compensated sub-bottom data was primarily post-processed for corrected navigation in ETRS89 UTM31N and corrected for time stamps, before being vertically corrected to VORF LAT vertical datum.

The navigation data was merged with the sub-bottom seismic data using a proprietary in-house algorithm. This algorithm oversamples the 1 Hz-sampled navigation data to 20 Hz and then applies a best-matching routine in the time domain to accurately coordinate the seismic from the navigation. Any remnant bunching and gapping of the sub-bottom pings was then treated using another proprietary in-house algorithm. Based on the statistics of the seismic dataset, these algorithms generated text file outputs to enable robust QC of both the blended navigation and the ping de-bunching/de-gapping.

For the creation of vertical corrected SEGY files, tide files were smoothed using a polynomial applied to the reduced GNSS heights using in-house MATLAB scripted software RUSH. The smoothed reduced height was converted to a time delay using the water sound velocities from the mini-SVS mounted adjacent to the MBES head. These calculations were included in the deliverable text file. The resultant time delay was applied to the SEGY trace data using RadExPro v2018.1.

After horizontal and vertical correction, the seismic signal was processed in RadExPro v2018.1 software package. Band-pass filters, burst noise removal, 2D spatial filter and amplitude corrections were applied to the data as described in the EBCDIC headers.

The processing sequence utilized for this project is detailed below:

Processing Sequence:

1) Heave Dynamic Correction;
2) Tidal Static Correction;
3) Bandpass Filtering: L/C 2000Hz Slope 8db/Oct, H/C Slope 5db/Oct 20000Hz;
4) Amplitude Correction;
5) Burst Noise Removal;
6) 2D Spatial Filtering; and

7) Amplitude Corrections.

The tide corrected SEGYs underwent QC in IHS Kingdom suite v2017. These were validated and attached to the project using SeismicDirect IHS module. Within Kingdom, the seabed-return, as seen in the SEGY data, was compared to LAT grids of the corresponding MBES data, having been converted to two-way time using average water column velocities from sound velocity profiles (SVP) carried out during the survey.

A small percentage of SEGY files still showed a small vertical difference of +/-0.3ms and +/-0.4ms from the bathymetry grid after the tide correction and a bulk static shift of +/-0.2ms was applied to these to provide a better match to the bathymetry and to the large percentage of SEGY files which showed a good vertical correlation of +/-0.2ms difference from the bathymetry grids.

The static vertical shifts were carried using RadExPro processing software.

6.8.1 Horizon Interpretation

Interpretation of significant geological horizons up to 10 m below the seabed was carried out using the tide corrected, processed SEGY data within in IHS Kingdom suite v2017. The interpretation was correlated between inline and cross lines, then cross referenced between the SSS mosaics, MBES and existing geotechnical data.

The seabed return was interpreted in RadExPro and edited in Kingdom with the horizon depth below seabed being calculated in Kingdom using a constant sediment velocity of 1600 m/s.

6.8.2 Buried Contact Interpretation

The peaks of diffraction hyperbolae, indicative of the top of buried targets, were picked on the heave compensated, tide corrected, processed sub-bottom data. Interpretation was carried out with reference to known infrastructure in the survey area and where possible, buried targets were assigned to such features as comments in the buried target listing.

Data interpretation was exported from Kingdom software programme and imported into ArcGIS software package

The complexity of the acoustic signal found in the survey area provided different levels of confidence in the picks. Confidence levels (1-5) were assigned to each buried target as follows to provide a quantified indication of the interpretation accuracy and positioning.

Confidence intervals were assigned to the buried contacts as follows:

1. Identified on one data file from one sensor only;
2. Identified on multiple data files from the same sensor (where there are overlapping files); however, contacts are too dense to reconcile individual objects;
3. Identified on multiple data files from one sensor only – position reconciled between files;
4. Identified on data files from multiple sensors – position reconciled between files; and
5. Position and interpretation verified with background information (wreck site, etc.).

6.9 Deliverables to MSDS Marine

Following processing of the data and contact picking of anomalies the following deliverables in Table 3 were provided to MSDS Marine for further archaeological assessment;

Table 3. Survey Deliverables to MSDS Marine

Sensor	Deliverables
Sidescan sonar	Gazetteer of all identified anomalies Shapefile of all identified anomalies Images of all identified anomalies Unprocessed nav corrected .XTF's Processed mosaics
Multibeam bathymetry	Gazetteer of all identified anomalies Shapefile of all identified anomalies Tidally corrected x,y,z files (both raw and processed/cleaned) Processed mosaics
Magnetometer	Gazetteer of all magnetic anomalies over 5nT Shapefile of all magnetic anomalies over 5nT Raw ASCII data Processed ASCII data Geosoft Oasis Montaj Project
Sub bottom profiler	Raw data as SEGY Processed data as SEGY

6.10 Archaeological Review

The archaeological review of data was undertaken by a qualified and experienced maritime archaeologist with a background in geophysical and hydrographic data acquisition, processing and interpretation.

Following delivery of the data from Hornsea Project Four, an initial review of the dataset was undertaken to gain an understanding of the geological and topographic makeup of the survey area. Within the extents of the survey area the potential for variations in the seabed are high and can affect the interpretation of contacts.

The interpretation report considers the full data extents. Whilst some of the data extends beyond the constraints of the development area the purpose of the assessment is to characterise the historic environment therefore all available data has been considered.

SSS is considered the best tool for the identification of anthropogenic contacts on the seabed due to the ability to ensonify small features and as such forms the basis of any archaeological assessment of data.

Magnetometer data indicates the presence of ferrous and thus usually anthropogenic material both on, and under the seabed. Where line spacing allows, typically to a specification for the detection of UXO, can provide accurate positions of buried ferrous anomalies. The survey line spacing for Hornsea Project Four ranges between 50m and 3km which is too great for the accurate positioning of magnetic anomalies. Where possible significant magnetic anomalies were correlated with contacts visible on the seabed.

Whilst SBP and MBES are useful tools for archaeological assessment their primary use, outside of seabed and paleo-landscape characterisation, is in the corroboration of contacts identified in the SSS and magnetometer data and establishing positional accuracy.

All contacts equal to, or greater in size than, 0.5m were assessed for archaeological potential primarily alongside the magnetometer data, however SBP and MBES data were used to corroborate identified contacts. The archaeological potential is based on the criteria in Table 4 below;

Table 4. Criteria for the Assessment of Potential

Potential	Criteria
Low	A contact potentially of anthropogenic origin but that is unlikely to be of archaeological significance – Examples may include; discarded modern debris such as rope, cable, chain or fishing gear, small isolated contacts with no wider context or small boulder-like features with associated magnetometer readings.
Medium	A contact believed to be of anthropogenic origin but that would require further investigation to establish its archaeological significance – Examples may include; larger unidentifiable debris or clusters of debris, unidentifiable structures or significant magnetic anomalies.
High	A contact almost certainly of anthropogenic origin and with a high potential of being of archaeological significance – high potential contacts tend to be the remains of wrecks, the suspected remains of wrecks or known structures of archaeological significance.

Where uncertainty existed as to the identification or archaeological potential of a contact the provided datasets were reviewed. SSS and SBP data were imported into Chesapeake SonarWiz 7.3 and reviewed on a line by line basis and MBES data were viewed in QINSy Cloud, Fledermaus or other point cloud visualisation software dependent on the requirement.

Contacts assessed as having archaeological potential were then compiled into a gazetteer and a shapefile created for further assessment alongside known features such as wrecks, mooring buoys, third party assets such as cables and pipelines and other seabed structures. The data are assessed in this way to ensure that contacts are not unnecessarily identified as having archaeological potential when the origination can be identified.

The interpretation of geophysical and hydrographic data is, by its very nature subjective, however with experience and by analysing the form, size and characteristics of a contact a reasonable degree of certainty as to the origin of a contact can be achieved.

Measurements can be taken in SSS, SBP and MBES processing software, and whilst largely accurate, discrepancies can be noted due to a number of factors. Where there is uncertainty as to the potential of a contact, or its origin, a precautionary approach is always taken to ensure the most appropriate mitigation for the historic environment.

It should be noted that there may be instances where a contact may exist on the seabed but not be visible in the geophysical data. This may be due to being covered by sediment or being obscured from the line of sight of the sonar. The use of both high coverage SSS and MBES data mitigates this by visualising contacts from multiples angles, including from above.

Contacts were named following the standard MSDS Marine naming convention. The contact ID originating from the geophysical contractor is retained within the gazetteers and Shapefiles. Should additional contacts be identified then their name will follow the same convention and the origination referenced in the final gazetteer.

6.11 Mitigation

To ensure the most appropriate and robust mitigation for the historic environment without unnecessarily impacting the development, mitigation recommendations will be determined on a contact by contact basis and will consider all available data including: potential significance, size, seabed type, seabed dynamics, the development type and potential negative impact. Mitigation strategies will be based on the criteria in Table 5 below;

Table 5. Mitigation Criteria

Potential	Criteria
Low	No archaeological significance interpreted. Maintain an operational awareness of the contacts location, and reporting through the agreed protocol should material of potential archaeological significance be encountered.
Medium	Avoidance of the contact's position and where appropriate an archaeological exclusion zone may be recommended. Ground truthing of the contact through the use of divers or an ROV would establish the archaeological potential.
High	Archaeological exclusion zones will be recommended based on the size of the contact, any outlying debris and the seabed dynamics as interpreted from the SSS and MBES data.

Where a contact is visible in the multibeam data, that position will generally be used for the implementation of mitigation recommendations. The position obtained from the multibeam data is generally more accurate due to the sensor and the GPS receiver being fixed to the vessel in known planes. SSS sensors are towed and thus the margin for error is greater even with USBL as the positional tolerance can be between 0.5m and 2.0m.

A phased approach to mitigation has been used for Hornsea Project Four corresponding with the planned future survey strategy. With the data resolution and coverage set to increase with each survey the confidence in interpretation and appropriateness of mitigation strategies will also increase.

At this phase a differentiation has been made between contacts that are visible and identifiable in the survey data, contacts that have been identified but where positions are not precisely known and potential contacts that have not been identified in the survey data but are likely to exist on the seabed.

The mitigation strategies detailed in Table 6 have been used;

Table 6. Mitigation Strategies

Strategy	Criteria
Archaeological Exclusion Zones (AEZs)	For contacts that are clearly identifiable in the survey data and where the extents are largely known Archaeological Exclusion Zones (AEZs) will be recommend. AEZs will remain for the life of the project or until ground truthing or higher resolution data determines a reduction in potential, significance or extents.
Temporary Archaeological Exclusion Zones (TAEZs)	Where a contact is not visible in the survey data but likely to exist on the seabed at a known position or where the extents of a contact are not fully identifiable Temporary Archaeological Exclusion Zones (TAEZs) will be recommended. TAEZs have been identified as highly likely to be altered following higher resolution or full coverage data assessment however they will remain in place until alterations have been formally agreed.
Areas of Archaeological Potential (AAP)	Areas of Archaeological Potential (AAP) are primarily reserved for magnetic anomalies where due to line spacing positions are not accurately known. AAPs demonstrate that there is potentially a contact of archaeological significance around the given position. The contact is likely to be identified following higher resolution or full coverage data assessment but as the nature and position is unknown no formal exclusion zone is recommended but instead a general awareness of the position is considered appropriate at this phase.

Following the assessment of higher resolution or full coverage data TAEZs and AAPs will be re-assessed and either removed or formal AEZs appropriate to the size of the contact recommend.

7. Results

A total of 222 contacts of potential anthropogenic origin were identified within the Project Four data, 129 of which fall within the PEIR boundary, these are categorised by potential in Table 7.

Table 7. Distribution of Contacts

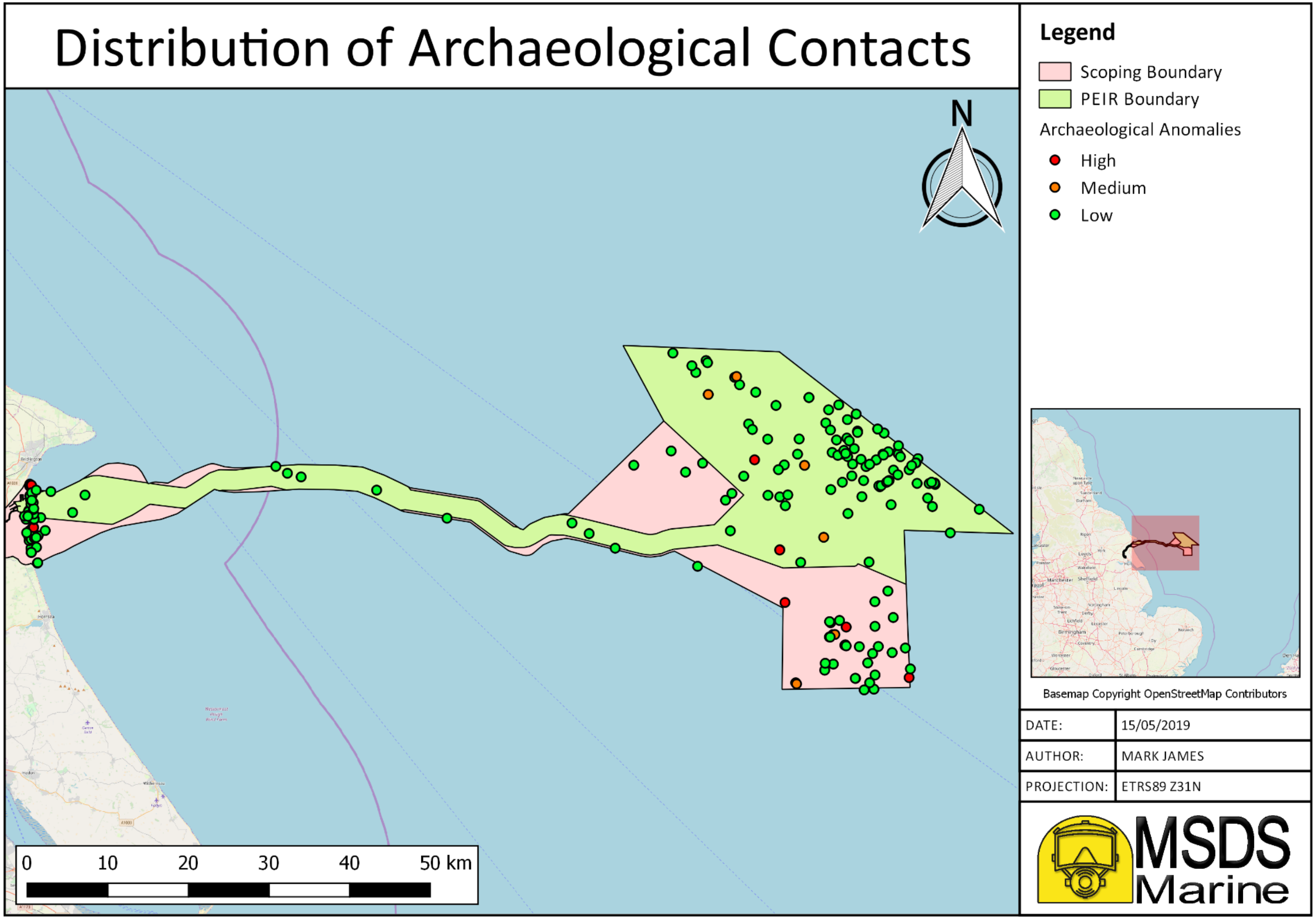
Potential	PEIR Boundary	Data Extents	Total
Low	123	84	**207**
Medium	4	2	**6**
High	2	7	**9**
Total	**129**	**93**	**222**

1311 magnetic anomalies, without strongly correlating visible contacts, or magnetic anomalies with corresponding features that are likely boulders, were identified within the survey data, 663 of which fall within the PEIR boundary. Whilst the vast majority of these are unlikely to be of archaeological interest, the presence of a magnetic anomaly generally indicates ferrous material and thus the contacts have been included for completeness. Magnetic anomalies have been discussed further in Section 8.

All contacts identified within the SBP dataset were interpreted as buried cables or pipes, correlated with contacts visible on the surface or are smaller contacts potentially indicating buried boulders or other geology or small debris.

The distribution of contacts is shown in Figure 5, as can be noted the distribution is fairly uniform across the surveyed areas with an increase on density towards the shore. This is a typical distribution and demonstrates a consistent approach to the assessment. The low, medium and high potential contacts are discussed below according to their assessed potential.

Figure 5. Archaeological Contact Location



7.1 Low Potential Contacts

207 contacts were identified as of low archaeological potential within the Hornsea Project Four area data, 123 of which fall within the PEIR boundary, the contacts can be broken down into broad categories as follows;

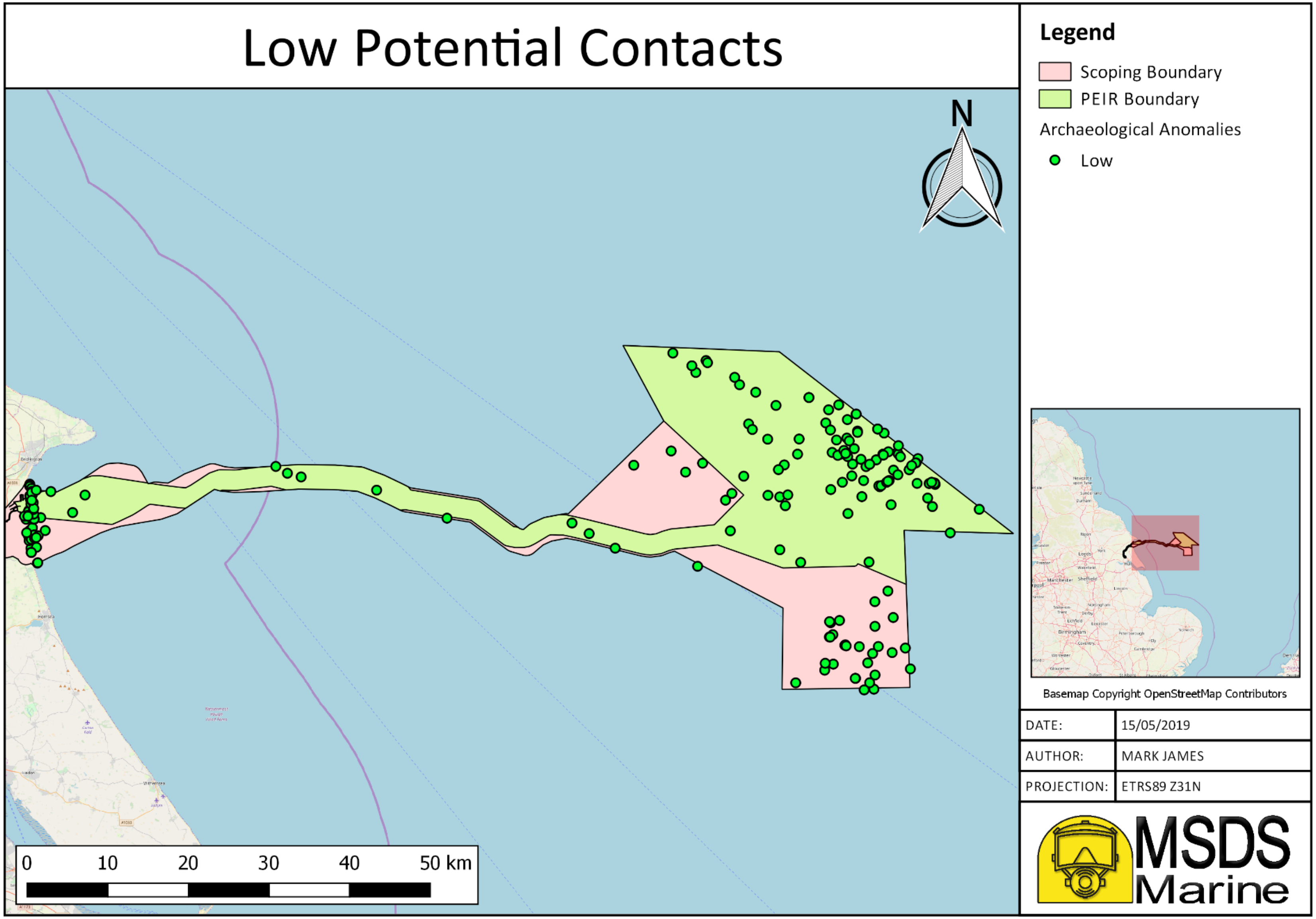
Table 8. Low Potential Contact Types

Type of contact	Number
Potential anthropogenic debris	103
Potential anthropogenic debris with associated magnetic anomaly	102
Potential mound	1
Potential wreck debris	1
Total	**207**

The contacts identified as low potential were a mixture of small features, often boulder like, or isolated linear features and modern debris such as rope, chain, fishing gear or lost equipment or seabed contacts with associated magnetic anomalies. Where certain of identification, anomalies such as fishing gear were removed from the dataset. Each contact was reviewed and established to be of low archaeological potential. a further review was undertaken following assessment of the whole area.

Low potential contacts have been assessed against all available evidence and are deemed to be unlikely to be of archaeological significance and as such will not be discussed further within the results section of this report. The distribution of contacts is displayed in Figure 6, further information regarding mitigation can be found in Section 10, more information regarding positions and dimensions can be found in Appendix A - *Gazetteer of Potential Archaeological Contacts*.

Figure 6. Low Potential Archaeological Contacts



7.2 Medium Potential Contacts

Six contacts were identified as of medium archaeological potential within the Hornsea Project Four data, four of which fall within the PEIR Boundary, the contacts can be broken down into broad categories as follows in Table 9 and the distribution is shown in Figure 7.

Table 9. Medium Potential Contact Types

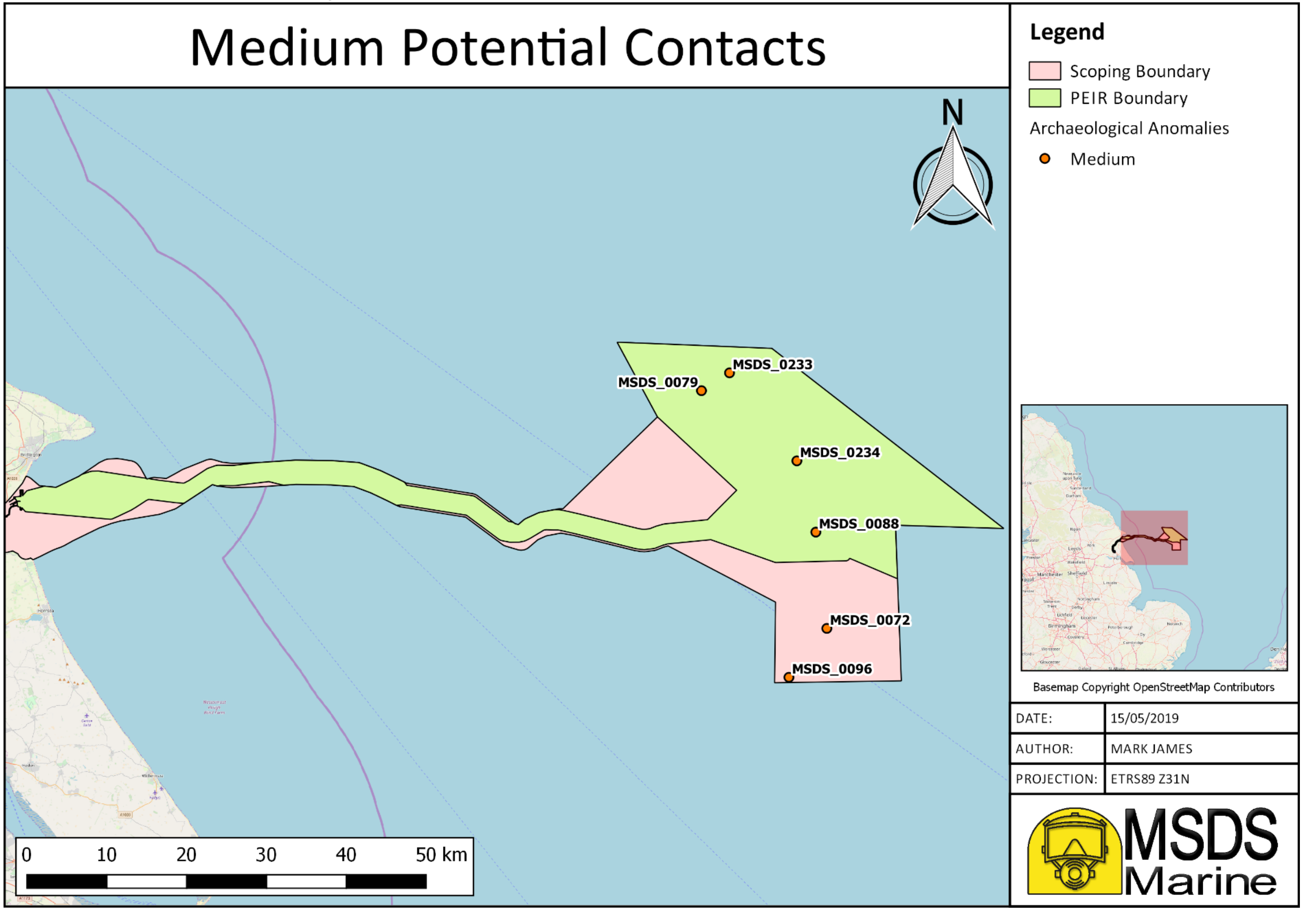
Type of contact	PEIR Boundary	Data Extents	Total
Potential wreck	0	1	**1**
Potential wreck debris	1	0	**1**
Potential anthropogenic debris	1	0	**1**
Mound	0	1	**1**
Potential anthropogenic debris with large magnetic anomaly	1	0	**1**
Potential ballast mound	1	0	**1**
Total	**4**	**2**	**6**

The contacts identified as being of medium archaeological potential range from a potential wreck to isolated anthropogenic debris.

The positions of large magnetic anomalies were investigated to identify mounds or disturbed seabed, indicating buried material, or potentially corresponding contacts that may indicate anthropogenic material over a wider area. Whilst contacts were identified with associated mounds or small scatters of potential debris, these were localised and fit with the criteria for medium archaeological potential.

All medium potential contacts identified during the assessment are discussed within Chapter 7.2 and presented in Figure 8 to Figure 13. Further information can be found in Appendix A – *Gazetteer of Potential Archaeological Contacts*.

Figure 7. Medium Potential Archaeological Contacts



7.2.1 Contact MSDS_HOW04_2019_ARCH_0072

Contact MSDS_HOW04_2019_ARCH_0072 (MSDS_0072 in Figure 8) lies within the data extents but outside the PEIR boundary and is a prominent mound, bisecting a sand wave and unusual in the surrounding area. The contact measures 12.3m x 5.8m and has a measurable height of 0.9m and is contained with no evidence of disarticulated material in the surrounding area. Mounds can represent buried, or partially buried anthropogenic material.

The contact is not associated with a magnetic anomaly, potentially due to being c.50m from the magnetometer, which could indicate geological origin. However, the prominence in the surrounding environment and the unusualness means that a medium potential rating is appropriate as anthropogenic origin cannot be discounted.

7.2.2 Contact MSDS_HOW04_2019_ARCH_0079

Contact MSDS_HOW04_2019_ARCH_0079 (MSDS_0079 in Figure 9) lies to the north-east of the array area within the PEIR boundary and is an approximately square feature 4.1m x 4.7m and with a measurable height of 0.3m. The contact is characterised by raised edges with a depression in the middle which corresponds with the surrounding seabed. The southern edge appears broken with potential debris visible.

The contact is not associated with a magnetic anomaly but lies c.30m from the magnetometer track. The form is unusual and regular which likely represents an anthropogenic feature although the origin is uncertain. The size and the form do not suggest a wreck, or wreck material, therefore a medium potential rating is considered appropriate.

7.2.3 Contact MSDS_HOW04_2019_ARCH_0088

Contact MSDS_HOW04_2019_ARCH_0088 (MSDS_0088 in Figure 10) lies to the south of the array area within the PEIR boundary and is a dense cluster of boulder like features over an area 22.0m x 12.3m. The features are contained within this area and the coverage is generally uniform with a few small bare areas of seabed. The contact is associated with a magnetic anomaly of 135.9nT indicating the presence of ferrous material.

The form is unusual in the surrounding area, but within hydrographic data could represent a boulder field. The presence of ferrous material could indicate anthropogenic origin and as such the feature could potentially be interpreted as a ballast mound. However, this interpretation should be approached with caution and thus a medium potential rating has been assigned.

7.2.4 Contact MSDS_HOW04_2019_ARCH_0096

Contact MSDS_HOW04_2019_ARCH_0096 (MSDS_0096 in Figure 11) lies at the southern edge of the data extents but outside the PEIR boundary and is a distribution of features over an area 70.2m x 16.8m and with a measurable height of 0.2m. Within the sidescan data the features could be interpreted as either a debris or bolder field. Within the multibeam data an irregularity within the surrounding sand waves in noted.

The feature corresponds with the UKHO record 9403, an area of debris swept clear at 29.9m in 1986. The record suggests a broken up wreck but no identity is given. The contact is associated with a magnetic anomaly of 7nT, which given the size of the potential debris field seems low. The form of the contact could indicate a wrecked vessel, albeit largely broken up, this would have been accentuated by the wire sweep in 1985.

The broken up and deteriorated nature of the site means it has been ascribed a medium potential rating, although recommended mitigation will be appropriate for its potential as a wreck site and the spread out nature of all the features.

Figure 8. Contact MSDS_HOW04_2019_ARCH_0072

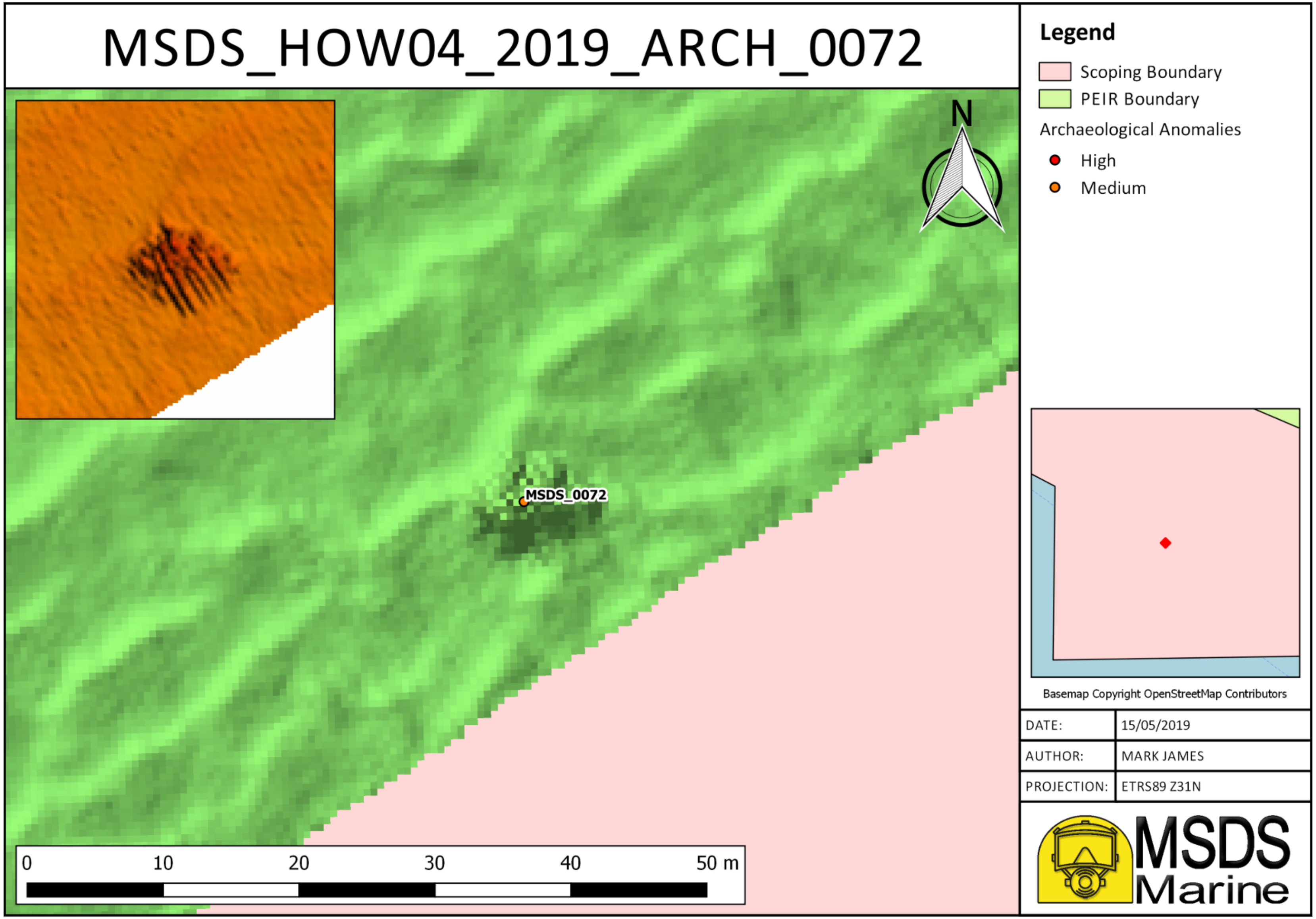


Figure 9. Contact MSDS_HOW04_2019_ARCH_0079

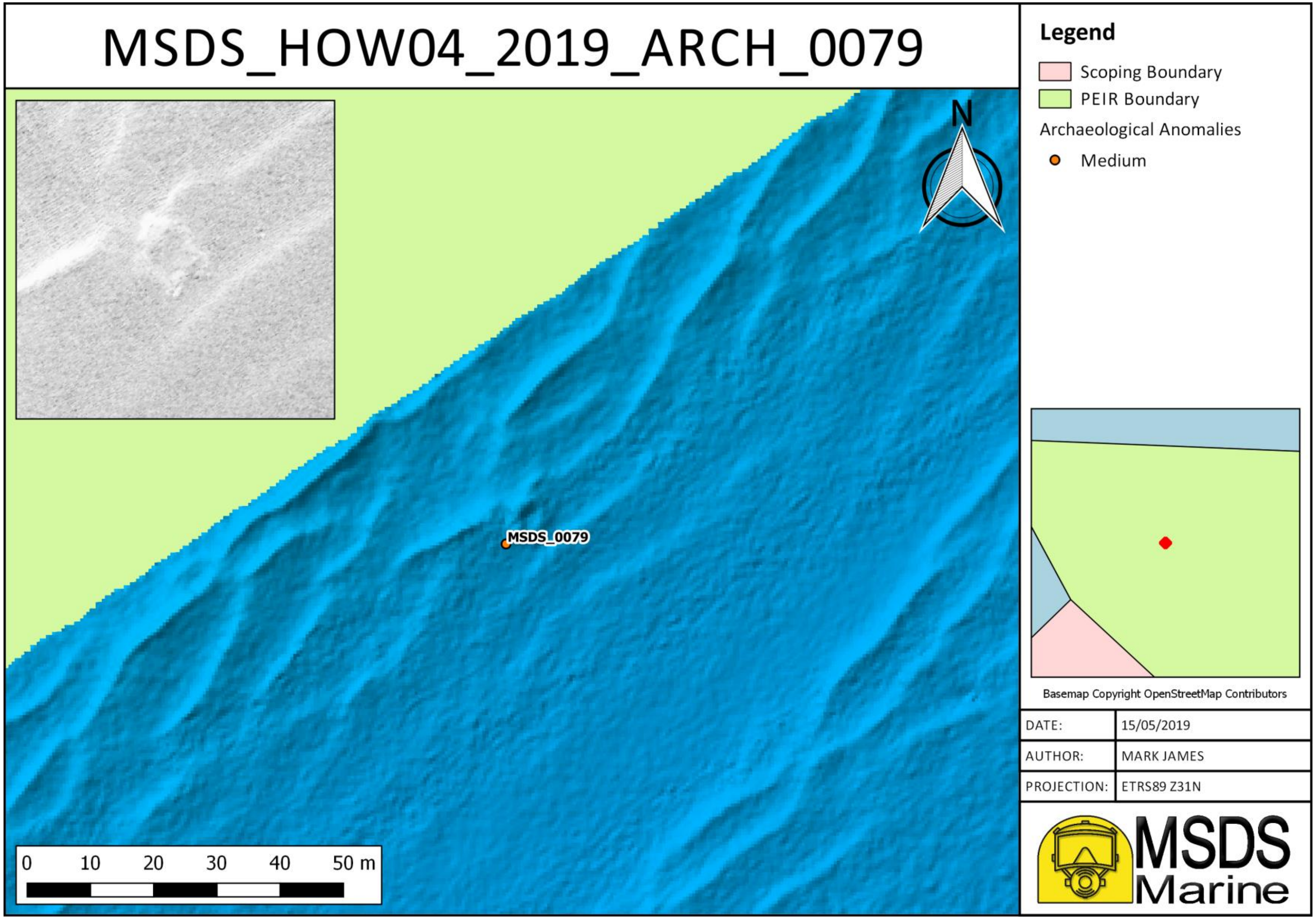


Figure 10. Contact MSDS_HOW04_2019_ARCH_0088

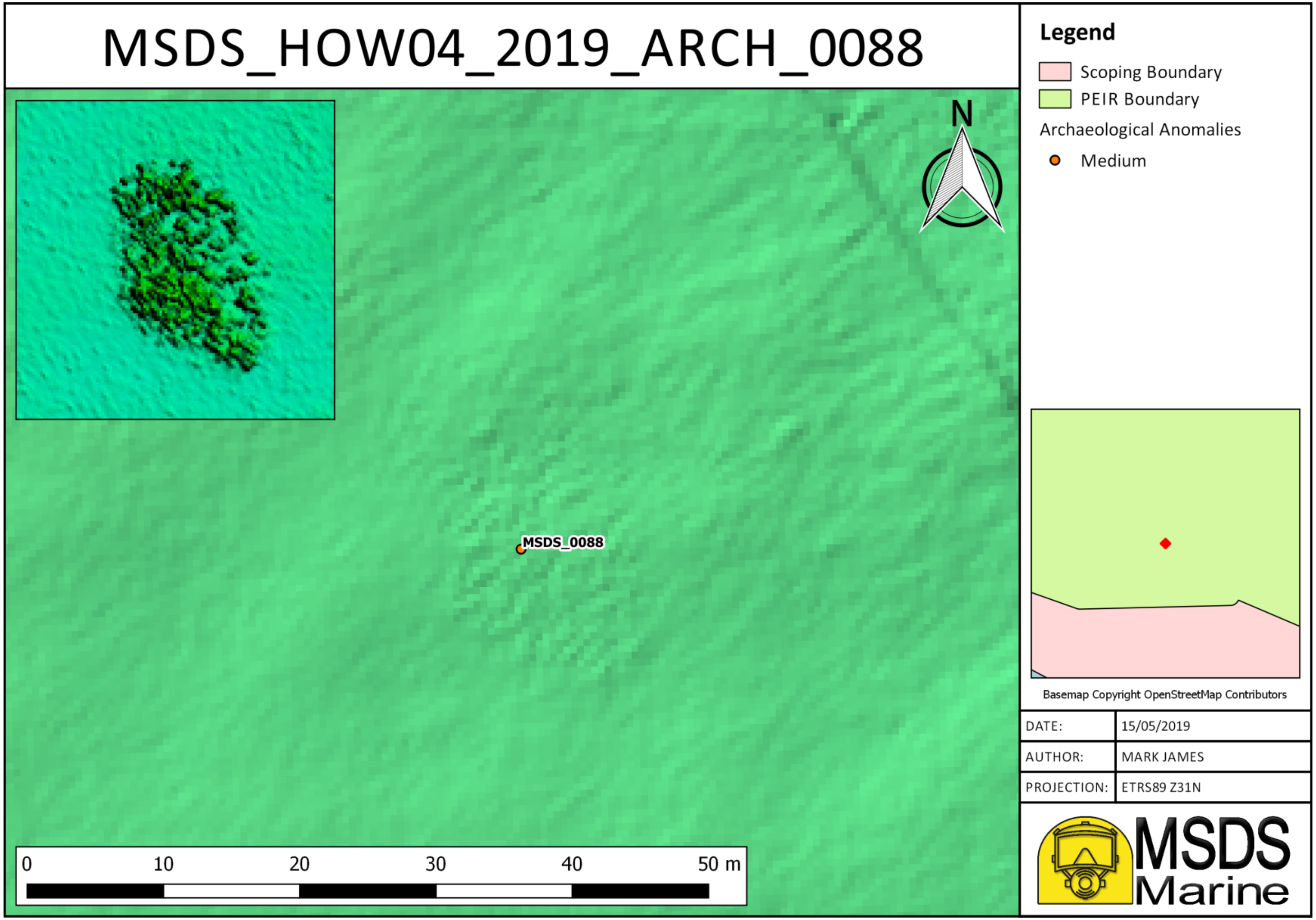
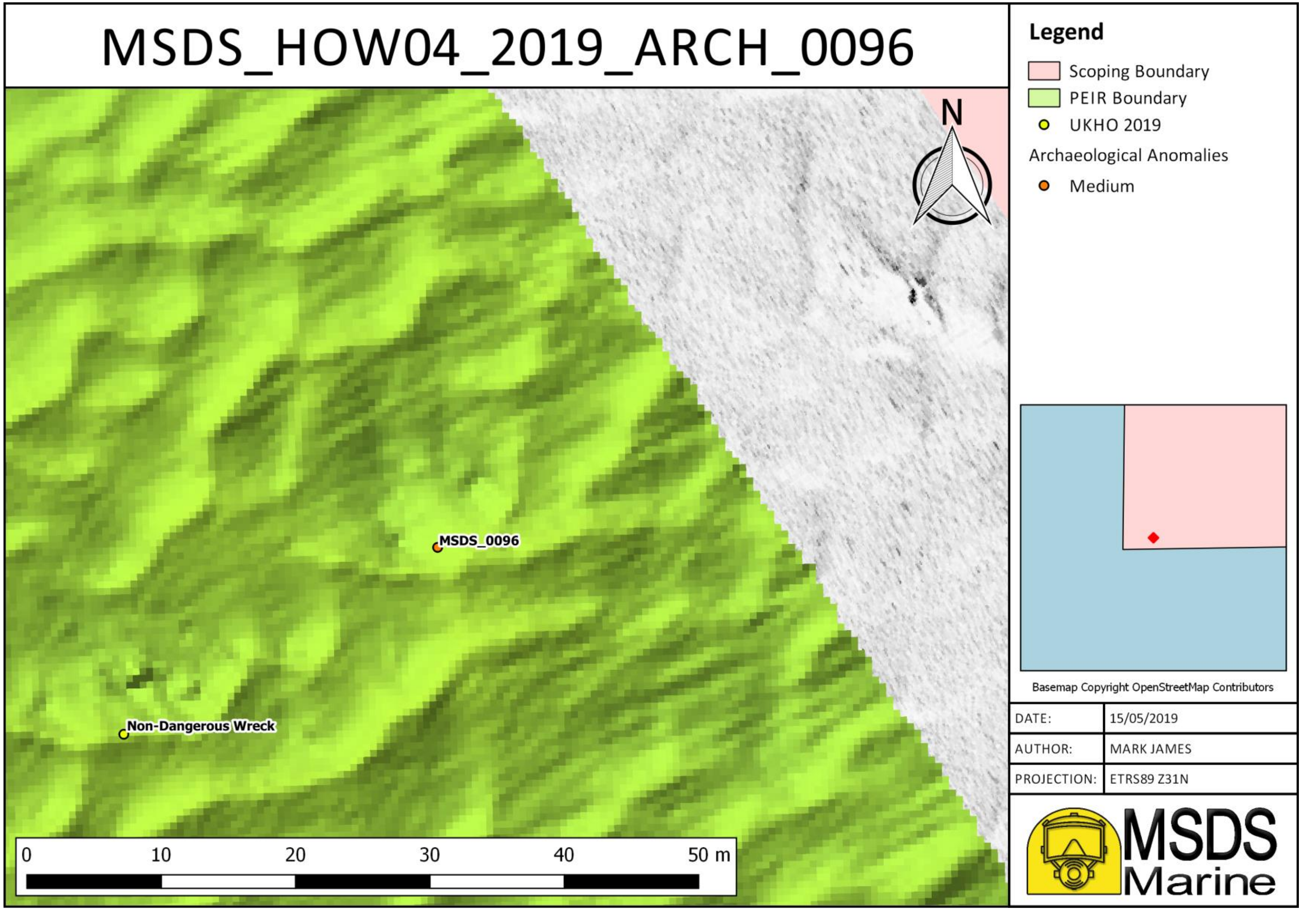


Figure 11. Contact MSDS_HOW04_2019_ARCH_0096



7.2.5 Contact MSDS_HOW04_2019_ARCH_0233

Contact MSDS_HOW04_2019_ARCH_0233 (MSDS_0233 in Figure 12) lies to the north of the array area within the PEIR boundary and is an area of disturbed seabed 25.4m x 10.4m at the far extents of the multibeam data. The feature is not dissimilar to other areas of seabed within the wider survey area but has been noted due to being c.100m to the north-east of UKHO contact 6830.

UKHO contact 6380 is the record of an extant wreck with measured dimensions of 36m x 16m originally detected in 1981 and last detected in 1986. Whilst the feature identified in the multibeam data is likely unrelated a precautionary approach means that it has been recorded within this assessment.

7.2.6 Contact MSDS_HOW04_2019_ARCH_0234

Contact MSDS_HOW04_2019_ARCH_0234 (MSDS_0234 in Figure 13) lies towards the centre of the array area and within the PEIR boundary and is a cluster of features over an area 16.6m x 7.7m. The main elements of the feature are concentrated within an area 10.3m x 7.7m with a smaller separate feature to the north. Of significance to the assessment as medium potential is the associated significant magnetic anomaly of 1653.8nT. The form and the magnetic anomaly suggest a significant quantity of ferrous material, potentially from the engine of a small wreck or a large quantity of lost/discarded chain.

Whilst the origin is undeterminable, the strength of the magnetic anomaly means a medium potential rating is appropriate.

Figure 12. Contact MSDS_HOW04_2019_ARCH_0233

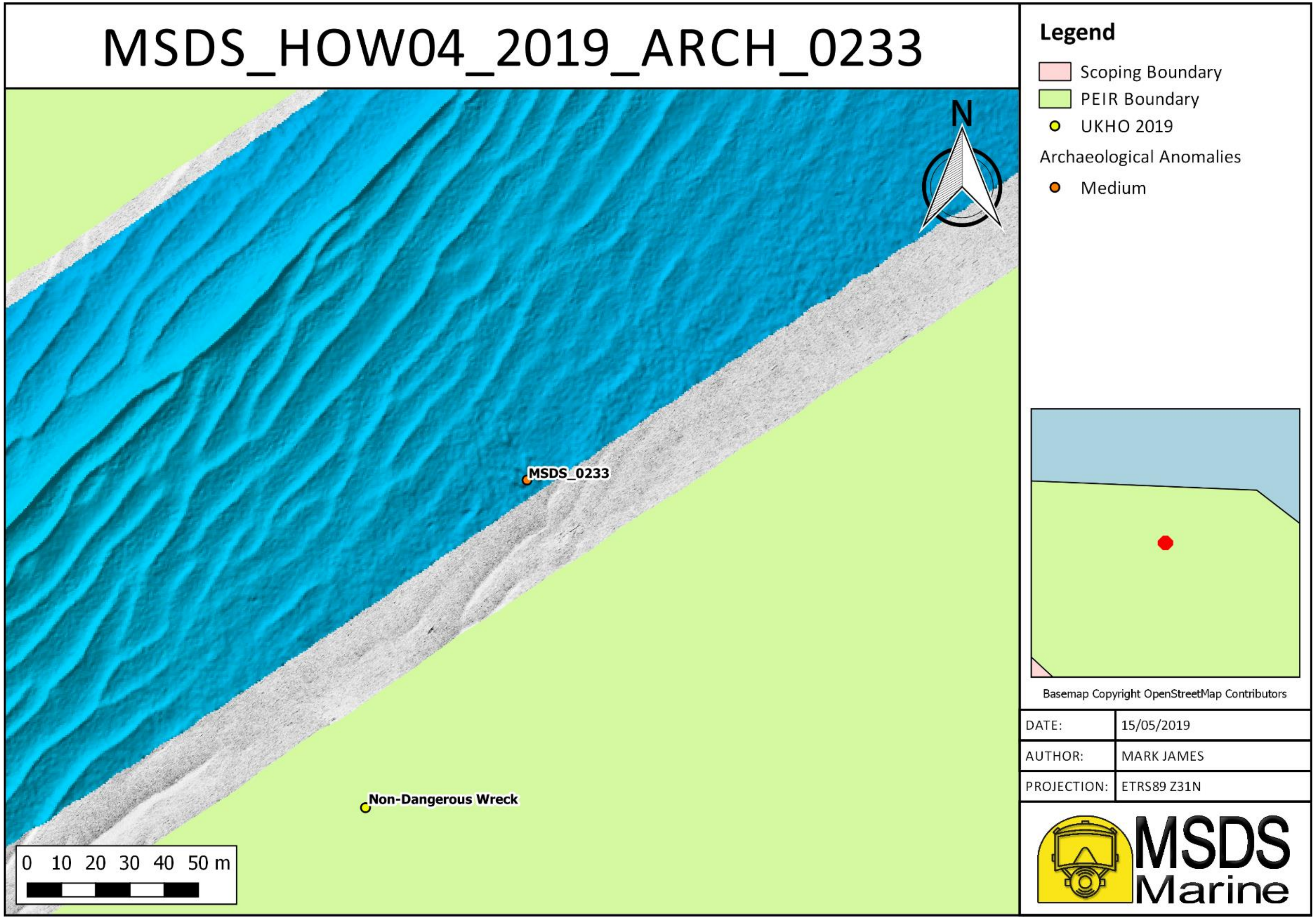
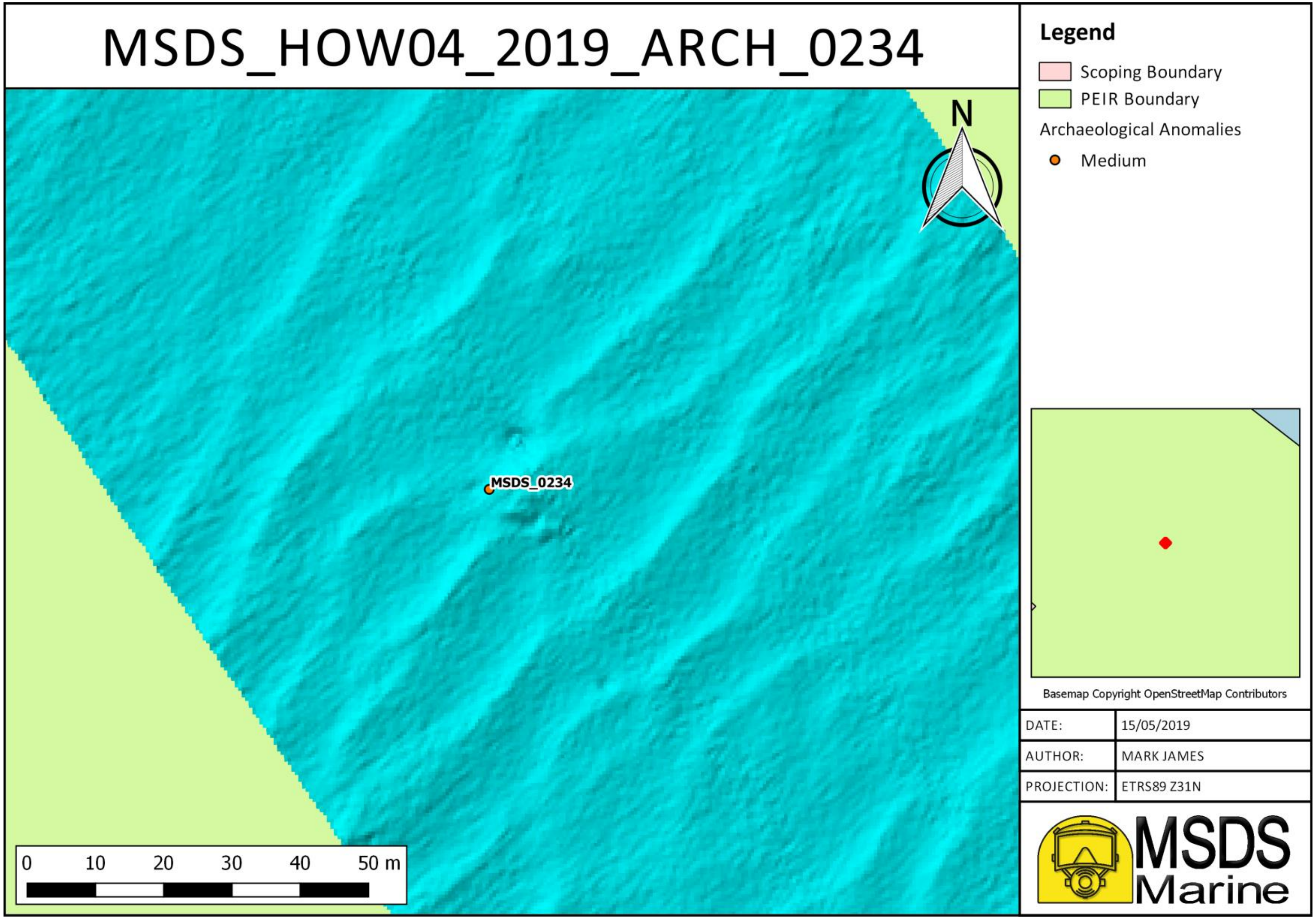


Figure 13. Contact MSDS_HOW04_2019_ARCH_0234



7.3 High Potential Contacts

Nine contacts were identified as of high archaeological potential within the Hornsea Project Four data, of which two fall within the PEIR boundary. The contacts can be broken down as follows in Table 10 and the distribution is shown in Figure 14.

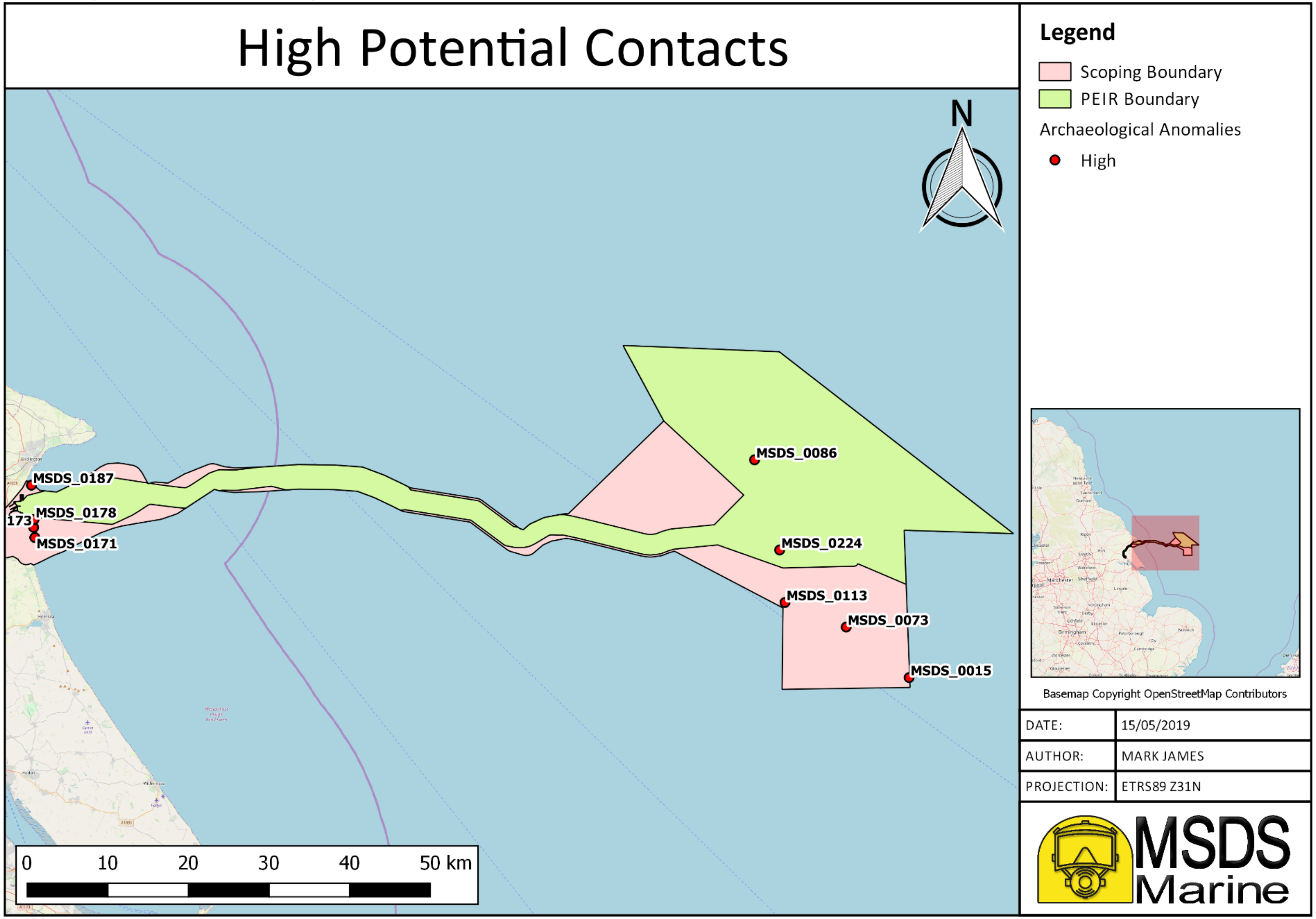
Table 10. High Potential Contact Types

Type of contact	PEIR Boundary	Data Extents	Total
Wreck	1	6	**7**
Potential wreck	1	1	**2**
Total	**2**	**7**	**9**

The contacts identified as of high archaeological potential have been interpreted as wrecks or potential wrecks. Five have corresponding UKHO records (or which three have been attributed an identity) and six have corresponding magnetic anomalies ranging from 23.5nT to 9581nt.

All high potential contacts identified during the assessment are discussed within Chapter 7.3 and presented in Figure 15 to Figure 23. Further information can be found in Appendix A – *Gazetteer of Potential Archaeological Contacts*.

Figure 14. High Potential Archaeological Contacts



7.3.1 Contact MSDS_HOW04_2019_ARCH_0015

Contact MSDS_HOW04_2019_ARCH_0015 (MSDS_0015 in Figure 15) lies to the south-east of the data extents outside the PEIR boundary and is the semi-coherent remains of a wrecked vessel 21.1m x 7.9m and with a measurable height of 3.1m. The wreck is associated with a significant magnetic anomaly of 8940nT. The wreck lies within an area of sand waves, whilst the outline of the vessel is clear there is the potential for further material to lie buried in the immediate area, other features in the surrounding area may indicate associated, partially buried, debris. The size of the magnetic anomaly and the coherent form likely indicate a steel vessel.

The UKHO record the wreck under record 9410, an unknown wreck located in 1986 and probably in an advanced state of decay. The measured length given by the UKHO is 40m which is not consistent with those taken during this assessment, this could be for a number of reasons including further degradation, partial burial or the measurement of conjoining sand waves.

The feature is clearly a wrecked vessel, but of unknown age and identity, there is evidence of further debris in the vicinity, therefore a high potential rating is considered appropriate.

7.3.2 Contact MSDS_HOW04_2019_ARCH_0073

Contact MSDS_HOW04_2019_ARCH_0073 (MSDS_0073 in Figure 16) lies to the south of the data coverage outside the PEIR boundary and is the coherent remains of a wrecked vessel lying towards the outer extents of the survey data and thus partially ensonified. The visible remains measure 32.4m x 9.6m and with a measurable height of 2.8m. There is no magnetic anomaly associated with the wreck, likely due to the distance of c.40m from the magnetometer track. The wreck material appears largely contained with material likely due to collapse at the north-western end.

The UKHO record the wreck under record 9377, the *Flirt* (possibly) a British ketch sank in 1897 following a collision with the Swedish steamship *Talis*. The *Flirt* was a small vessel of 60 tons and likely consistent with the measured dimensions. Although potentially only partially ensonified, the UKHO record the surveyed dimensions as 37m x 10m indicating that the majority of the wreck is visible.

The age of the wreck and apparent reasonable state of preservation indicate a high potential rating is appropriate.

7.3.3 Contact MSDS_HOW04_2019_ARCH_0086

Contact MSDS_HOW04_2019_ARCH_0086 (MSDS_0086 in Figure 17) lies to the east of the array area within the PEIR boundary and is an unusual contact consisting of a spread of potential debris over an area 34.1m x 15.7m and with a maximum measurable height of 0.3m. The feature is associated with a significant magnetic anomaly of 1960.4nT. The feature is characterised in the multibeam data by an area of disturbed seabed, and within the sidescan data as a prominent rectangular feature with further features to the north and the south-east.

The contact is not associated with a UKHO record.

The prominent rectangular feature and the significant magnetic anomaly make this feature unusual and the origin cannot be determined through the geophysical assessment. Therefore until further data is available a high potential rating is considered appropriate.

Figure 15. Contact MSDS_HOW04_2019_ARCH_0015

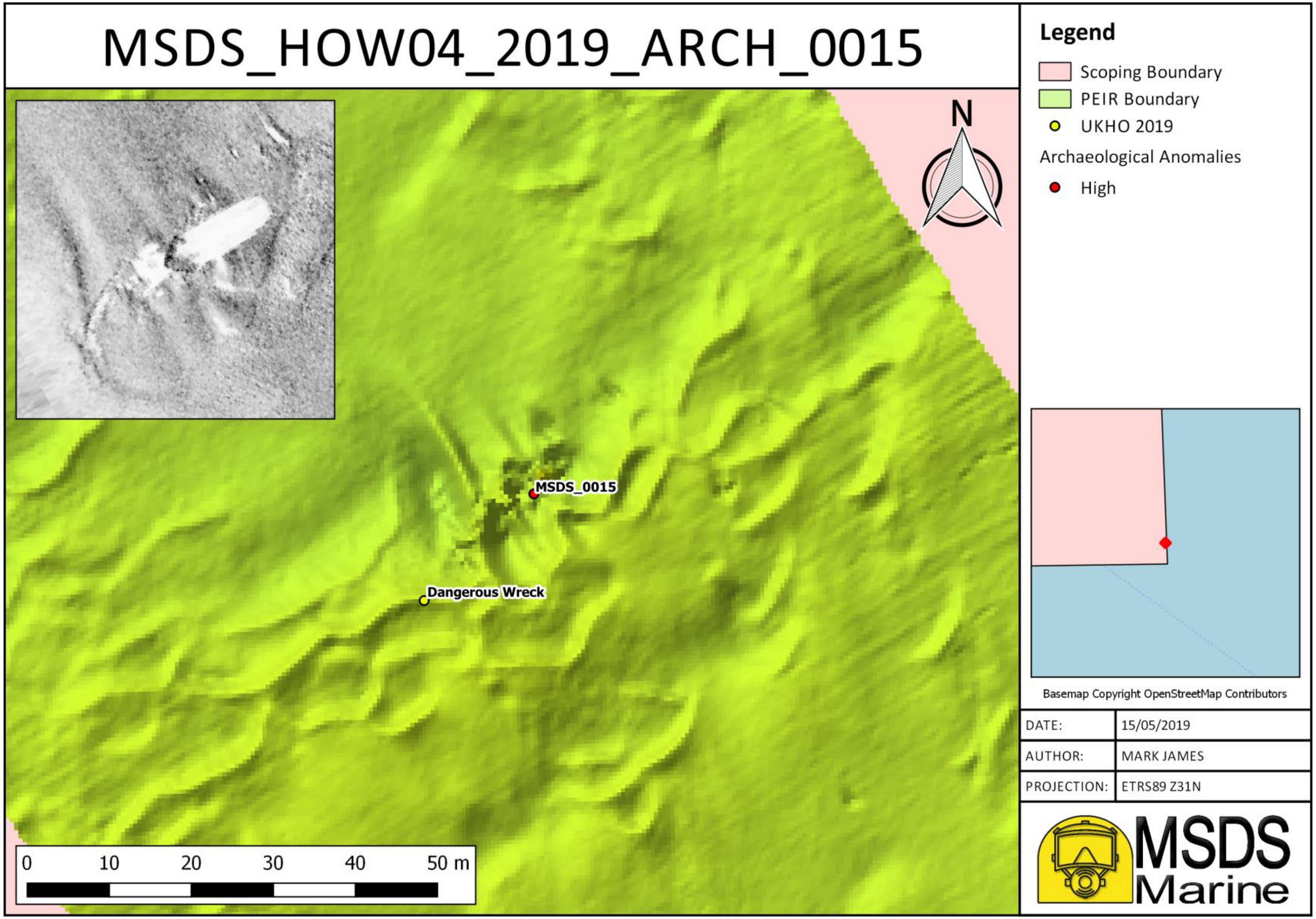


Figure 16. Contact MSDS_HOW04_2019_ARCH_0073

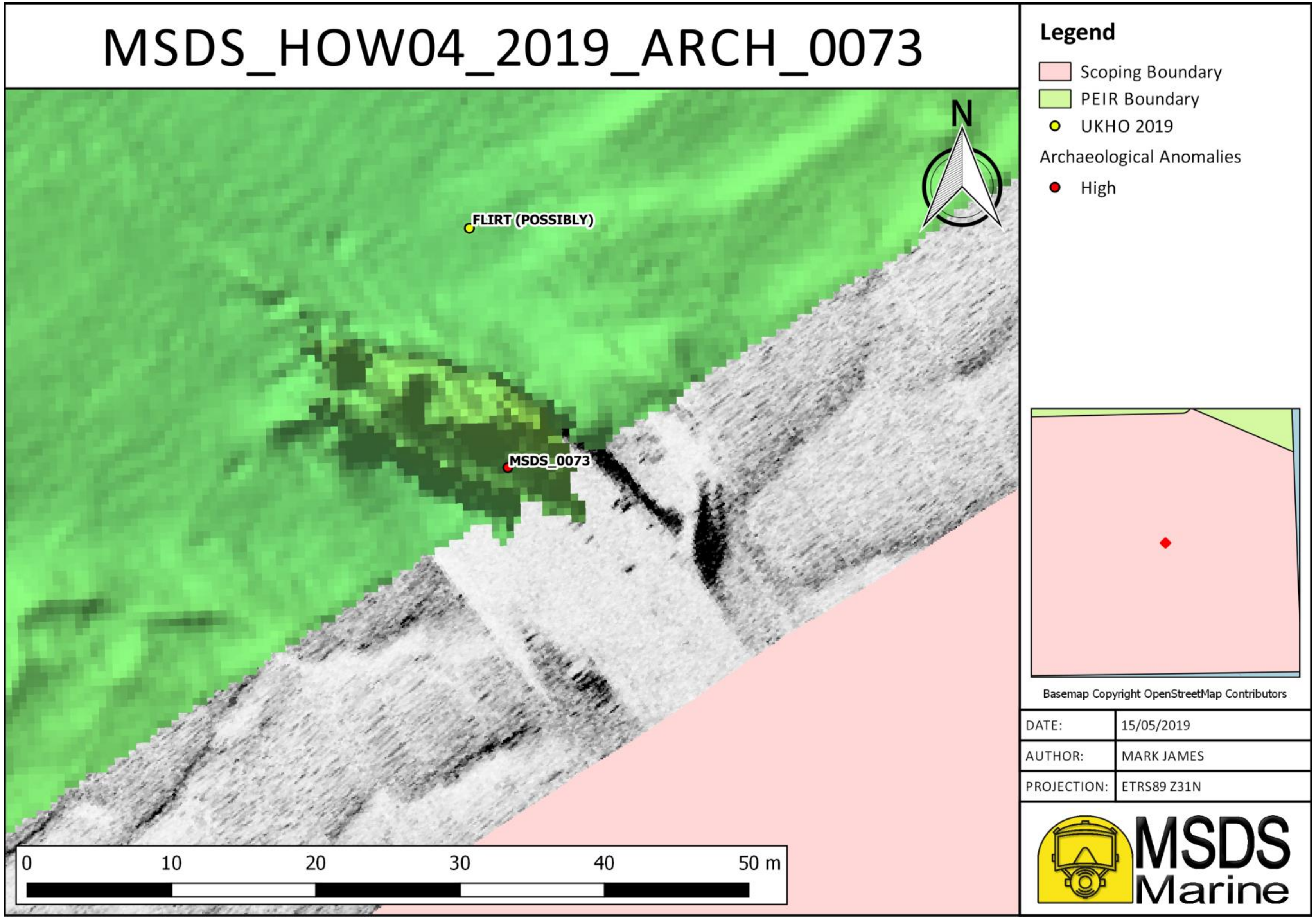
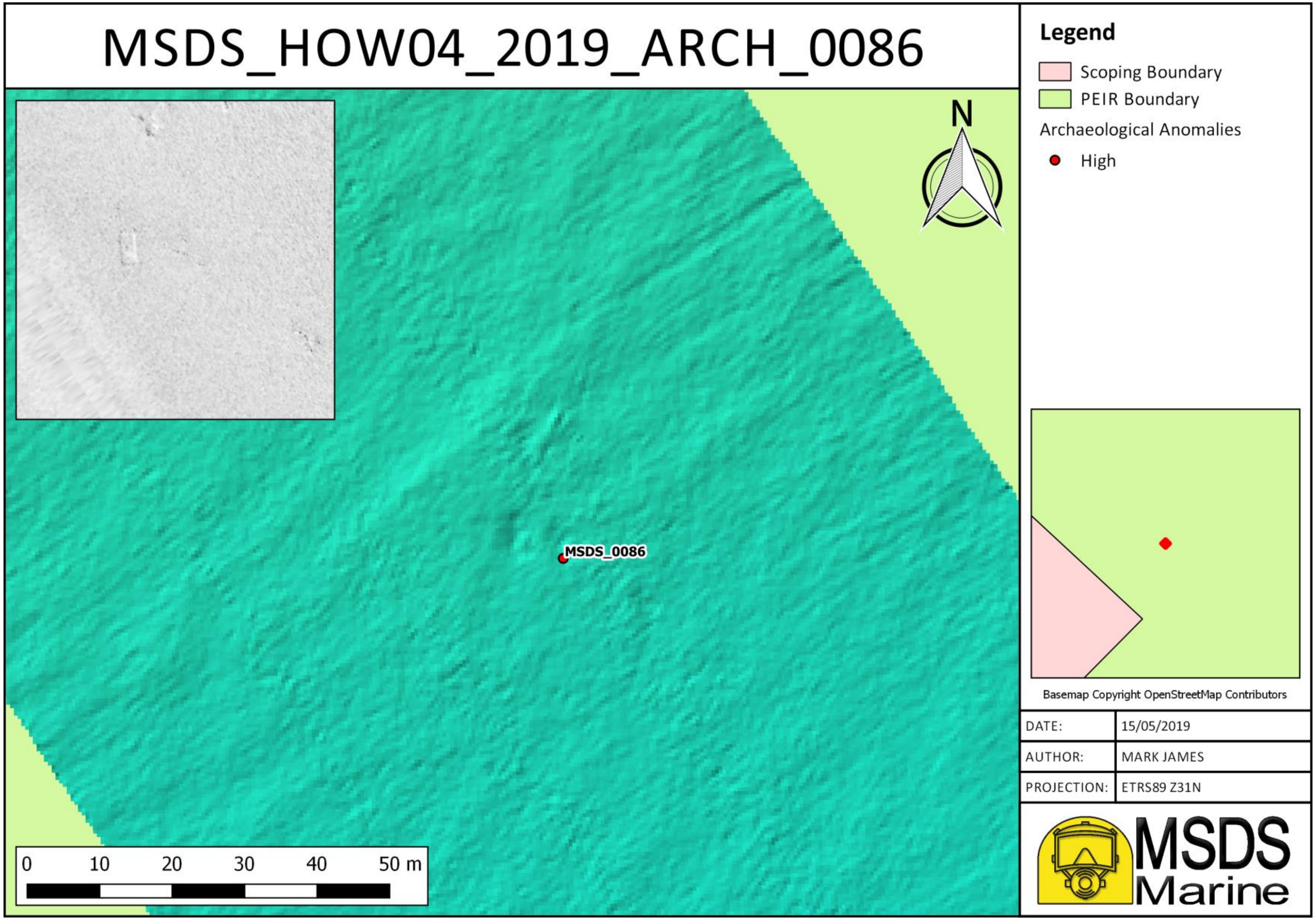


Figure 17. Contact MSDS_HOW04_2019_ARCH_0086



7.3.4 Contact MSDS_HOW04_2019_ARCH_0113

Contact MSDS_HOW04_2019_ARCH_0113 (MSDS_0113 in Figure 18) lies within the data extents but outside the PEIR boundary and is the coherent remains of a wrecked vessel measuring 21.1m x 7.7m and with a measurable height of 1.8m. The wreck lies within an area of sand waves with scour evident towards the end, potentially the stern. The wreck appears contained with little evidence of a debris field, although as with any seabed feature in areas of mobile seabed the potential for buried material is increased. It should be noted that three boulder like contacts extend to the north-west up to c.113m, whilst likely geological in origin, given the size of the wreck, the form of the contacts and the distance from the wreck, they have been detailed here for completeness. Additional survey works during the course of the project should provide further information as to their origin. The wreck is associated with a small magnetic anomaly of 23.5nT

The wreck is recorded with the UKHO under record 9401 as an intact wreck first identified in 1985 although the identity is unknown.

Due to the unknown age and identity of the wreck a high potential rating is considered appropriate.

7.3.5 Contact MSDS_HOW04_2019_ARCH_0171

Contact MSDS_HOW04_2019_ARCH_0171 (MSDS_0171 in Figure 19) lies to the western extents of the data close to shore but outside the PEIR boundary and is the likely remains of a wrecked vessel measuring 13.4m x 4.1m and with a measurable height of 0.4m. The wreck is outside the bounds of the multibeam data and has no corresponding magnetic anomaly. The wreck lies in a predominantly flat area of seabed on the edge of an area of small sand waves.

The wreck is prominent in the surrounding environment and characterised by defined straight edges along the length of the hull with visible deck beams or bulkheads. Both the bow and the stern are not visible in the data, potentially collapsed and buried. Some scour is apparent to the north-east.

The wreck is not recorded with the UKHO. Due to the unknown age and identity of the wreck a high potential rating is considered appropriate.

7.3.6 Contact MSDS_HOW04_2019_ARCH_0173

Contact MSDS_HOW04_2019_ARCH_0173 (MSDS_0173 in Figure 20) lies to the western extents of the data close to shore but outside the PEIR boundary and is the likely remains of a wrecked vessel measuring 15.5m x 4.2m and with a measurable height of 0.1m. The wreck is partially ensonified within the multibeam data appearing as a mound within a slight depression, there is no associated magnetic anomaly. The wreck is fully visible, as an outline, within the sidescan data. The wreck is characterised by a number of relatively regular features forming the outline of a vessel, potentially frames, the data appears to show a flat stern and a more pointed bow.

The identity, construction or origin of the wreck is not clear and it is not recorded with the UKHO. Thus, a high potential rating is considered appropriate.

Figure 18. Contact MSDS_HOW04_2019_ARCH_0113

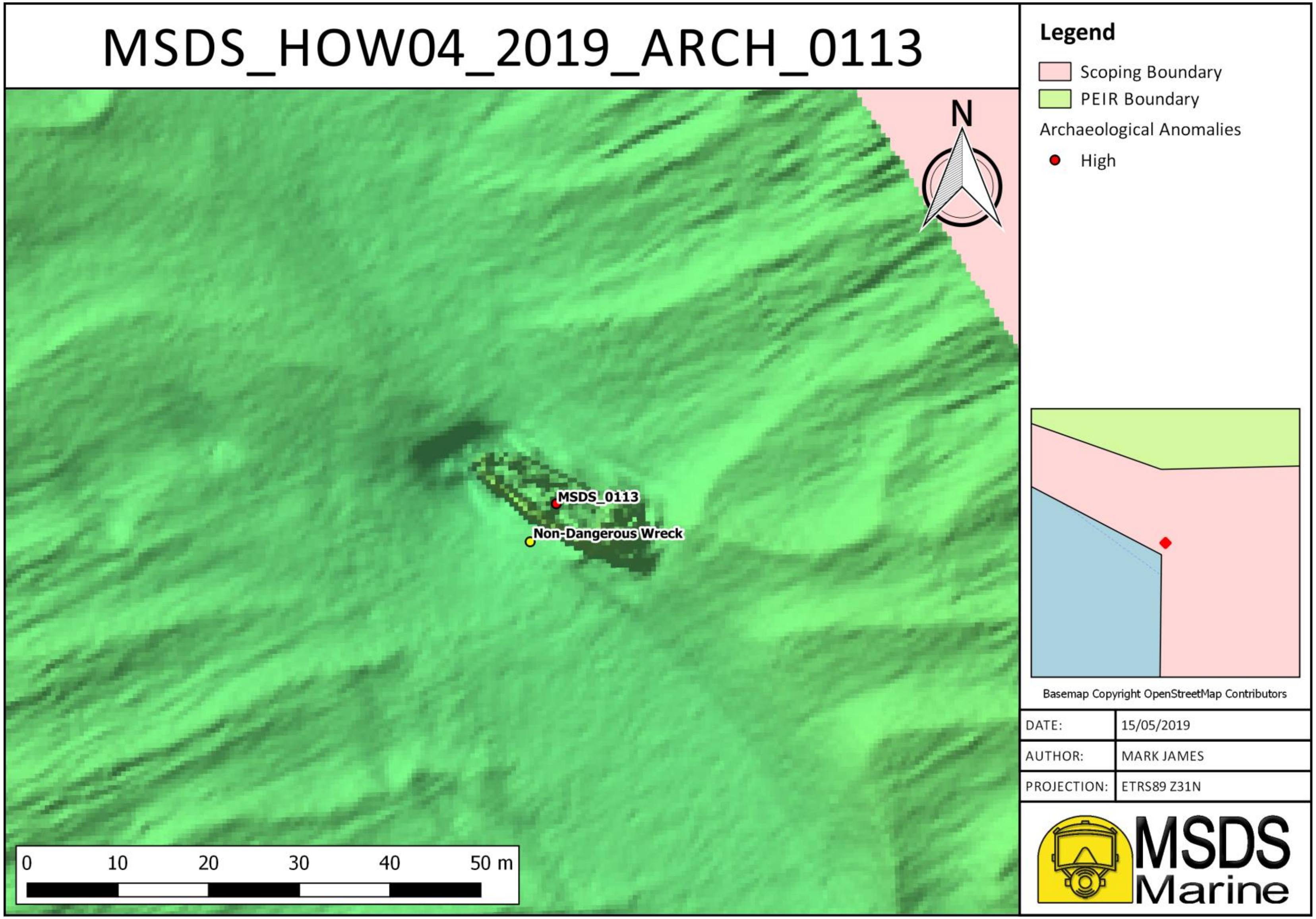


Figure 19. Contact MSDS_HOW04_2019_ARCH_0171

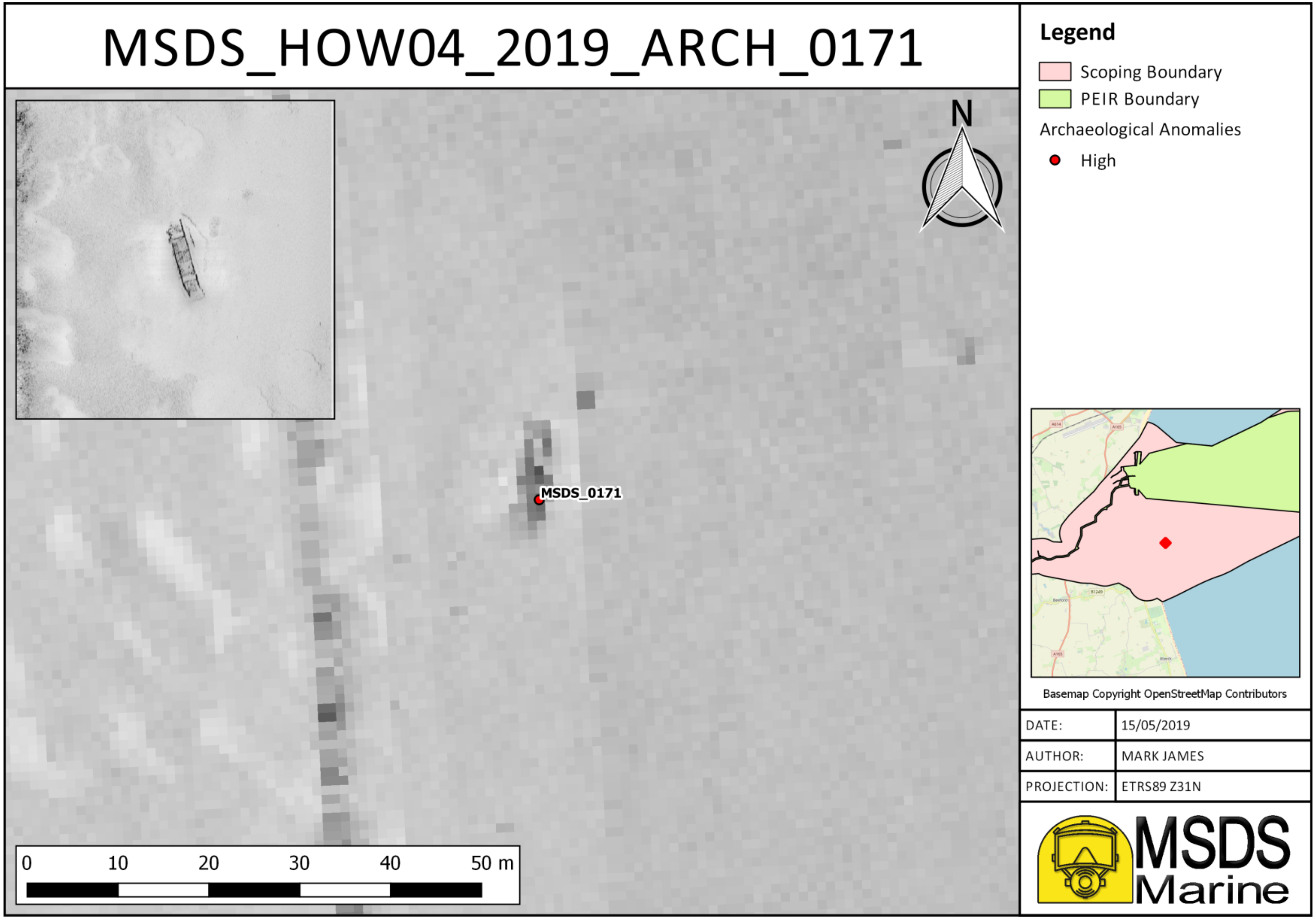
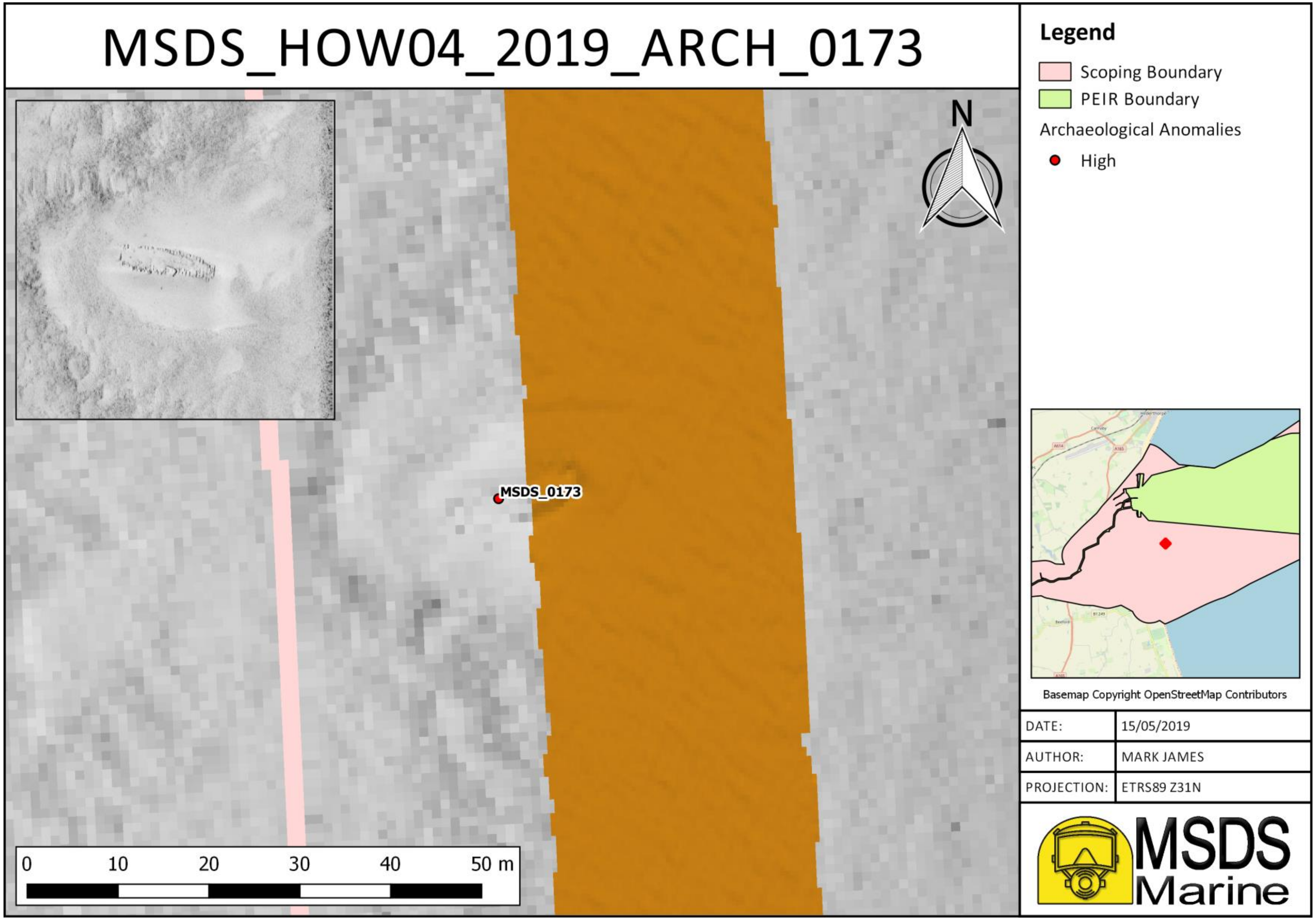


Figure 20. Contact MSDS_HOW04_2019_ARCH_0173



7.3.7 Contact MSDS_HOW04_2019_ARCH_0178

Contact MSDS_HOW04_2019_ARCH_0178 (MSDS_0178 in Figure 21) lies to the western extents of the data close to shore but outside the PEIR boundary and is the remains of a wrecked vessel covering an area 77.3m x 33.8 with a measurable height of 0.1m. The wreck appears steel in construction and is largely collapsed although structural elements such as frames are still visible. The main structure of the wreck is largely to the south-west with further material running c.50m to the north-east and the south-west. The wreck is associated with a significant magnetic anomaly of 9581.4nT. A number of further magnetic anomalies have been identified within c.100m of the centre point, whilst potentially related to the wreck they do not correspond with seabed features and thus have been included within the magnetic anomalies section of this report.

The UKHO records the wreck under record 5805, the aft section (the bow having been towed ashore) of the *Sote*. The *Sote* was a Swedish steamship of 76m built in 1883 and sunk by torpedo in 1918, the vessel was towed however the aft section broke off and was dispersed by explosives.

Although the wreck is dispersed, a high potential rating is considered appropriate.

7.3.8 Contact MSDS_HOW04_2019_ARCH_0187

Contact MSDS_HOW04_2019_ARCH_0187 (MSDS_0187 in Figure 22) lies to the western extents of the data close to shore but outside the PEIR boundary and is a prominent, distinct and isolated mound measuring 16m x 10m and with a measurable height of 1.3m. The surface of the mound is irregular, and likely made up of a number of individual features, similar to a mound of boulders. The feature is contained with no evidence of material scattered within the immediate area. The mound is associated with a magnetic anomaly of 790.8nT and is not recorded with the UKHO.

The origin of the mound is uncertain, and could potentially be a geological feature. However, the presence of a large magnetic anomaly indicates some material of anthropogenic origin within, or on top, of the mound. The size of the magnetic anomaly could indicate that the mound is related to a wrecked vessel, such as a ballast mound and as such a high potential rating is appropriate.

7.3.9 Contact MSDS_HOW04_2019_ARCH_0224

Contact MSDS_HOW04_2019_ARCH_0224 (MSDS_0224 in Figure 23) lies towards the southern edge of the array area inside the PEIR boundary and is the semi-coherent remains of a wrecked vessel measuring 39.2m x 15.5m and with a measurable height of 4.0m. The outline of the vessel is visible and defined with some apparent collapsing to the northern end. Along the north-east edge, and outboard, higher points are visible, this could be debris from the wreck as this area appears more collapsed or an accumulation of sediment. Scour on the wreck is predominantly towards the north. The wreck is associated with a significant magnetic anomaly of 1938.4nT.

The UKHO records the wreck under record 9400, the possible wreck of the *Lapwing*. The *Lapwing* was a British fishing trawler of 217 tons sunk after a collision with a British mine in 1940. The vessel was requisitioned by the Admiralty for periods during WWI and WWII, each time returned to the owners. The vessel was in the possession of its owners at the time of sinking.

Figure 21. Contact MSDS_HOW04_2019_ARCH_0178

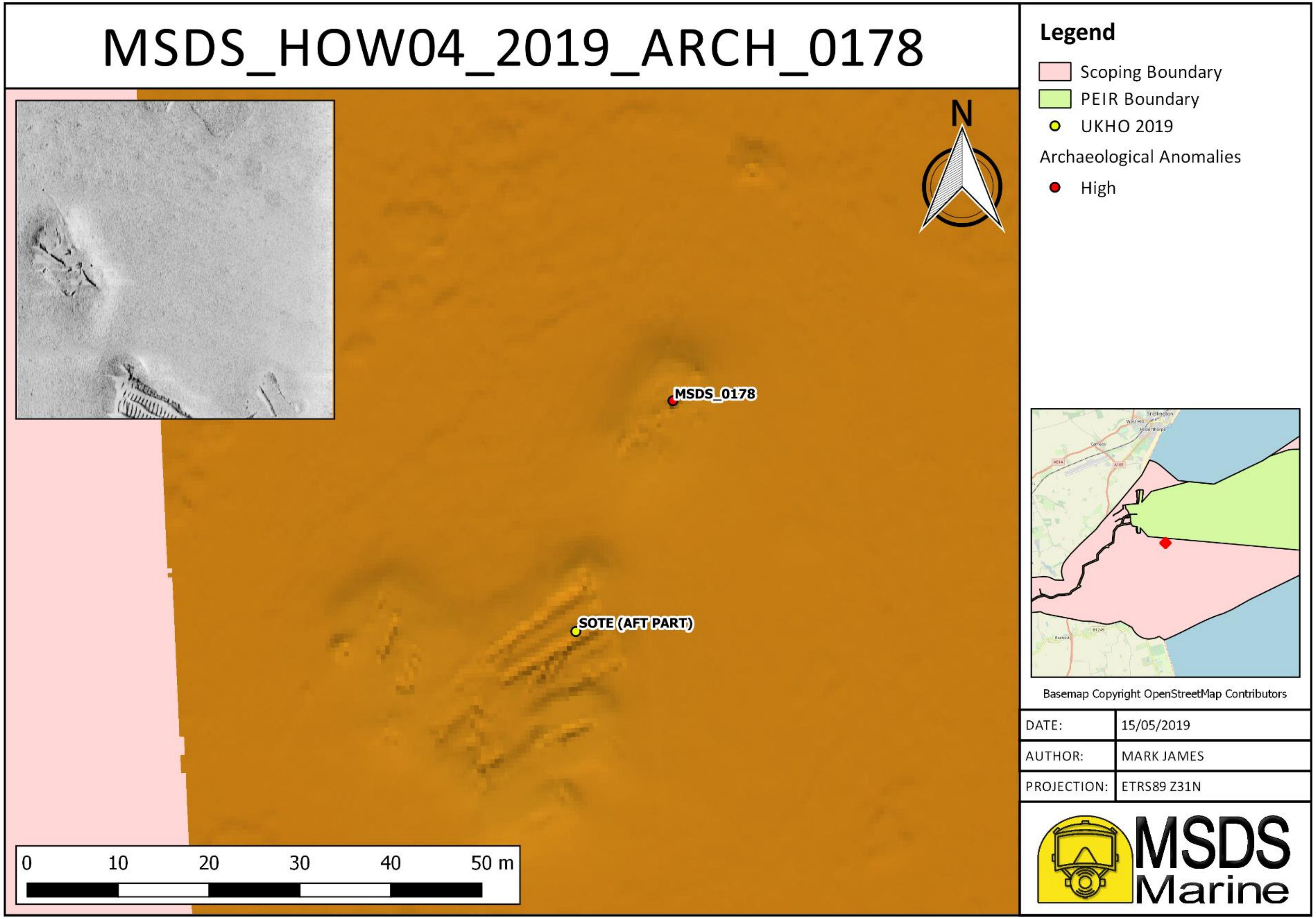


Figure 22. Contact MSDS_HOW04_2019_ARCH_0187

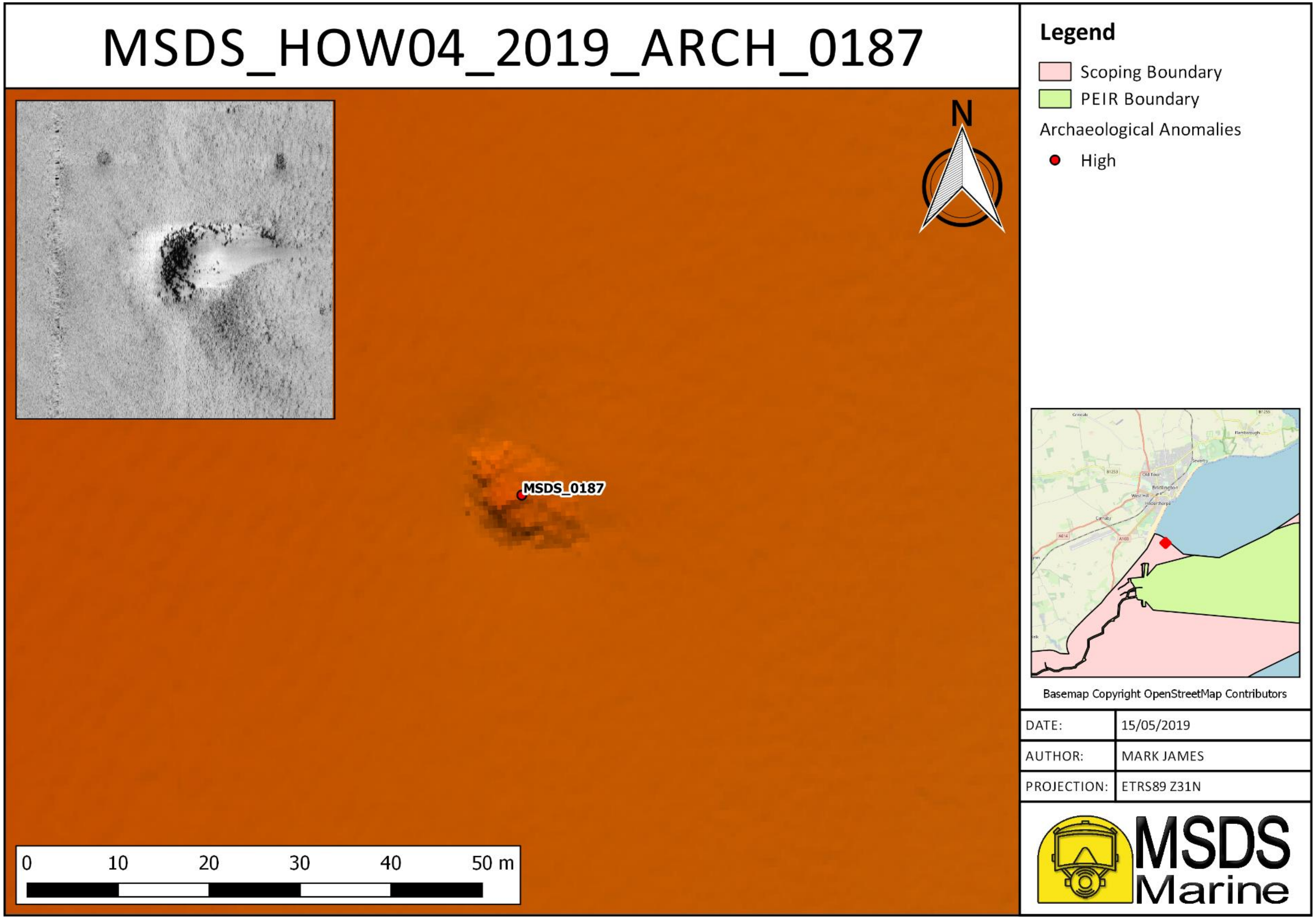
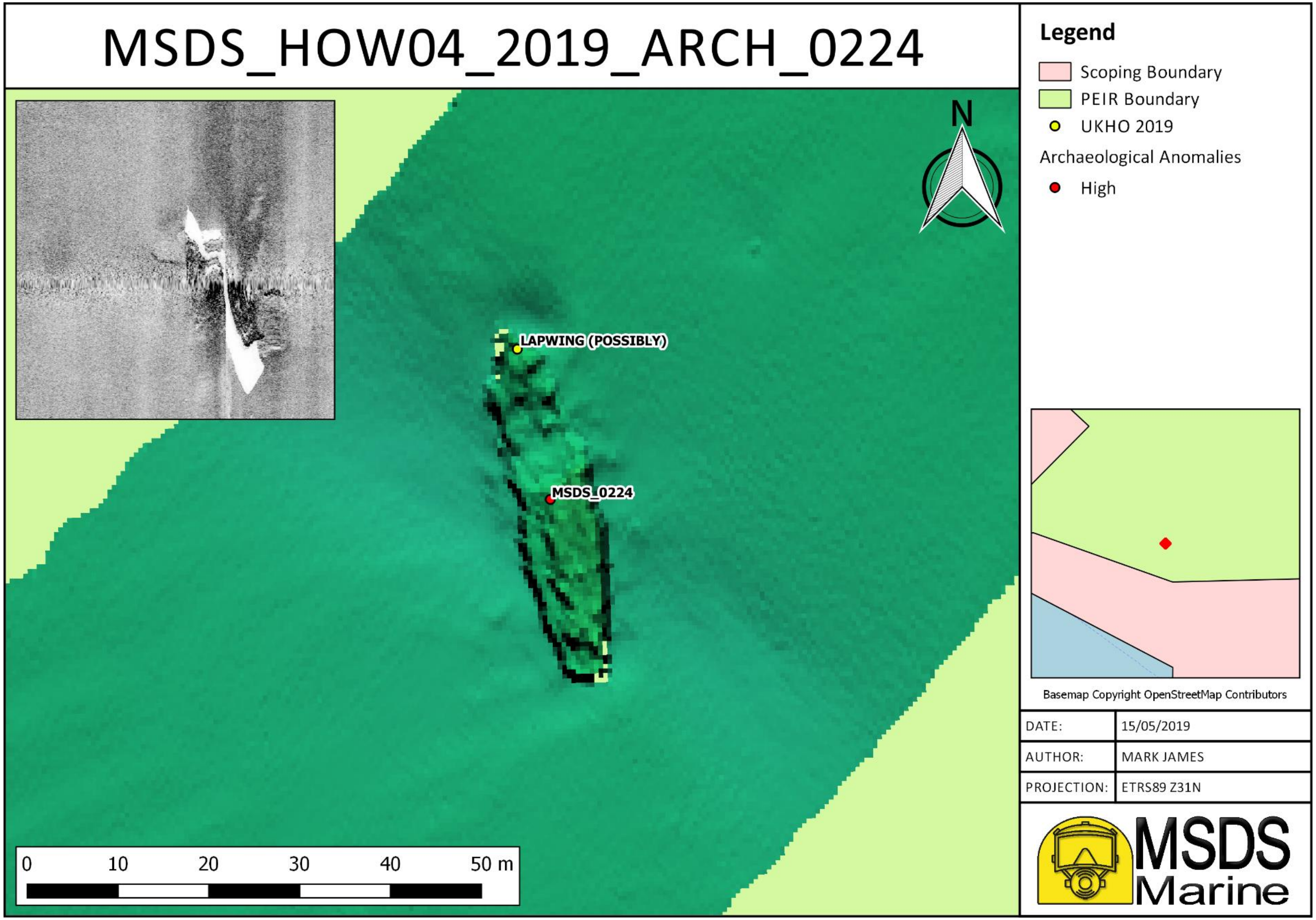


Figure 23. Contact MSDS_HOW04_2019_ARCH_0224



8. Magnetic Anomalies

1309 magnetic anomalies, not correlating with known features or associated with contacts of archaeological potential, were identified within the survey extents, 663 of which lie within the PEIR boundary, the distribution of intensities is shown below in Table 11 and the distribution presented in Figure 24.

Table 11. Magnetic Anomalies

Intensity (nT)	PEIR Boundary	Data Extents	Total
5 - 50	603	558	**1161**
50 - 100	36	47	**83**
100 - 200	18	29	**47**
200+	6	12	**18**
Total	**663**	**646**	**1309**

Contacts identified from the magnetometer data are ferrous and thus generally anthropogenic in origin although they can be associated with geological features, however there is no visual interpretation as with other geophysical data.

The data collection methodology across the Hornsea Project Four survey area was intended to provide an overall understanding of the site. As such line spacing varied from c.50m inshore in the ECC to c.75m - 0.3km in the array area. The position for a magnetic anomaly can only be determined from directly below the sensor, or where lines are run close enough together to be able to confidently position an anomaly seen on two, or more, lines.

The positions of magnetic anomalies were viewed in the available datasets and where there was a strong correlation with a seabed contact they were assessed for archaeological potential. All remaining contacts have been included within this section.

8.1.1 Large Magnetic Anomalies

65 magnetic anomalies considered large (>100nT) have been identified within the data extents, of which 24 lie within the PEIR boundary, these anomalies have the potential to represent material of anthropogenic origin that may be of potential significance. The values and positions are shown below in Table 12 and presented in Figure 25.

The distribution of magnetic anomalies is as would be expected, with a greater concentration inshore and a relatively even distribution heading offshore. Within this data set it must be noted that the density of data is greater inshore which will also impact the density of contacts.

Table 12. Large Magnetic Anomalies

MSDS ID	Easting (m)	Northing (m)	Intensity (nT)	Within PEIR Boundary
MSDS_HOW04_2019_MAG_2279	321035.3	5995327.7	100.6	Yes
MSDS_HOW04_2019_MAG_2280	290598.5	5991883.9	102.4	Yes
MSDS_HOW04_2019_MAG_2285	331877.0	5994607.8	115.4	Yes
MSDS_HOW04_2019_MAG_1477	383345.0	5997883.0	115.8	Yes
MSDS_HOW04_2019_MAG_1479	387631.0	6000164.0	121.5	Yes

MSDS_HOW04_2019_MAG_1482	374960.0	5999833.0	128.8	Yes
MSDS_HOW04_2019_MAG_1483	382128.0	5986602.0	130.2	Yes
MSDS_HOW04_2019_MAG_1484	403109.0	5985587.0	131.0	Yes
MSDS_HOW04_2019_MAG_2294	290723.0	5991072.0	135.5	Yes
MSDS_HOW04_2019_MAG_2296	290132.9	5992080.2	146.9	Yes
MSDS_HOW04_2019_MAG_2297	327976.5	5995647.1	151.5	Yes
MSDS_HOW04_2019_MAG_1489	393488.0	5993710.0	160.0	Yes
MSDS_HOW04_2019_MAG_1490	388618.0	5998621.0	166.9	Yes
MSDS_HOW04_2019_MAG_1492	379512.0	5994749.0	169.2	Yes
MSDS_HOW04_2019_MAG_2301	333190.2	5992380.5	180.8	Yes
MSDS_HOW04_2019_MAG_1494	371666.0	6001044.0	183.7	Yes
MSDS_HOW04_2019_MAG_1495	379489.0	5994783.0	189.1	Yes
MSDS_HOW04_2019_MAG_2304	331606.8	5995242.2	192.7	Yes
MSDS_HOW04_2019_MAG_1496	380061.0	5993875.0	229.2	Yes
MSDS_HOW04_2019_MAG_1498	398466.0	5987861.0	255.5	Yes
MSDS_HOW04_2019_MAG_2306	290180.8	5993114.9	275.7	Yes
MSDS_HOW04_2019_MAG_1499	378695.0	5989836.0	294.7	Yes
MSDS_HOW04_2019_MAG_2310	292680.5	5993228.4	578.6	Yes
MSDS_HOW04_2019_MAG_1504	378737.0	5995085.0	593.8	Yes
MSDS_HOW04_2019_MAG_2277	337335.3	5989502.2	100.2	No
MSDS_HOW04_2019_MAG_2278	315275.7	5995838.7	100.6	No
MSDS_HOW04_2019_MAG_2281	290273.3	5990776.8	107.4	No
MSDS_HOW04_2019_MAG_2282	290000.0	5987911.0	107.5	No
MSDS_HOW04_2019_MAG_1476	391153.0	5972115.0	108.9	No
MSDS_HOW04_2019_MAG_2283	361226.1	5987713.5	113.5	No
MSDS_HOW04_2019_MAG_2284	290108.3	5990276.2	113.6	No
MSDS_HOW04_2019_MAG_2286	290413.7	5989534.0	118.5	No
MSDS_HOW04_2019_MAG_2287	291022.4	5990541.0	118.5	No
MSDS_HOW04_2019_MAG_1478	392329.0	5970255.0	118.7	No
MSDS_HOW04_2019_MAG_2288	290982.9	5990500.6	119.3	No
MSDS_HOW04_2019_MAG_2289	372900.5	5991043.8	120.1	No
MSDS_HOW04_2019_MAG_2290	290015.6	5987786.5	121.2	No
MSDS_HOW04_2019_MAG_2291	290173.3	5989502.5	124.8	No
MSDS_HOW04_2019_MAG_1480	382857.0	5979946.0	126.3	No
MSDS_HOW04_2019_MAG_2292	292248.5	5987050.0	127.3	No
MSDS_HOW04_2019_MAG_1481	392309.0	5970286.0	127.7	No
MSDS_HOW04_2019_MAG_1485	395205.0	5971814.0	131.7	No
MSDS_HOW04_2019_MAG_2293	368079.6	5991144.4	131.7	No
MSDS_HOW04_2019_MAG_2295	357183.7	5989191.6	146.2	No
MSDS_HOW04_2019_MAG_1487	391619.0	5974821.0	146.5	No
MSDS_HOW04_2019_MAG_2298	290580.2	5986878.7	153.5	No

MSDS_HOW04_2019_MAG_1488	385253.0	5979451.0	159.7	No
MSDS_HOW04_2019_MAG_1491	389069.0	5977490.0	167.6	No
MSDS_HOW04_2019_MAG_2299	290037.2	5989313.7	174.8	No
MSDS_HOW04_2019_MAG_1493	392288.0	5970312.0	178.0	No
MSDS_HOW04_2019_MAG_2300	290075.6	5990120.2	178.7	No
MSDS_HOW04_2019_MAG_2302	290946.1	5989099.7	182.6	No
MSDS_HOW04_2019_MAG_2303	290095.7	5988765.2	184.8	No
MSDS_HOW04_2019_MAG_2305	290265.2	5989148.7	239.0	No
MSDS_HOW04_2019_MAG_1497	388980.0	5979704.0	252.9	No
MSDS_HOW04_2019_MAG_2307	290514.4	5990102.0	276.9	No
MSDS_HOW04_2019_MAG_1500	382816.0	5979919.0	310.1	No
MSDS_HOW04_2019_MAG_1501	382822.0	5979920.0	314.9	No
MSDS_HOW04_2019_MAG_1502	395194.0	5971813.0	358.7	No
MSDS_HOW04_2019_MAG_2308	371689.4	5989813.2	364.5	No
MSDS_HOW04_2019_MAG_2309	290469.9	5988292.6	408.3	No
MSDS_HOW04_2019_MAG_1503	392324.0	5970255.0	414.0	No
MSDS_HOW04_2019_MAG_1505	382660.0	5979471.0	674.1	No
MSDS_HOW04_2019_MAG_1506	390920.0	5970427.0	859.0	No
MSDS_HOW04_2019_MAG_2311	290134.6	5987140.6	971.6	No

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Figure 24. Magnetic Anomalies

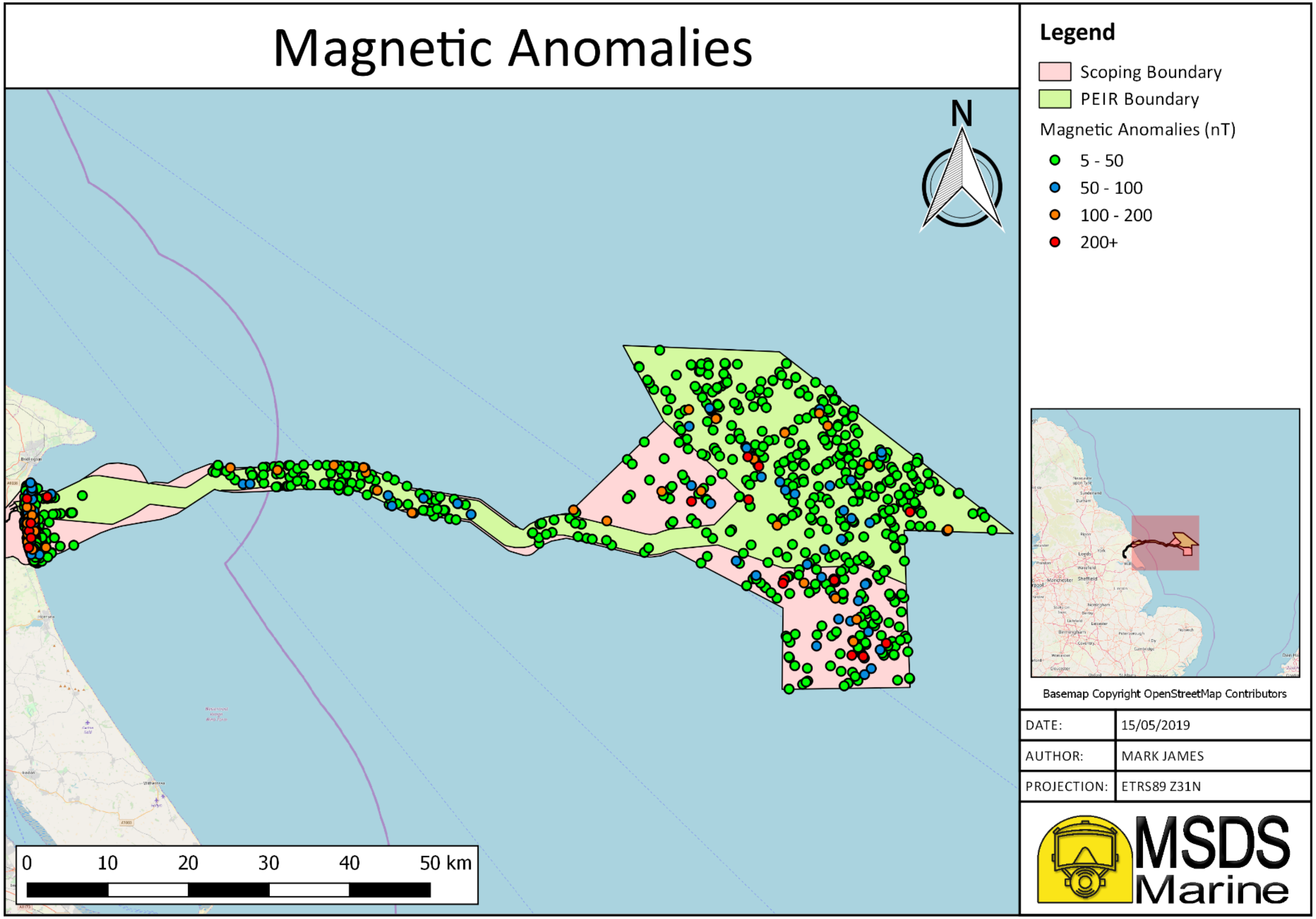
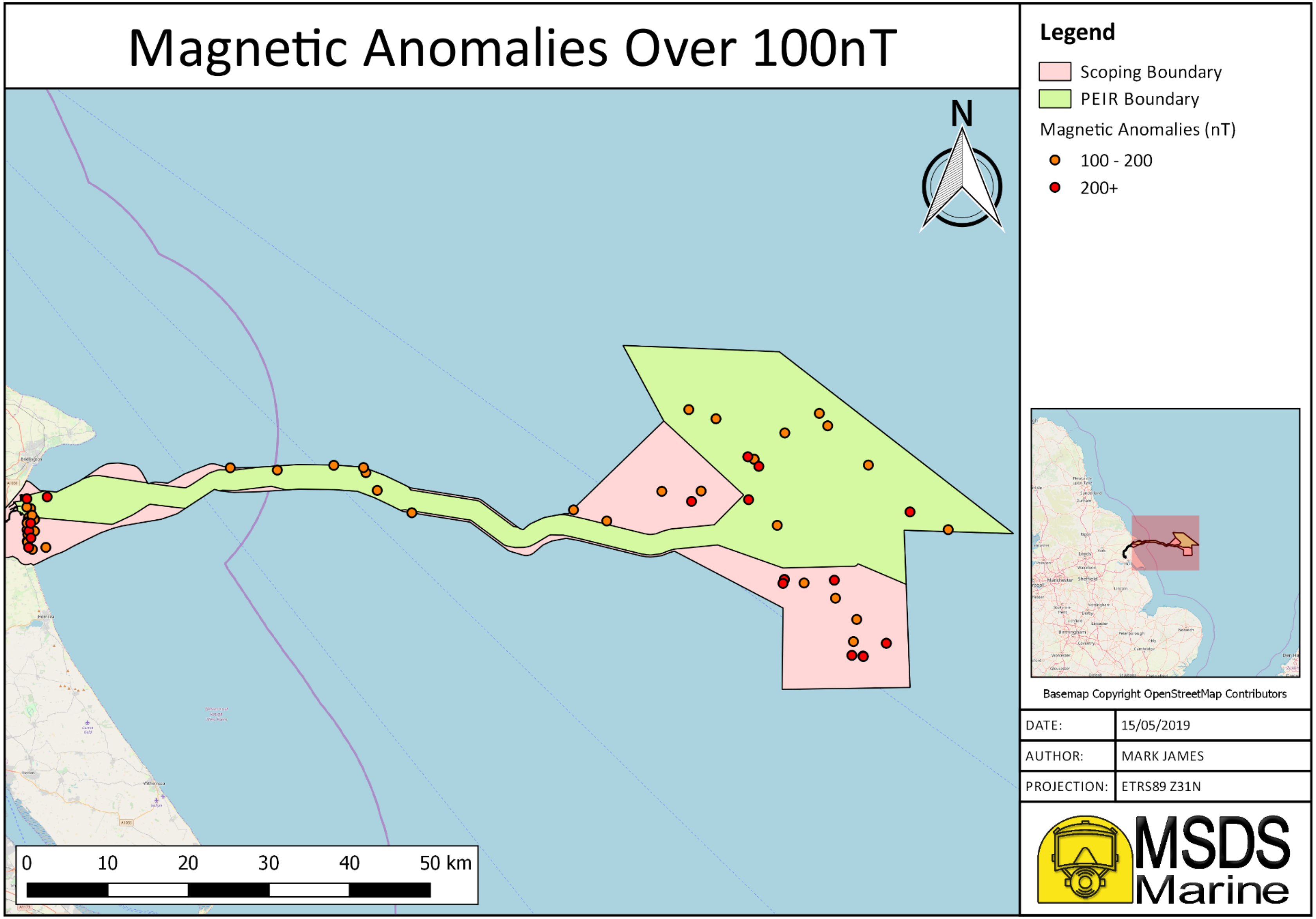


Figure 25. Large Magnetic Anomalies



9. United Kingdom Hydrographic Office Data

United Kingdom Hydrographic Office (UKHO) data from 2019 was obtained for the Hornsea Project Four scoping area for the cross correlation of contacts identified during the assessment.

Fifteen UKHO records, or potential features relating to records, were identified within the data extents, the distribution is shown in Figure 26.

Seven records were identified as corresponding with contacts of archaeological potential on the seabed (Table 13) and have been discussed within this report.

Table 13. Archaeological Contacts with Corresponding UKHO Records

MSDS ID	Potential	Description	UKHO ID	UKHO Name
MSDS_HOW04_2019_ARCH_0015	High	Wreck	9410	UNKNOWN
MSDS_HOW04_2019_ARCH_0073	High	Wreck	9377	FLIRT (POSSIBLY)
MSDS_HOW04_2019_ARCH_0113	High	Wreck	9401	UNKNOWN
MSDS_HOW04_2019_ARCH_0178	High	Wreck	5805	SOTE (AFT PART)
MSDS_HOW04_2019_ARCH_0224	High	Wreck	9400	LAPWING (POSSIBLY)
MSDS_HOW04_2019_ARCH_0096	Medium	Possible wreck	9403	UNKNOWN
MSDS_HOW04_2019_ARCH_0233	Medium	Possible wreck debris	6830	UNKNOWN

A further eight records fall with the extents of the data but no features of potential archaeological potential were identified at the positions. Five of the records, including all four records of wreck, are recorded as dead meaning that they have not been identified in a number of previous surveys. The remaining three live records relate to lost geotechnical equipment, foul ground and a possible cable. The records are summarised in Table 14 below.

Table 14. UKHO Records Not Identified in the Dataset

UKHO ID	UKHO Name	Status	Description
9374		Dead	Non-dangerous wreck
9375	Cumberland	Dead	Non-dangerous wreck
78636		Live	Lost geotechnical equipment
6859		Live	Possible cable
6858		Live	Foul ground
66239	Adventure	Dead	Non-dangerous wreck
6721		Dead	Non-dangerous wreck
66493		Dead	Obstruction

The wider assessment of the UKHO data is being undertaken by Maritime Archaeology Ltd (MA Ltd) and does not form part of this assessment. However, for completeness the distribution of UKHO records within the development area is presented in Figure 27 to demonstrate the concentration outside of the data extents.

Figure 26. Distribution of UKHO Records Within the Dataset

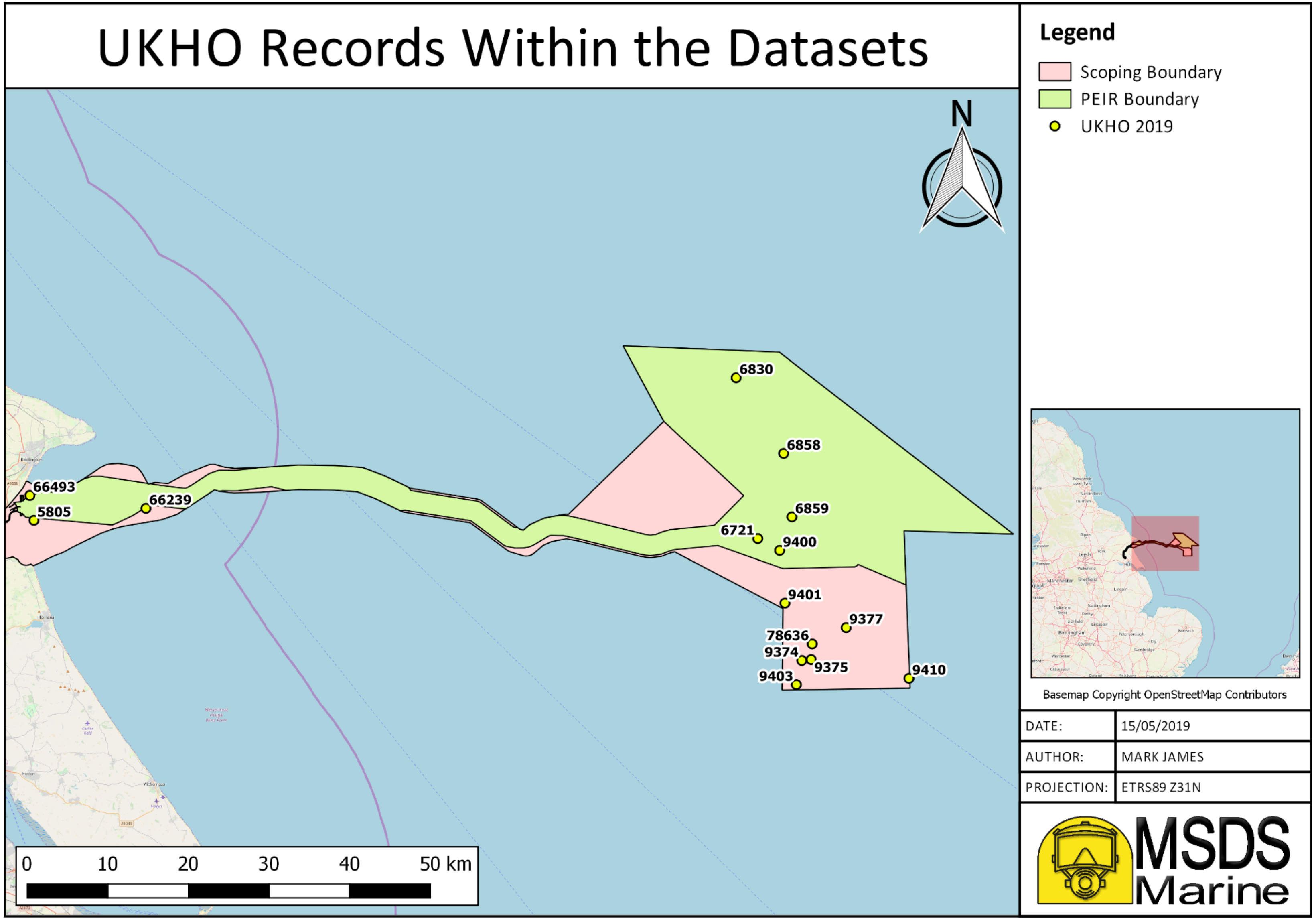
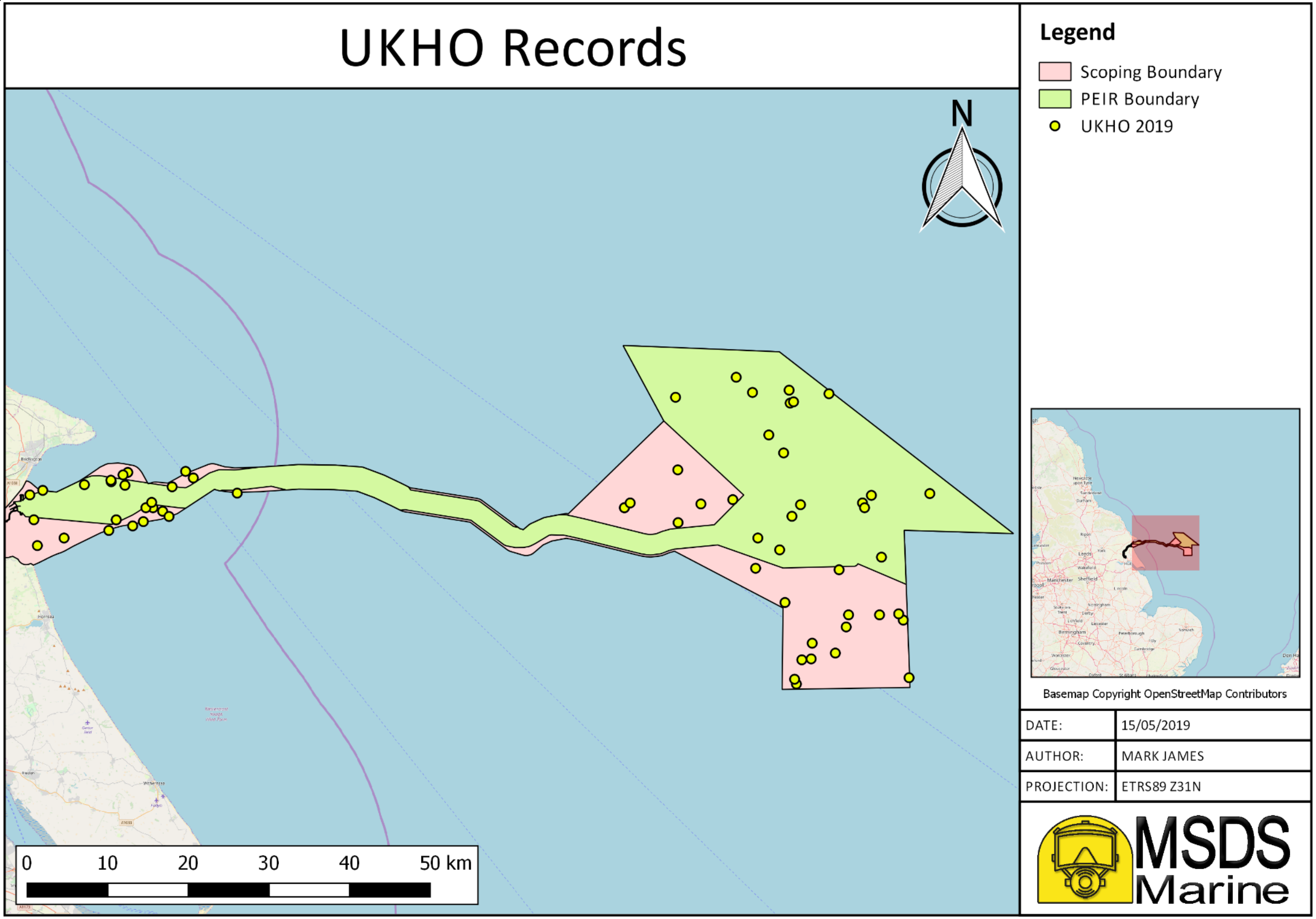


Figure 27. Distribution of UKHO Records



10. Mitigation

Recommended mitigation strategies have been based on the criteria identified in Section 6.11 Mitigation.

The mitigation strategies recommended for seabed contacts within this report are not comprehensive for the whole development area due to the limited data coverage, however they serve to characterise the potential for exclusion zones. Mitigation will be developed through each phase of survey works as detailed within Section 11 Recommendations for Future Work.

Whilst high and medium potential contacts have been identified within the data extents, only those contacts falling within, or close to, the PEIR boundary have been assessed for mitigation as no development is planned outside this area.

10.1 Low Archaeological Potential Contacts

Low potential contacts have been identified as potentially anthropogenic in origin but unlikely to be of archaeological significance and no exclusion zones are recommended for these contacts. Should material of potential archaeological significance be identified during the course of pre-development and development works they should be reported under an appropriate protocol for archaeological discoveries such as the Protocol for Archaeological Discoveries: Offshore Renewables Projects (The Crown Estate 2014).

10.2 Archaeological Exclusion Zones

High and medium potential contacts have been identified as likely to be of anthropogenic origin and potentially of archaeological significance. These contacts have been recommended archaeological exclusion zones based on the size of the contact, any outlying debris, the potential significance of the contact, the likely impact of the development and the seabed dynamics within the area.

Exclusion zone radius' have been determined from the centre point of the contact or cluster of contacts. Contacts and their recommended exclusion zones are detailed in Table 15 and Table 16 and the distribution shown Figure 28. Each exclusion is presented in Figure 30 to Figure 34. Note, where discrepancies exist between the position within different datasets, the position deemed to be most accurate has been used.

In total five recommended archaeological exclusion zones have been assigned within the PEIR boundary, two high potential and three medium potential. One medium potential contact (MSDS_HOW04_2019_ARCH_0233) has not been recommended an exclusion zone as it relates to a seabed disturbance which is potentially not related to a UKHO record outside of the data extents.

Table 15. High Potential Recommended Archaeological Exclusion Zones. Note: AEZ radius' are from the given position which relates to the centre point of the contact

MSDS ID	Potential	Basic Description	Easting	Northing	AEZ Radius (m)
MSDS_HOW04_2019_ARCH_0086	High	Potential wreck	379559.3	5994689.6	75
MSDS_HOW04_2019_ARCH_0224	High	Wreck	382353.2	5983573.2	100

Table 16. Medium Potential Recommended Archaeological Exclusion Zones. Note: AEZ radius' are from the given position which relates to the centre point of the contact

MSDS ID	Potential	Basic Description	Easting	Northing	AEZ Radius (m)
MSDS_HOW04_2019_ARCH_0079	Medium	Potential anthropogenic debris	374099.1	6002824.4	15
MSDS_HOW04_2019_ARCH_0088	Medium	Potential ballast mound	387801.1	5984995.7	30
MSDS_HOW04_2019_ARCH_0233	Medium	Possible wreck debris	377622.9	6004925.2	0*
MSDS_HOW04_2019_ARCH_0234	Medium	Potential anthropogenic debris with large magnetic anomaly	385666.0	5993861.0	25

* *Contact* MSDS_HOW04_2019_ARCH_0233 *has not been recommended an exclusion zone, the contact relates to a seabed disturbance which is potentially not related to a UKHO record outside of the data extents.*

10.3 Temporary Archaeological Exclusion Zones

Temporary archaeological exclusion zones are recommended during the archaeological assessment of early phases of survey data. Their use is primarily to provide mitigation for contacts that are likely to exist, but fall outside the survey data extents, this can include UKHO records. Temporary exclusion zones will be based upon all available information including the stated positional accuracy, the recorded size of the target and the potential archaeological significance. When further higher resolution and full coverage data becomes available the exclusion zones would be adjusted to a size providing appropriate and robust mitigation for the contact.

The assessment of UKHO and other records falls outside the scope this report and is being undertaken by MA Ltd, therefor no recommendations for temporary archaeological exclusion zones have been made.

10.4 Areas of Archaeological Potential

Magnetic anomalies with no strongly correlating seabed features will be reconciled and positions fixed during future high resolution and full coverage survey works. These works will provide magnetic data suitable for the identification of potential Un-Exploded Ordnance (pUXO) and will be assessed by an archaeologist to determine archaeological potential prior to any seabed impacts.

Magnetic anomalies >100nT within the PEIR boundary have been identified to characterise the Hornsea Project Four area and identify Areas of Archaeological Potential. No formal exclusion zones are recommended at this stage but the submission of positions of significant magnetic anomalies identifies the potential for archaeological contacts and that the areas will be monitored during future assessments. The positions and amplitudes are detailed in Table 17 and the distribution shown in Figure 25;

Table 17. Areas of Archaeological Potential

MSDS ID	Easting (m)	Northing (m)	Intensity (nT)
MSDS_HOW04_2019_MAG_2279	321035.3	5995327.7	100.6
MSDS_HOW04_2019_MAG_2280	290598.5	5991883.9	102.4
MSDS_HOW04_2019_MAG_2285	331877.0	5994607.8	115.4
MSDS_HOW04_2019_MAG_1477	383345.0	5997883.0	115.8
MSDS_HOW04_2019_MAG_1479	387631.0	6000164.0	121.5
MSDS_HOW04_2019_MAG_1482	374960.0	5999833.0	128.8
MSDS_HOW04_2019_MAG_1483	382128.0	5986602.0	130.2
MSDS_HOW04_2019_MAG_1484	403109.0	5985587.0	131.0
MSDS_HOW04_2019_MAG_2294	290723.0	5991072.0	135.5
MSDS_HOW04_2019_MAG_2296	290132.9	5992080.2	146.9
MSDS_HOW04_2019_MAG_2297	327976.5	5995647.1	151.5
MSDS_HOW04_2019_MAG_1489	393488.0	5993710.0	160.0
MSDS_HOW04_2019_MAG_1490	388618.0	5998621.0	166.9
MSDS_HOW04_2019_MAG_1492	379512.0	5994749.0	169.2
MSDS_HOW04_2019_MAG_2301	333190.2	5992380.5	180.8
MSDS_HOW04_2019_MAG_1494	371666.0	6001044.0	183.7
MSDS_HOW04_2019_MAG_1495	379489.0	5994783.0	189.1
MSDS_HOW04_2019_MAG_2304	331606.8	5995242.2	192.7
MSDS_HOW04_2019_MAG_1496	380061.0	5993875.0	229.2
MSDS_HOW04_2019_MAG_1498	398466.0	5987861.0	255.5
MSDS_HOW04_2019_MAG_2306	290180.8	5993114.9	275.7
MSDS_HOW04_2019_MAG_1499	378695.0	5989836.0	294.7
MSDS_HOW04_2019_MAG_2310	292680.5	5993228.4	578.6
MSDS_HOW04_2019_MAG_1504	378737.0	5995085.0	593.8

10.5 Notes on Exclusion Zones

Exclusion zones have been recommended based on the available evidence as interpreted by an experienced and qualified maritime archaeologist, they are to be agreed between Hornsea Project Four, and the curator, Historic England and the Marine Management Organisation (MMO). Exclusion zones are implemented to protect, in-situ, potentially archaeologically significant material.

Where an exclusion zone has been implemented, no development work impacting the seabed is to take place within the prescribed area. Should an exclusion zone impact the development program it is recommended that a program of ground truthing be undertaken to establish the identity of a contact in order that the potential archaeological significance can be assessed by a qualified and experienced archaeologist. Following identification and assessment, the exclusion zone can be re-assessed to ensure mitigation is appropriate to the archaeological significance of the contact

Figure 28. Distribution of Archaeological Exclusion Zones

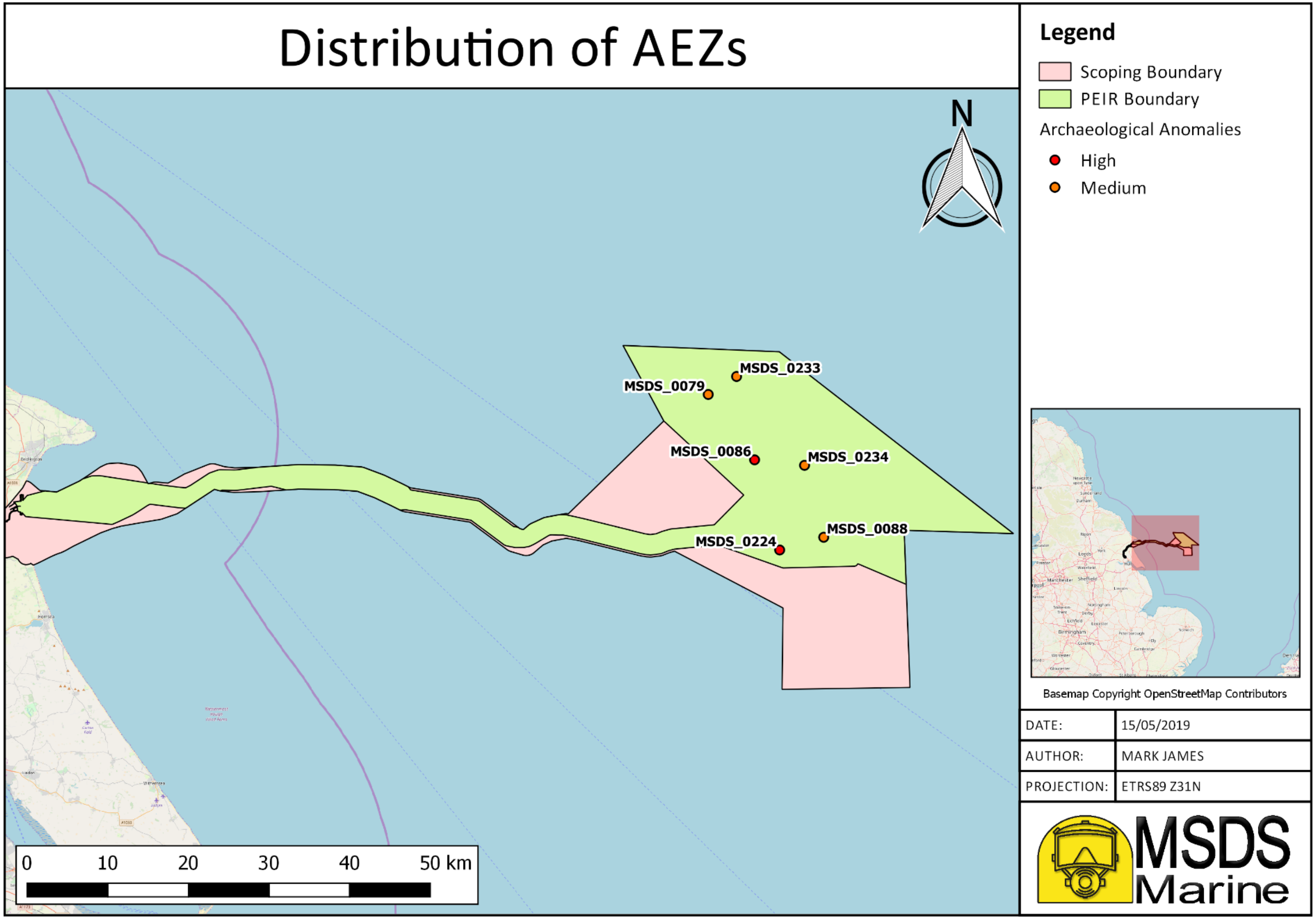


Figure 29. Areas of Archaeological Potential

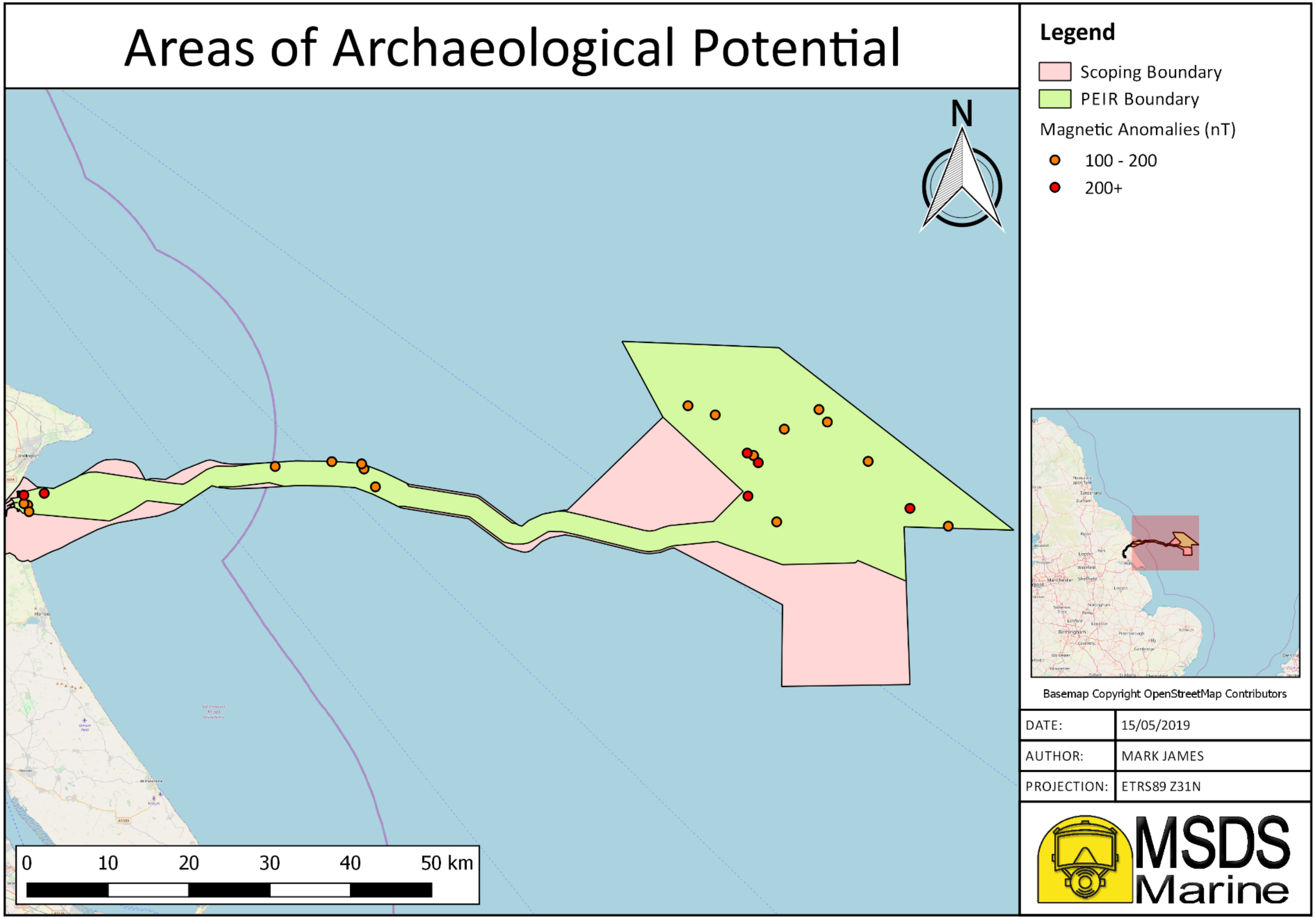


Figure 30. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0079

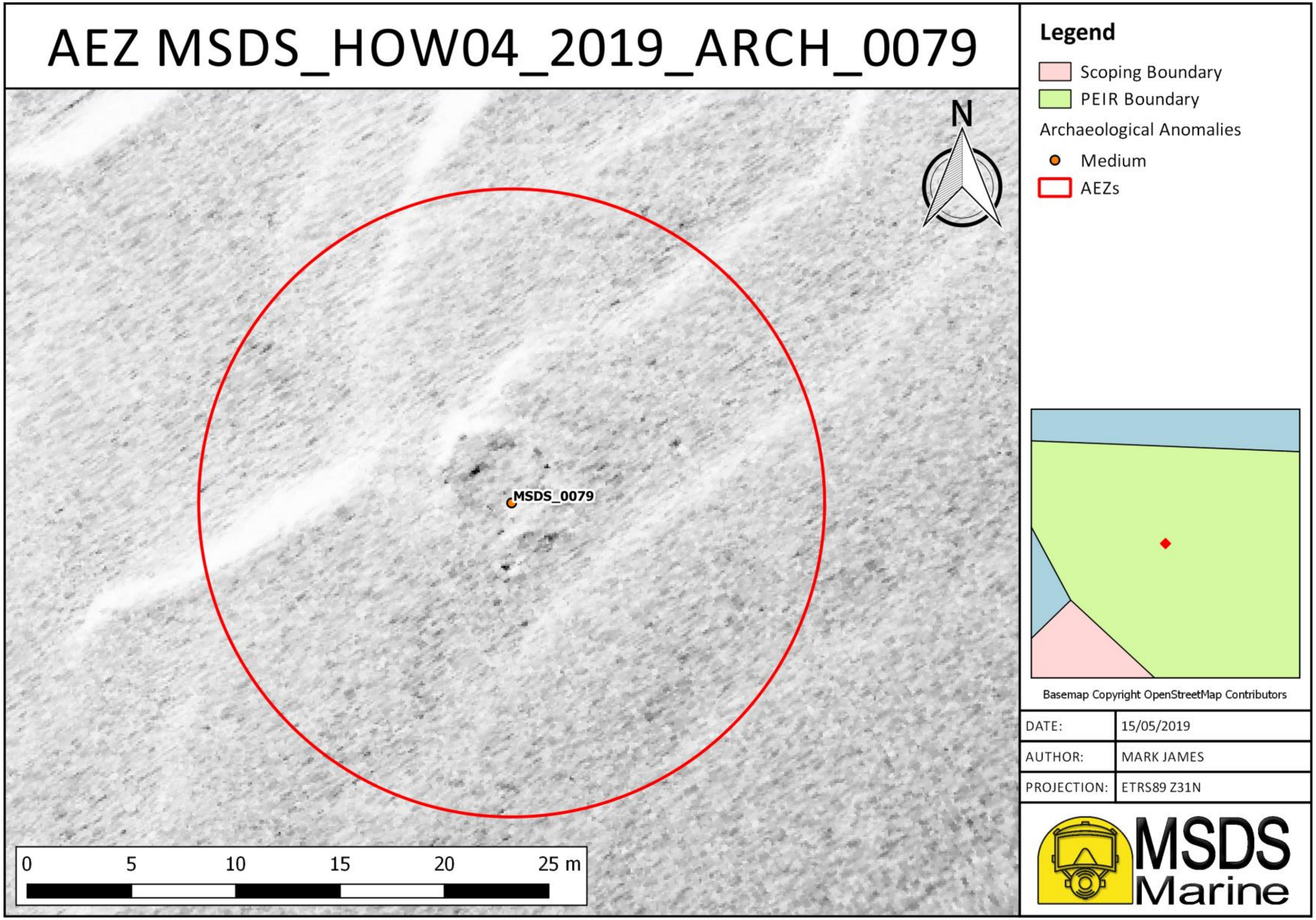


Figure 31. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0086

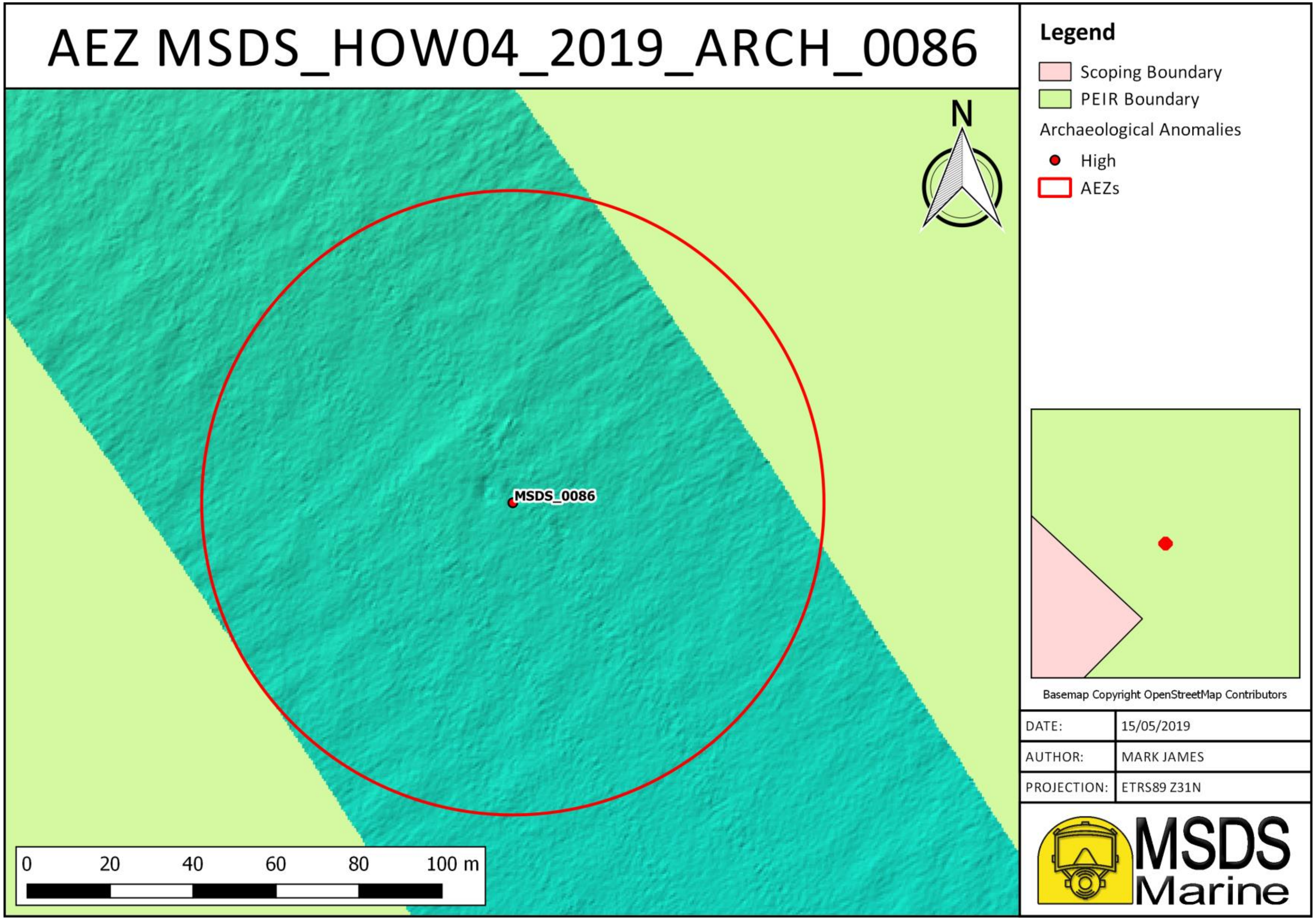


Figure 32. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0088

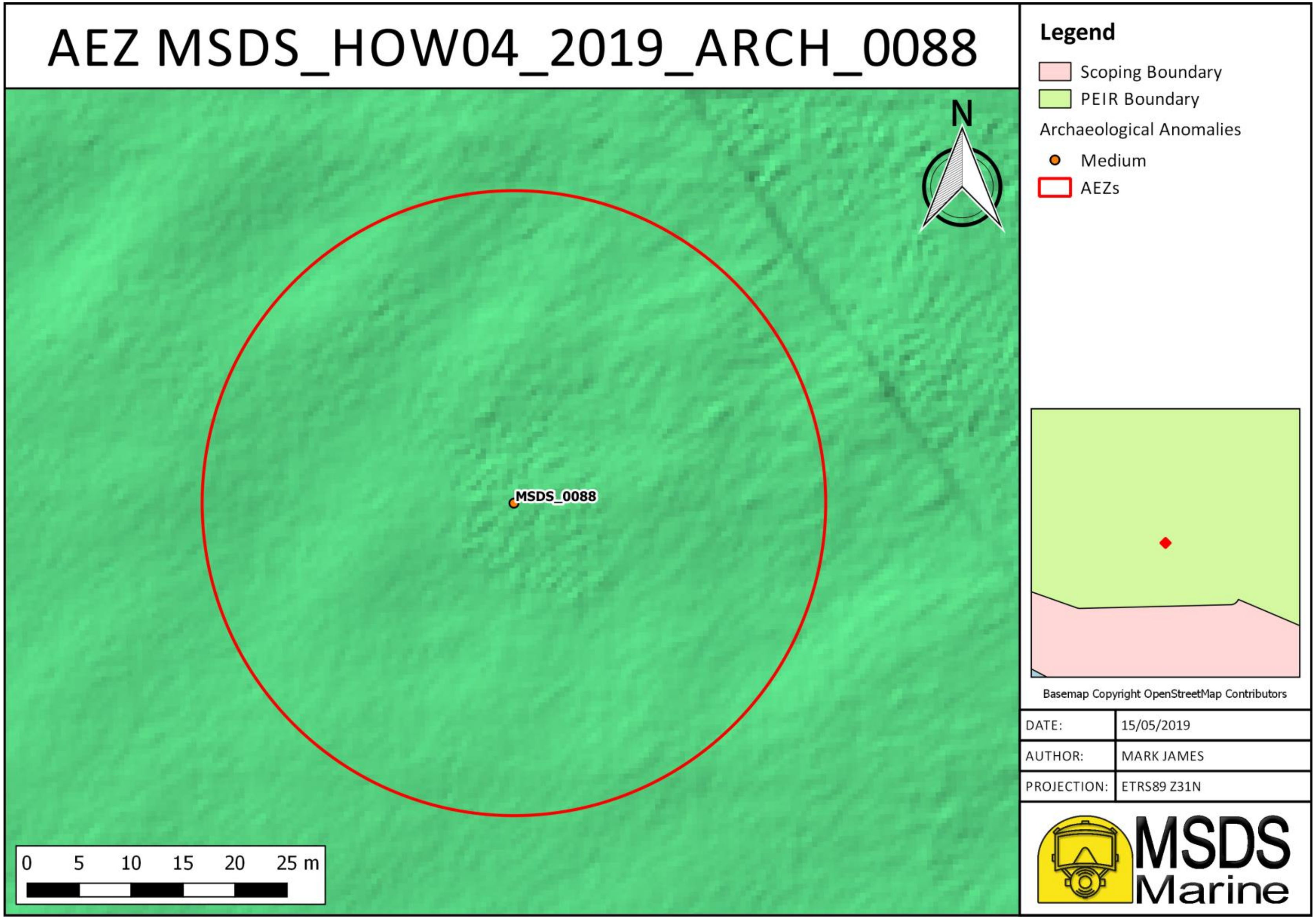


Figure 33. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0224

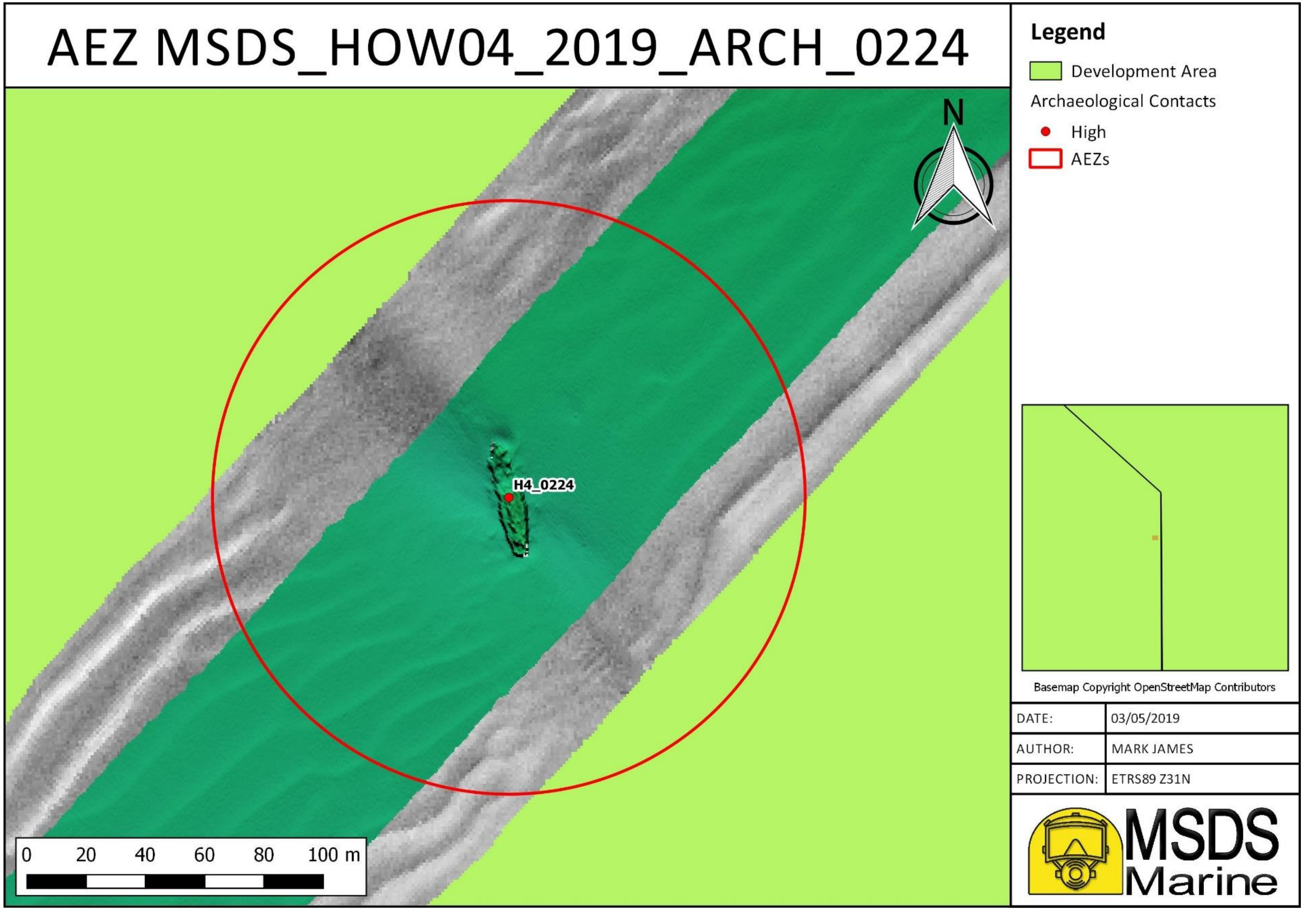
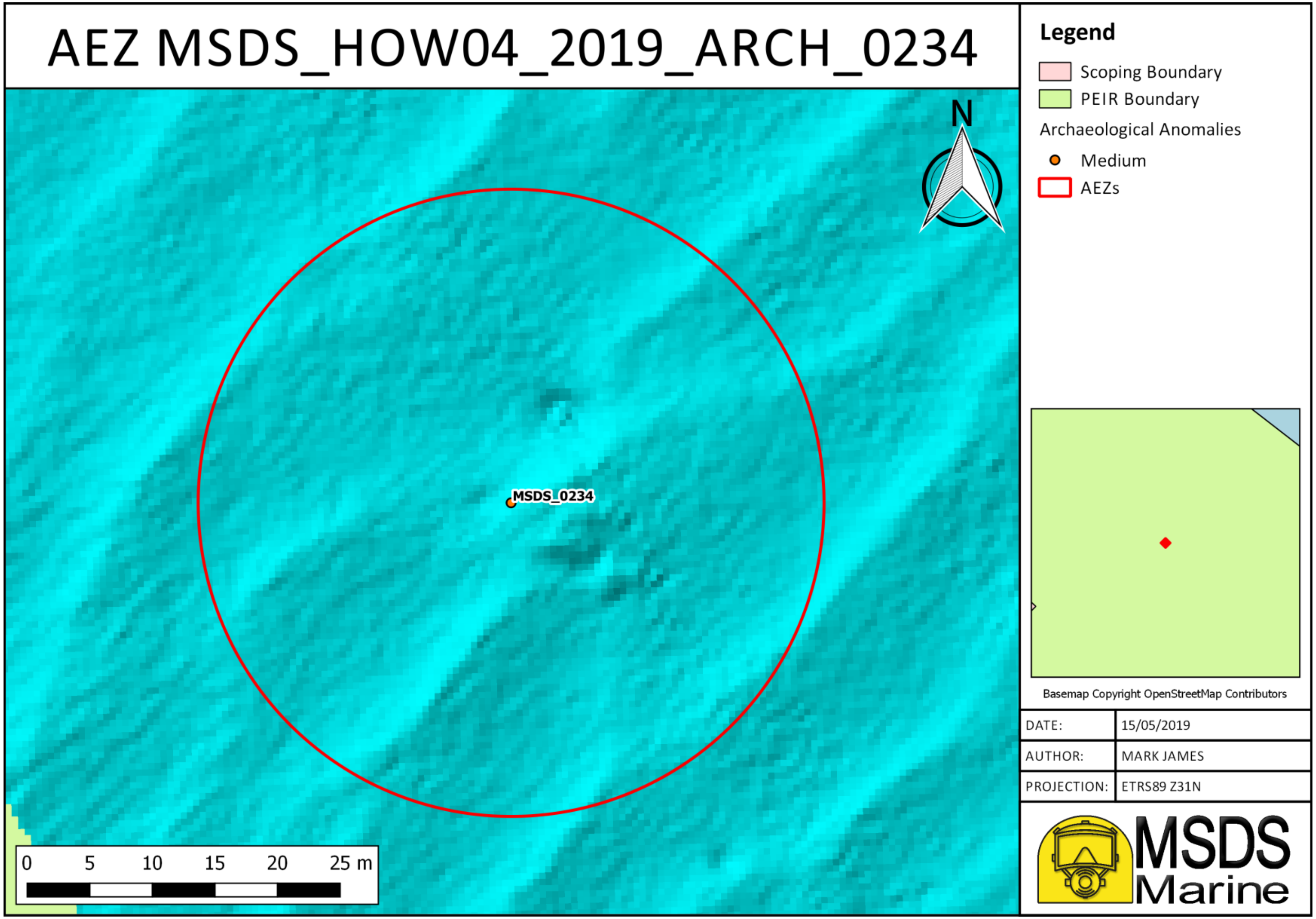


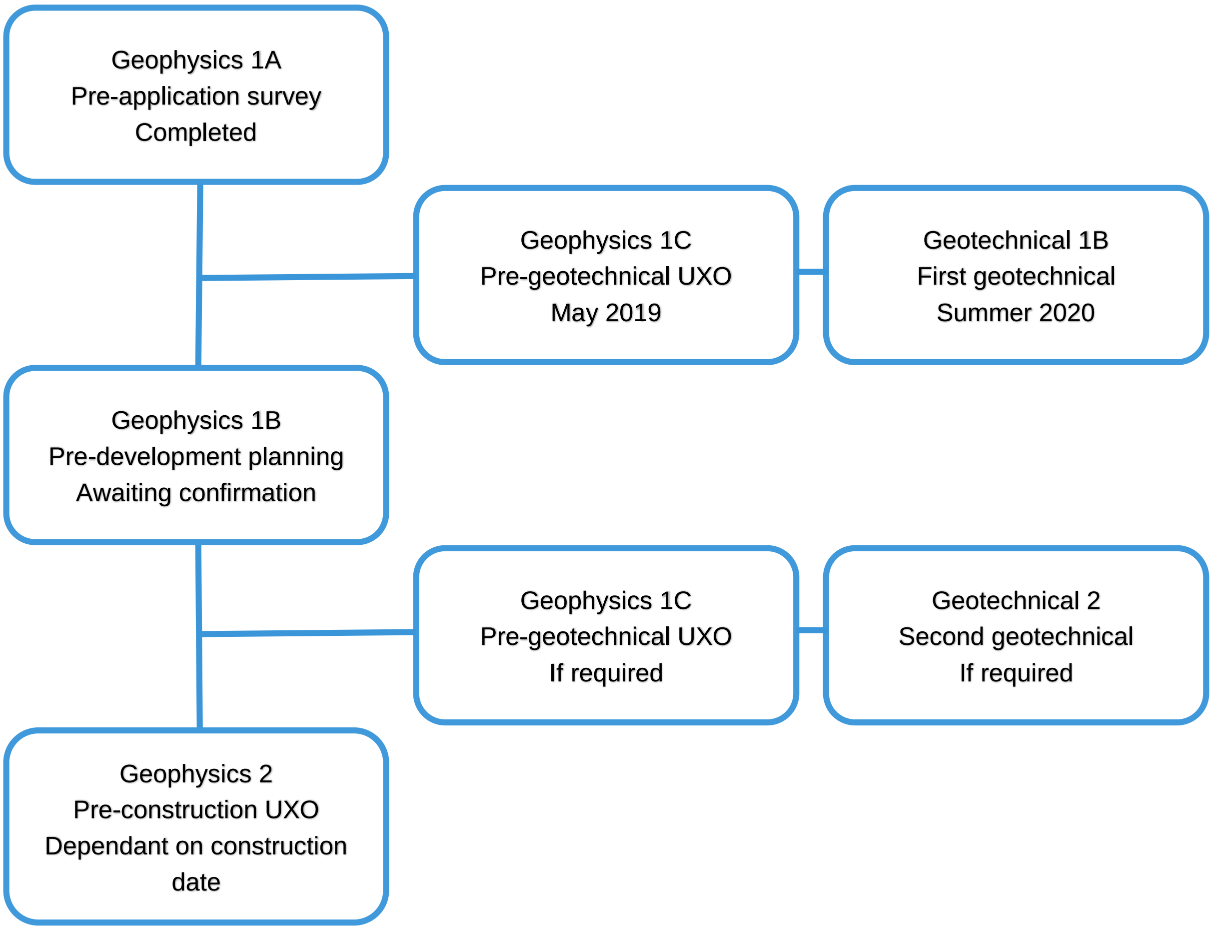
Figure 34. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0234



11. Recommendations for Future Work

The archaeological interpretation of the geophysical data collected at the pre-application stage, to which this assessment pertains, fits within a wider framework of planned geophysical survey for Hornsea Project Four. The anticipated timeframes for planned survey works are outlined in Figure 35;

Figure 35. Planned and Completed Survey Works for Hornsea Project Four



The survey strategy and framework is established within Ørsted and has been used on previous Ørsted projects including; Hornsea Project Two, Hornsea Project Three and Walney Extension Offshore wind farms. The specification for data collection has been designed to ensure that the data are sufficient for all users at each phase, this includes archaeological assessment, UXO identification, benthic studies and development planning.

Table 18. Hornsea Project Four Planned and Completed Survey Works

Survey Phase	Description
Geophysics 1A Pre-application survey Completed 2018	Geophysics 1A is a program of survey works to inform the application process and characterise the project area. Line spacing is generally wide and the survey is not full coverage. The survey is designed to ensonify seabed contacts >1.0m. Sensors: MBES, SSS, MAG, SBP

Geophysics 1B Pre-development planning In stages Awaiting confirmation	The geophysics 1B survey is undertaken in stages and aims to provide data for pre-development planning, this includes more targeted areas of survey, additional data where required and data infill. The survey is designed to ensonify seabed contacts >0.5m. Sensors: MBES, SSS, MAG, SBP
Geophysics 1C Pre-geotechnical As required May 2019	Geophysics 1C is a targeted program of survey works specific to geotechnical locations. Each location will be bounded by a 10m radius where UXO specification survey works will be undertaken The survey is designed to ensonify seabed contacts >0.3m. Sensors: MBES, SSS, MAG, SBP
Geophysics 2 Pre-construction UXO Dependant on construction date	Geophysics 2 is the final planned survey and will provide full coverage of the planned development area, including the Offshore Array and Export Cable Corridor. The survey is designed to be high resolution and suitable for the detection of UXO ensonifying seabed contacts >0.3m. The survey informs the final route planning, UXO clearance works and final archaeological mitigation.

The broad minimum specification for each tranche of surveys can be found in Table 19 below.

Table 19. Survey Specifications for Each Phase of Survey

Survey Phase	Line Spacing	Resolution	
		Multibeam Echosounder	Side Scan Sonar
Geophysical 1A	50m – 3km	0.5m x 0.5m and 1m x 1m grids	0.5m x 0.5m
Geophysical 1B	20m	0.5m x 0.5m	0.5m x 0.5m
Geophysical 1C	Variable, UXO specification	0.5m x 0.5m	0.3m x 0.3m
Geophysical 2	Variable, UXO specification	0.5m x 0.5m	0.3m x 0.3m

The following recommendations are made for future survey works:

11.1.1 Archaeological Assessment of Data

All geophysical data collected as part of the project will be assessed for archaeological potential by a qualified and experienced maritime archaeologist where relevant to the development. It is recommended that the archaeologist have a demonstrable background in both the collection and processing of geophysical data as well as the archaeological review of data.

The archaeological review of data at these stages is considered necessary, not only for the robust assessment of the historic environment and archaeological potential but also for development planning. As the planned surveys increase in coverage and resolution, but decrease in area it is beneficial to be aware of any potential archaeological mitigation that may be required to ensure minimal re-planning.

Prior to any impact on the seabed UXO specification data will be made available to, and reviewed by, the archaeologist. This includes, but is not limited to, cable laying operations, WTG installations, jack up barge positioning, anchor positions, UXO and boulder clearance and geotechnical works.

The methodology for the archaeological interpretation of data will follow those previously agreed with Historic England on both current and previous Ørsted projects and the methodology on which this review is based. Whilst it is anticipated that methodologies will not vary a great deal between phases of work it is important to draw upon previous results to ensure the method proposed is both robust but practical, as such the methodology will be reviewed by a suitably qualified archaeologist prior to commencement.

11.1.2 Survey Specification

Survey specifications will vary dependent on a number of factors including, water depth, vessel and equipment, however certain recommendations can be made such as coverage, size of contact to be ensonified and positional accuracy.

Of particular relevance is the specification for Geophysics 1c and Geophysics 2, these phases of survey are undertaken prior to impacts, 1c for geotechnical impacts and 2 for construction impacts. Both surveys are undertaken to a specification suitable to reduce the UXO risk to As Low As Reasonably Practical (ALARP). In almost all instances data collected for UXO assessment is highly suitable for archaeological assessment. General specifications are detailed below;

Sidescan Sonar: data should be high frequency (at least 400-600kHz), collected with a minimum of 200% coverage and the fish should be flown at an optimal altitude (typically c.10% of range). The fish should be positioned with a correctly calibrated USBL system and layback recorded as a backup. The data should be of a quality and resolution to identify seabed contacts >0.3m.

Sub-bottom Profiler: data should be collected at a frequency and power appropriate to the seabed type and the required penetration, vertical resolution should be <0.3m where possible and the data should be heave corrected. Sub-bottom data are only collected below the sensor; therefore, data should be collected on all magnetometer lines as these are generally the tightest spacing.

Multibeam Echo Sounder: for archaeological interpretation multibeam data are used for general seabed characterisation and quality control for the positioning of contacts identified in the sidescan data. Data should be high resolution (typically 300-400kHz) and acquired within IHO Special Order specifications (IHO 2008), this includes full coverage data and a requirement to detect features >1.0m on the seabed.

Magnetometer: the method for magnetometer surveys will vary between multiple close survey lines or multiple magnetometers in an array and wider survey lines. Magnetometer surveys for UXO identification should aim for full coverage with a blanking distance of 2.5m, a target positioning accuracy of +/-2.5m and an absolute accuracy of <2nT. The fish should be flown between 2.0m and 4.0m and positioned with a correctly calibrated USBL system and layback recorded as a backup.

11.1.3 Reporting

Reporting following each phase of survey and archaeological assessment will be submitted to Historic England and the MMO no later than three months following the end of the survey campaign and no later than one month prior to the start of construction works or any pre-construction impacts to the seabed.

11.2 Protocol for Archaeological Discoveries

A suitable protocol for archaeological discoveries is a key element of the mitigation procedure for contacts identified as low archaeological potential. A suitable protocol should also be implemented during any works that may visually inspect the seabed or recover material to deck.

A Protocol for Archaeological Discoveries will be implemented, it is recommended it takes the form of the Protocol for Archaeological Discoveries: Offshore Renewables Projects (The Crown Estate 2014).

11.3 Ground Truthing

Should archaeological exclusion zones impact on the proposed development works it is recommended that a program of ground truthing is undertaken to establish the identity of the contacts so that further archaeological assessment can be undertaken and interpretations revised as appropriate.

12. References

Bibby Hydromap, 2018. *Hornsea 04 Lot 7, Operations Report*. Report produced for Ørsted

Bibby Hydromap, 2018. *Hornsea 4 Offshore Wind Farm, Lot 7 GP1a Export Cable Corridor, Processing Report*. Report produced for Ørsted

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The Crown Estate, 2014. *Protocol for Archaeological Discoveries: Offshore Renewables Projects*. Wessex Archaeology: Salisbury

Wessex Archaeology, 2010. *Model Clauses for Archaeological Written Schemes of Investigation, Offshore Renewables Projects*. Report produced for the Crown Estate.

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Appendix A - Gazetteer of Potential Archaeological Contacts

MSDS_ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Amplitude (nT)	Potential	AEZ (m)	Description	UKHO ID	Name
MSDS_HOW04_2019_ARCH_0015	397915.2	5967530.0	21.1	7.9	3.1	8940	High	0	Wreck	9410	UNKNOWN
MSDS_HOW04_2019_ARCH_0073	390303.7	5973917.4	32.4	9.6	2.8	Null	High	0	Wreck	9377	*FLIRT* (POSSIBLY)
MSDS_HOW04_2019_ARCH_0086	379559.3	5994689.6	34.1	15.7	0.3	1960.4	High	75	Scattered area of debris, potential wreck	Null	Null
MSDS_HOW04_2019_ARCH_0113	382843.7	5977119.7	21.1	7.7	1.8	23.5	High	0	Wreck	9401	UNKNOWN
MSDS_HOW04_2019_ARCH_0171	290938.4	5988320.3	13.4	4.1	0.4	Null	High	0	Wreck	Null	Null
MSDS_HOW04_2019_ARCH_0173	290847.9	5989562.7	15.5	4.2	0.1	Null	High	0	Wreck	Null	Null
MSDS_HOW04_2019_ARCH_0178	290939.4	5990524.9	77.3	33.8	0.1	9581.9	High	0	Wreck	5805	*SOTE* (AFT PART)
MSDS_HOW04_2019_ARCH_0187	290814.3	5994746.5	16	10	1.3	790.8	High	0	Potential wreck	Null	Null
MSDS_HOW04_2019_ARCH_0224	382353.2	5983573.2	39.2	15.5	4	1938.4	High	100	Wreck	9400	*LAPWING* (POSSIBLY)
MSDS_HOW04_2019_ARCH_0072	388881.8	5973033.8	12.3	5.8	0.9	Null	Medium	0	Mound	Null	Null
MSDS_HOW04_2019_ARCH_0079	374099.1	6002824.4	4.1	4.7	0.3	Null	Medium	15	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0088	387801.1	5984995.7	22	12.3	0	135.9	Medium	30	Potential ballast mound	Null	Null
MSDS_HOW04_2019_ARCH_0096	384020.4	5967081.9	70.2	16.8	0.2	7	Medium	0	Possible wreck	9403	UNKNOWN
MSDS_HOW04_2019_ARCH_0233	377622.9	6004925.2	25.4	10.4	Null	Null	Medium	0	Potential wreck debris	6830	UNKNOWN
MSDS_HOW04_2019_ARCH_0234	385666.0	5993861.0	16.6	7.7	Null	1653.8	Medium	25	Potential anthropogenic debris with large magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0001	395891.9	5970651.4	2.1	0.8	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0002	393723.4	5967947.5	1.7	0.5	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0003	384899.4	5981988.7	3.6	3.8	1	Null	Low	0	Potential mound	Null	Null
MSDS_HOW04_2019_ARCH_0004	369914.2	6007994.9	1.4	1.8	0.7	8.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0005	381088.9	5990307.0	15.9	11.9	0.6	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0006	393480.4	5970587.8	1.9	2.2	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0007	383187.9	5988979.3	3.1	2.6	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0008	382530.1	5990076.2	0.7	2.7	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019_ARCH_0012	372652.0	6005553.7	1.2	1	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0013	394204.7	5971438.9	0.7	0.6	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0014	383524.4	5990294.4	3.4	1.1	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0016	378944.7	5999094.6	1.1	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0017	379386.4	5998406.8	5.3	3.7	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0018	373947.5	6006971.0	4.1	3.4	1	12.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0019	383187.0	5993973.8	2.3	1.4	0.9	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0020	381228.6	5997172.0	3.6	1.6	0.9	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0021	377962.0	6003911.4	1	0.5	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0022	384844.3	5995249.8	2.6	1	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0023	393297.9	5981833.8	6.7	3.3	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0024	395535.4	5978220.5	1.8	1.2	0.9	7.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0025	379914.5	6002941.0	1.3	0.3	0.2	5.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0026	390845.2	5987833.9	1.9	1.3	0.6	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0027	385083.1	5997096.5	2.3	0.8	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0028	382351.3	6001270.7	4.9	1.9	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0029	389090.3	5995353.2	2.1	0.2	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0030	392605.9	5989863.3	0.4	1	0.8	14.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0031	391557.2	5993872.4	0.5	1.1	0.9	31.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0032	392861.0	5991823.9	0.4	0.2	1	76.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0033	389658.7	5996865.2	1.3	1.2	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0034	394828.8	5991023.9	0.6	0.4	0.2	17.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0035	394717.8	5991140.8	1.2	0.7	0.5	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0036	392597.4	5994429.0	2.3	1.3	0.5	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0037	390937.9	5997070.3	4.2	2.5	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019_ARCH_0038	396168.5	5988792.1	2.2	1	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0039	388780.4	6000576.9	0.9	1.3	1.7	13.4	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0040	394463.6	5994314.9	2.5	0.9	0.2	12.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0041	395993.1	5991760.6	1.4	0.8	0.7	6.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0042	392255.0	5997889.5	1.9	1	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0043	390030.1	6001143.9	1.9	0.5	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0044	392256.3	5997729.2	1.3	0.9	0.7	19.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0045	392143.8	5999977.5	1.9	2.4	0.6	43.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0046	395304.2	5995000.5	1.1	0.8	2.3	13.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0047	399414.6	5991335.0	1.5	0.7	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0048	395504.9	5997574.4	0.9	0.6	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0049	398478.4	5993020.4	2.9	1.4	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0050	397076.6	5995169.1	1.1	0.3	0.6	10.4	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0051	397199.9	5994967.0	1.4	0.5	1.1	12.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0052	397441.7	5994636.8	4.1	2.3	0.7	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0053	401230.1	5988451.1	2.8	0.5	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0054	400669.8	5989506.7	1	1.1	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0055	401573.4	5991322.2	1.7	2.7	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0056	401571.2	5991324.6	1.2	3.2	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0057	378179.0	5992723.4	2.2	1.6	0.6	9.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0058	390083.7	5971684.6	1.3	1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0059	390150.7	5971735.3	0.7	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0060	388399.8	5974496.4	0.9	0.3	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019_ARCH_0061	388272.6	5974632.9	0.9	0.7	0.7	11.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0062	390244.9	5971604.5	2.6	1.2	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0063	393544.8	5966202.4	1.7	1.2	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0064	393035.9	5967007.1	5.9	2.6	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0065	397225.1	5995993.4	1.8	0.4	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0066	388810.9	5990817.2	1.8	0.6	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0067	391431.6	5992426.4	0.5	0.8	0.6	9.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0068	395003.5	5991151.6	1.8	1.3	1.8	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0069	400895.3	5991283.9	0.9	1.4	0.4	32.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0071	388639.4	5973024.2	2.6	1.2	0.7	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0074	398093.1	5968596.7	6.5	0	0	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0075	387531.1	5968682.5	3.8	0.7	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0076	388609.1	5969401.7	1.4	0.8	0.9	29.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0077	391308.3	5967583.1	0.8	1.8	1.1	28	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0078	406971.8	5988000.2	2.6	1.9	0.9	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0080	391048.9	5999322.0	1.4	2	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0081	390142.8	5995122.7	1.4	1.4	0.1	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0082	389769.1	5994985.7	3.5	1.5	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0083	392852.2	5969451.1	3.1	0.6	0.2	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0084	389502.4	5974748.4	0.3	0.3	0.2	5.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0087	372195.1	6006382.7	0.7	0.2	0.3	6.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0089	393848.6	5973922.7	0.9	1.3	0.4	17.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null

MSDS_HOW04_2019_ARCH_0090	382454.2	5993412.4	0.3	0.8	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0091	374114.9	6006703.4	0.4	0.3	0.7	14.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0092	397530.0	5971175.4	0.8	0.4	0.1	9.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0093	393904.5	5976954.3	0.6	0.2	0.2	8.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0094	396121.7	5974958.3	0.5	1.1	0.2	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0095	383919.0	5967214.1	1.2	1.5	0.2	25.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0097	386410.0	6002132.3	1.1	0.9	0.8	15.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0098	386409.5	6002131.2	1.4	0.6	1.1	15.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0099	390534.9	5995567.6	0.6	0.6	0.1	15.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0100	390973.6	5994804.3	0.8	1	0.7	6.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0101	388393.5	5998979.3	0.9	0.4	0.3	5.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0102	388945.0	5998102.5	0.9	0.6	0.3	13.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0103	390730.5	5995191.8	2.3	1.6	1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0104	393199.6	5993530.7	0.9	0.3	0.1	9.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0105	391214.0	5996719.6	1.1	1.2	2.3	6.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0106	391806.6	5995749.7	3.2	2.2	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0107	396555.5	5993019.1	1.3	1.1	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0108	403354.0	5985191.3	1.1	0.2	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019_ARCH_0109	401622.6	5991160.1	0.4	0.4	0.1	14.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0110	399582.6	5994355.3	0.6	0.3	0.3	12	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0111	401541.3	5991296.2	0.9	1.2	0.4	11.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0112	387615.7	5969528.1	0.4	0.7	0.5	31.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0114	388209.0	5972745.3	4.2	2.8	0	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0115	392340.5	5966141.0	0.7	0.2	0.2	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0116	395980.0	5995270.7	0.8	0.4	0.5	5.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0117	394477.3	5994327.3	0.6	0.5	0.9	6.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0118	395364.5	5994885.0	0.6	0.8	1.1	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0119	393646.2	5993798.0	0.4	0.7	0.6	30.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0120	390254.6	5991678.1	1.7	0.9	0.7	100.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0121	393644.2	5993800.6	0.3	0.5	0.9	18.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0122	399344.7	5993844.1	0.5	0.4	0.1	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0123	399288.2	5993832.9	0.8	0.2	0.2	5.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0124	395680.7	5991551.6	1.1	0.5	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0125	395914.9	5991710.0	0.8	0.6	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0126	395853.0	5991675.1	0.6	0.5	0.5	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null

MSDS_HOW04_2019_ARCH_0127	397078.5	5992435.6	0.5	0.4	0.5	25.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0128	398795.1	5993518.5	0.3	0.4	0.8	Null	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0129	401194.9	5991434.7	0.3	0.5	0.3	10	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0130	388302.5	5972734.5	1.6	0.4	0.4	5.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0131	391863.2	5971469.3	0.5	1.1	0.4	11	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0133	377387.5	6004827.5	1.3	1.9	1.3	87	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0134	394726.6	5998084.6	1.5	0.7	2.2	5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0135	394727.6	5998086.0	1.3	0.3	1.3	5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0136	391271.9	5967591.7	1.3	1.6	0.6	28	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0137	290410.1	5987027.8	2.1	1.5	0.5	7.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0138	289960.9	5990610.5	1.2	1.2	0.5	65.4	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0139	291775.0	5990723.5	4.3	3.4	0.7	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0140	290325.6	5991165.8	1.8	1.4	0.3	47.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0141	295713.1	5991172.8	7	4.9	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0142	293160.2	5993860.9	1.6	1.3	0.2	62.8	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0143	382376.7	5983600.2	2.5	2.2	0.4	Null	Low	0	Potential wreck debris	Null	Null
MSDS_HOW04_2019_ARCH_0144	290347.2	5991657.8	3	0.3	0.6	79.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0145	290287.7	5991520.6	0.5	0.4	0.2	28.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null

MSDS_HOW04_2019_ARCH_0146	290326.2	5989187.7	1	0.3	0.3	10.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
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Appendix D: MSDS Palaeogeographic Review of Geophysical Survey Data

Palaeographic Review of Geophysical Survey Data

Information from MSDS Marine for input into the EIA

MSDS Marine
April 2019

MSDS Marine

Palaeogeographic Review of Geophysical Survey Data

Information from MSDS Marine for input into EIA

Project Name	Palaeogeographic Review of Geophysical Survey Data
Client Project Number:	HOW04 (Archaeology)
Author and contact details	Sally Evans Sally@msdsmarine.co.uk 07791217114
Origination date	28/03/2019
Reviser (s)	Sally Evans
Date of last revision	01/04/2019
Version number:	1.0
Summary of changes	-

Contents

1.0 Introduction

1.1 Palaeogeographic Review of Geophysical Survey Data

1.1.1 The purpose of this task is to provide advice to support the palaeoenvironmental aspects of the ground model, created and led by Ørsted's site investigations team, ensuring that the resultant ground model will be of use for archaeological purposes. This includes archaeological input and guidance to identify areas where further geophysical and/or geotechnical work may be required, for example cores to ground truth the model. This is to ensure robust understanding of archaeological and palaeoenvironmental potential, while also ensuring impacts to the historic environment are offset by appropriate mitigation.

1.1.2 The end product for the ground model will be a series of mapped horizons showing the extent and thickness of all sub-surface deposits within the site, along with interpretations relating to the origin of the deposits. This will be used by MSDS Marine to identify areas of archaeological potential. The resulting "map" will be used to propose a mitigation strategy to the Marine Management Organisation (MMO) and Historic England (HE).

1.1.3 MSDS Marine will report the outcomes of this work to Ørsted in a document which details the following:

- Geophysical and geotechnical surveys undertaken for Hornsea Four (including dates surveys were undertaken, and specifications);
- Archaeological input into geotechnical locations;
- Geophysical survey acquisition and interpretation methods and their suitability for assessing archaeological potential based on the resultant ground model;
- A breakdown of each sedimentary horizon and how it has been assessed and recorded by geotechnical and geophysical work, and the interpretation of each deposit with particular reference to how each deposit has been derived;
- Areas where high archaeological potential has been identified (accompanied by shapefiles);
- Any input into mitigation strategies; and
- Any other relevant advice given.

1.1.4 The current document has been prepared as an interim statement of work relating to the development of the ground model and input into geotechnical investigations to-date. This document has been produced in order to feed the results of this ongoing work into the EIA documentation. This will be treated as a live document which will be updated as the ground model and palaeogeographic interpretation develop.

2.0 Geophysical Surveys

2.1.1 This section gives an overview of geophysical surveys undertaken to date, planned geophysical surveys and geophysical survey acquisition and interpretation methods and their suitability for assessing archaeological potential based on the resultant ground model.

2.1.2 Geophysical surveys for Hornsea Project Four are planned to take place in a series of phases. Each phase will provide more detailed surveys than the last, so that the final datasets present a high-resolution understanding of the sub-surface deposits within the site. Geophysical surveys were first undertaken in 2011. A sequence of surveys is planned to take place in the coming years. These are:

- Geophysical 1a (undertaken in 2018)
- Geophysical 1b
- Geophysical 1c
- Geophysical 2a

2.1.3 Geophysical surveys will be undertaken in a way which is compliant with the best practice guidance and aims set out within Historic England (2013) *Marine geophysical data acquisition, processing and interpretation.* Historic England have indicated that there are plans to update this guidance, however, this may not happen for a number of years. While techniques, strategies and equipment have developed since the publication of this guidance in 2013, the geophysical surveys undertaken will be appropriate for the production of a high-resolution ground model, and input from MSDS Marine will ensure that the final ground model is of sufficient quality to understand areas of archaeological potential and adequately mitigate impacts to the palaeolandscape and environment.

2.1.4 The geophysical survey data collected in 2011 and 2018 will form the basis for the Hornsea Project Four ground model to be used for EIA purposes. The ground model is currently in version one, and as of the end of February 2019 the ground model covering the array area was based on the 2011 data only. Ørsted plan to add in the 2018 data.

2.1.5 This ground model will be developed in the post-consent period by further geophysical surveys and geotechnical campaigns.

2.1.6 The 2011 geophysical surveys on which version 1 of the ground model is currently based include:

- MBES (1m bin grids)
- SBP (pinger data, 100m x 500m spacing, low penetration and resolution)
- UHRS (100m x 500m line spacing, to c. 100m below the seabed).

2.1.7 The 2018 geophysical surveys (geophysical 1a) included:

- Bathymetry and backscatter (est. 100m swathe)

- SBP (along run-line, covering the upper 5m below seabed, with 10-20cm resolution vertically)
- UHRS (array and booster station search area only. Along run-line, covering the upper 70m below seabed with 20-50cm vertical resolution)

2.1.8 Later geophysical campaigns (geophysical 1b, 2a and 1c) will add further detail. While line spacing is currently wide, future surveys will be undertaken with much narrower line spacing (geophysical 1b is set to have full coverage of the development area with 100m line spacing, geophysical 2a will include a 100m buffer around cable routes in addition to the areas around turbines and substations, with 15m line spacing). This, coupled with the high quality Innomar and UHRS survey equipment will ensure the collection of sufficiently detailed data production of a high-resolution ground model, with high vertical and horizontal resolution.

3.0 Geotechnical Investigations

3.1.1 The only geotechnical work conducted within the development area to-date comprises that undertaken in 2011 (see Figure 1). This included:

- BH-HZ13
- CPT-HZ12/12a
- CPT-HZ11
- CPT-HZ10
- CPT-HZ8
- CPT-HZ7
- CPT-HZ6

3.1.2 These investigations were all undertaken in the southern part of the site. A geotechnical campaign will take place in 2019 and future campaigns are also being planned. Further information on these campaigns is included below.

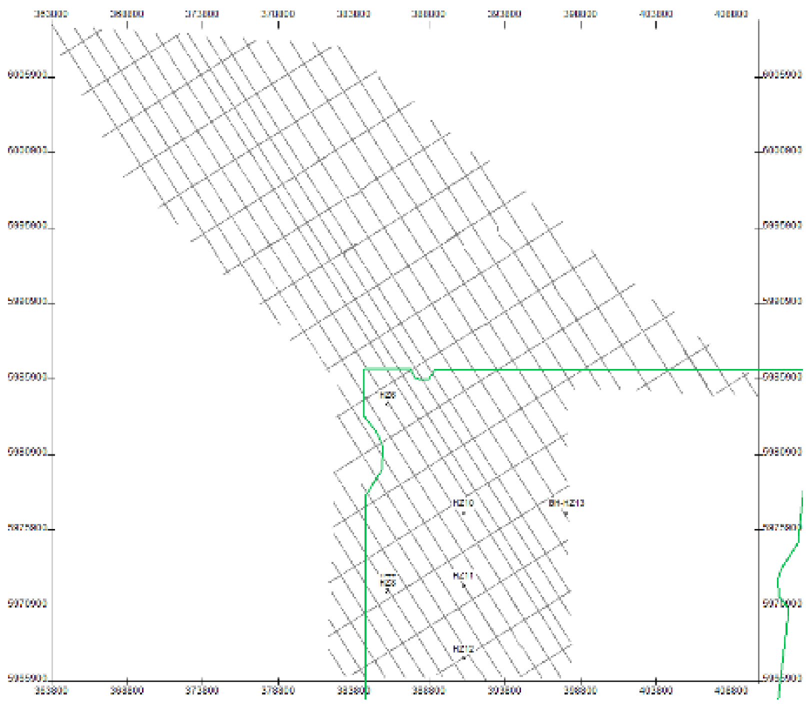

Figure 1: Locations of 2011 geotechnical investigations within HOW04 zone. Figure from Ørsted.

4.0 Sedimentary horizons identified within the development area

4.1.1 The Project Area has seen a series of cold cycles and warmer interludes associated with the Devensian, Wolstonian and Anglian glaciations and interglacial periods. These changing environmental conditions have left a sequence of deposits within the site, which have varying levels of archaeological and palaeoenvironmental potential. The archaeological potential for the area, based on desk-based sources and existing studies is set out within the scoping report. Key sources include the North Sea Palaeolandscape Project, Humber Regional Environmental Characterisation and work associated with other Hornsea Zone Projects. This section provides added detail which is the result of the ongoing assessment of geophysical survey data and ground model development.

Array Area

4.1.2 Table 1 provides an overview of the sedimentary sequence within the site. Those which are of archaeological and palaeoenvironmental interest have been highlighted in green in the table below. Of particular interest are potential Holocene deposits which predate the marine inundation of the area, Botney Cut deposits, Eem formation and Yarmouth Roads deposits. The latter are equated with the onshore Cromer Forest Beds which have produced evidence of *in situ* archaeological and palaeoenvironmental remains dating to the Lower Palaeolithic.

4.1.3 However, it must be noted that at this stage interpretations are based primarily on seismic data interpretation, supported by knowledge gained within the other Hornsea project areas and with reference to previous geotechnical work. In order to prove the interpretation of the deposits, further geotechnical investigation of each deposit must take place. Thus, at this stage interpretations are preliminary, and archaeological input is concerned with ensuring all interpretations for all deposits are correct, as correct interpretations within the ground model are vital for identifying areas and deposits of low or high archaeological potential.

Deposit	Description
Holocene	During the Holocene period the site was characterised by terrestrial, intertidal and then fully marine conditions. A Holocene shoreline is likely to have run along the north-eastern edge of the array area and studies show palaeochannels dating to this period may be present within the array area. Marine sands are underlain by early Holocene channels cut into the earlier glacial channels (Botney Cut). Depressions in possible morraines and other glacial features along the export cable route may hold organic deposits of Holocene date.
HGT20	Glaciotectonite
Botney Cut	Related to the Late Devensian and Early Holocene period. Predominantly glacio-fluvial features and till. Some of the botney cut features may be re-interpreted as Bolders bank
Bolders Bank	Related to the Devensian period. Diamicton probably formed by an ice lobe, with probable internal sub-glacial channels. Different phases of Bolders Bank glacial activity within the area. Present as a blanket deposit in the southern part of the array area, with more erosive properties to the north.
HGT30	Glaciotectonite
Eem Formation	Related to the Ipswichian interglacial. Fine to medium grained shelly marine sands, or intertidal/sub-tidal deposits.
HGT40	Glaciotectonite
Egmond Ground	Fine grained marine sands interbedded with clays
HGT52	Glaciotectonite
Swarte Bank	Related to the Anglian glaciation. Primarily characterised by sub glacial valleys incised into the Yarmouth Roads formation and underlying deposits (where present)
Yarmouth Roads	Related to the Cromerian Period. Fluvial or deltaic deposits with sands, silts, clays and reworked peat. Partially equated with the onshore Cromer Forest Beds which are associated with *in situ* archaeological material at Happisburgh and Pakefield. Multiple phases of Yarmouth Roads Formation have been identified within the site. Internal Yarmouth Road reflectors are clearly visible within seismic data.
Chalk	Bedrock
Pre Chalk	Bedrock

Table 1: Summary of sedimentary sequence and deposits of archaeological interest within the Hornsea Four Zone

4.1.4 Little is known about the glaciotectonites at present and interpretations are uncertain. Glaciotectonites mark areas in which deposits have undergone some form of ice-related deformation. In places the glaciotectonies may actually represent Botney cut and/or Swarte Bank channels. Future geotechnical campaigns will investigate these features. Archaeological interpretation will be revised when more data is available following this work.

4.2 Archaeological input into 2019 and future geotechnical locations

4.2.1 The first dedicated geotechnical campaign for Hornsea Project Four will take place in 2019. It will include collection of:

- 4 boreholes and 4 CPTs within the intertidal area.

4.2.2 MSDS Marine are providing archaeological input into geotechnical work, to ensure that Ørsted work in line with the guidance provided in the 2011 *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector* (Gribble and Leather, 2011). The positions of these boreholes and CPTs are currently under discussion with Ørsted, and will be reviewed by MSDS Marine prior to a final decision on the locations being made.

4.2.3 Initially geotechnical investigations in the array area and export cable route were also planned to take place in 2019. These investigations have now been postponed, however, it is likely that they will take place in the future. MSDS Marine, supported by Dr Michael Grant from Southampton University, provided input on core locations for the array area and export cable route in a two-day workshop which took place in February 2019. The locations reviewed were for:

- 9-11 boreholes within the array area; and
- Vibrocores and CPTs within the array area and cable route

4.2.4 Core locations are planned at intersections between cross-lines in the geophysical survey data. This is to aid interpretation and maximise the value of each core as the data from each can be used to interpret seismic profiles from two lines. This forms the most appropriate strategy for ground-truthing the geophysical survey data and is thus the best rationale for developing the ground model. However, if the cores cannot be taken at the primary location, secondary locations in the near vicinity have been made, with archaeological input, to target features of potential archaeological interest. The deposits targeted by each core have been indicated within the table below. All of the deposits will be sampled by at least one core, to ensure all deposits and ground model interpretations have been ground-truthed.

4.2.5 Core locations also focus on the northern and central part of the array area as the southern part was subject to geotechnical sampling in 2011.

New Name	V1 name	Holocene	HGT20	Botney Cut	Bolders Bank	HGT30	Eem	HGT40	EGM	HGT52	Swarte Bank	Internal YMR	Yarmouth Roads	Chalk	Pre-Chalk
BH06	Location 1	x			x	x					x		x		x
BH10	Location 3	x		x	x			x			x		x	x	
BH07	Location 4	x		x		x						x	x	x	
BH09	Location 5	x	x	x							x				
BH04	Location 6	x					x								x
BH01	Location 7	x							x		x				x
BH12	Location 8	x			x		x					x	x	x	
BH02	Location 11	x													x
BH03	Location 12	x		x							x			x	x

Table 2: Summary of possible geotechnical locations in the array area and deposits to be targeted

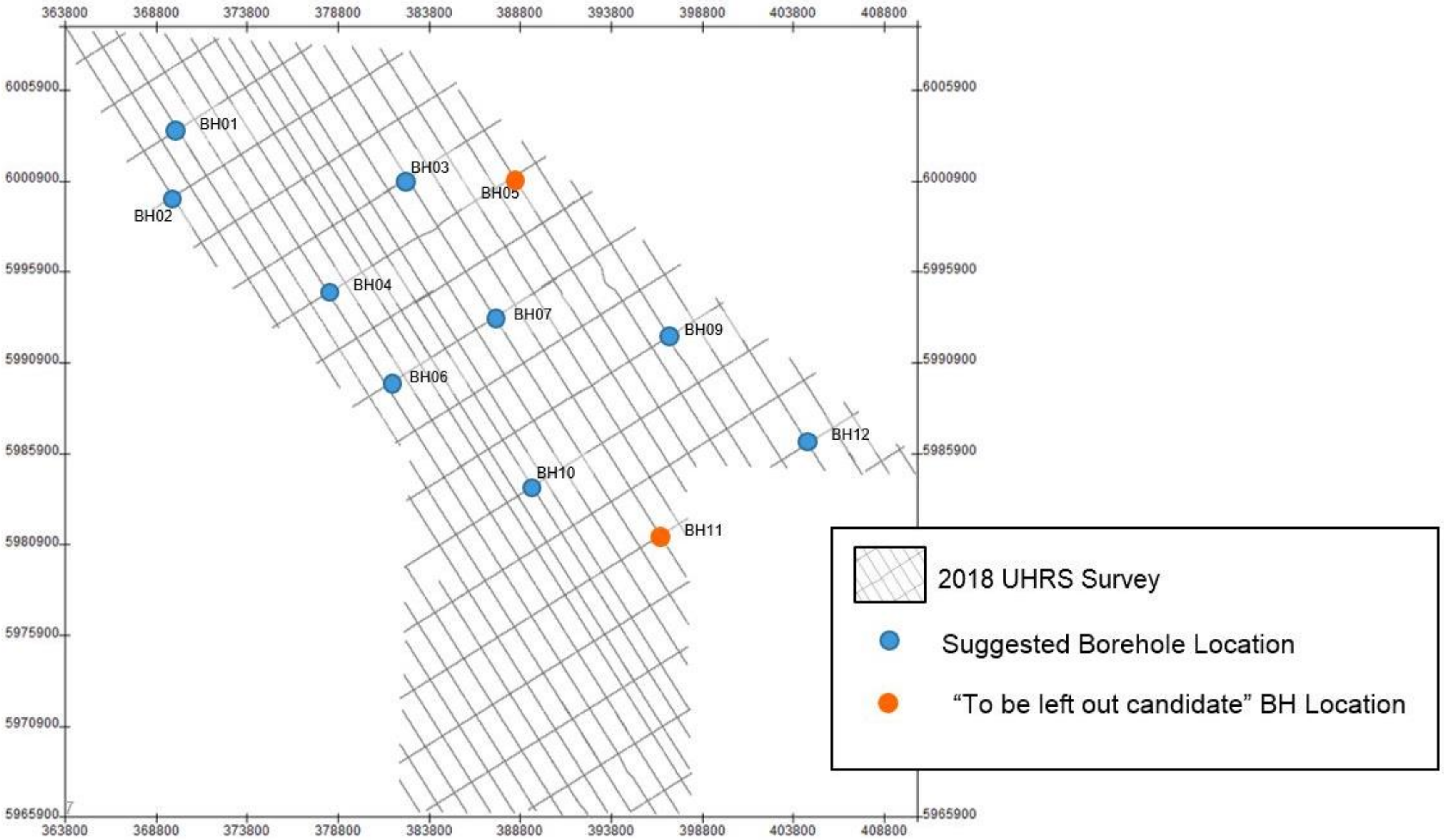

Figure 2: Possible borehole locations in the array area

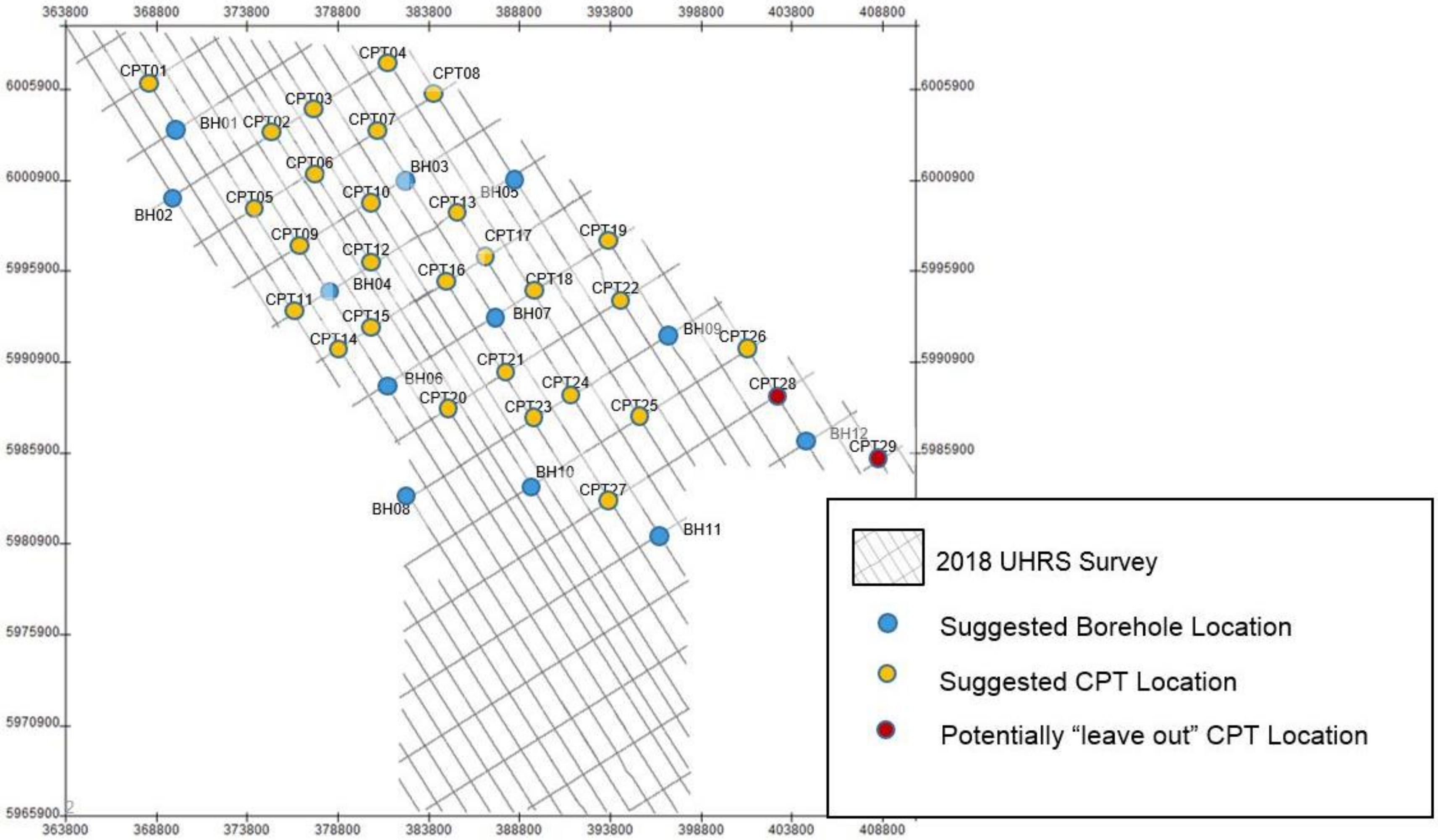

Figure 3:Possible CPT locations in the array area

Export Cable Route

4.2.6 The deposits within the export cable route have been identified following analysis of the geophysical survey data collected in 2018. This data was collected with 500m line spacing, east-west along the export cable route and out to the funnel. There are no cross lines except for where the export cable route meets the funnel area. This data is still in the process of being interpreted, however, the sequence has been characterised as Holocene deposits including mobile sands with some channels or depressions at the base. It is possible that these undulations in the Holocene deposits may represent undulations in underlying moraines. Such depressions can form the focus for accumulation of organic sediments.

4.2.7 The basal deposits include Bolders bank, Swarte bank and Yarmouth Roads, which lie on top of chalk or pre-chalk bedrock. In some areas a unit which underlies the Holocene deposits and overlies the basal deposit has been identified. Interpretations of the deposits is ongoing.

4.2.8 Future geotechnical campaigns are likely to take place along the export cable route. MSDS Marine and Dr Michael Grant have had input into the likely locations. The first round of geotechnical work is likely to include cores at 5km intervals. The table below indicates which deposits will be targeted by the possible geotechnical locations. These locations have all had archaeological input, though are subject to change. Any changes and revised locations will also be reviewed by an archaeologist.

New Name	OLD ID	Holocene	Possible very fine-grained unit	Channels	Intermediate unit	Basal unit
ECR_CPT04	KP08X	No geophysical survey data available on which to base interpretations of the sedimentary sequence.				
ECR_CPT05	KP10X					
ECR_CPT06	KP12X					
ECR_CPT07	KP15X					
ECR_CPT08	KP20X					
ECR_CPT09	KP25X	x				x
ECR_CPT10	KP30	x				x
ECR_CPT11	KP35	x				x
ECR_CPT12	KP40	x				x
ECR_CPT13	KP45_2	x		x		x
ECR_CPT14	KP50_2	x	x		x	x
ECR_CPT15	KP50_3	x	x		x	x
ECR_CPT16	KP55	x				x
ECR_CPT17	KP60	x			x	x
ECR_CPT18	KP65	x			x	x
ECR_CPT19	KP70	x			x	x
ECR_CPT20	KP75	x			x	x
ECR_CPT21	KP80	x		x	x	
ECR_CPT22	KP85	x				
ECR_CPT23	KP90	x		x	x	
ECR_CPT24	KP95	x		x	x	
ECR_CPT25	Extra 1	x		x	x	x
ECR_CPT26	Extra 2	x		x	x	x
ECR_CPT27	Extra 3	x			x	x

Table 3 Summary of possible geotechnical locations along the ECR and deposits to be targeted

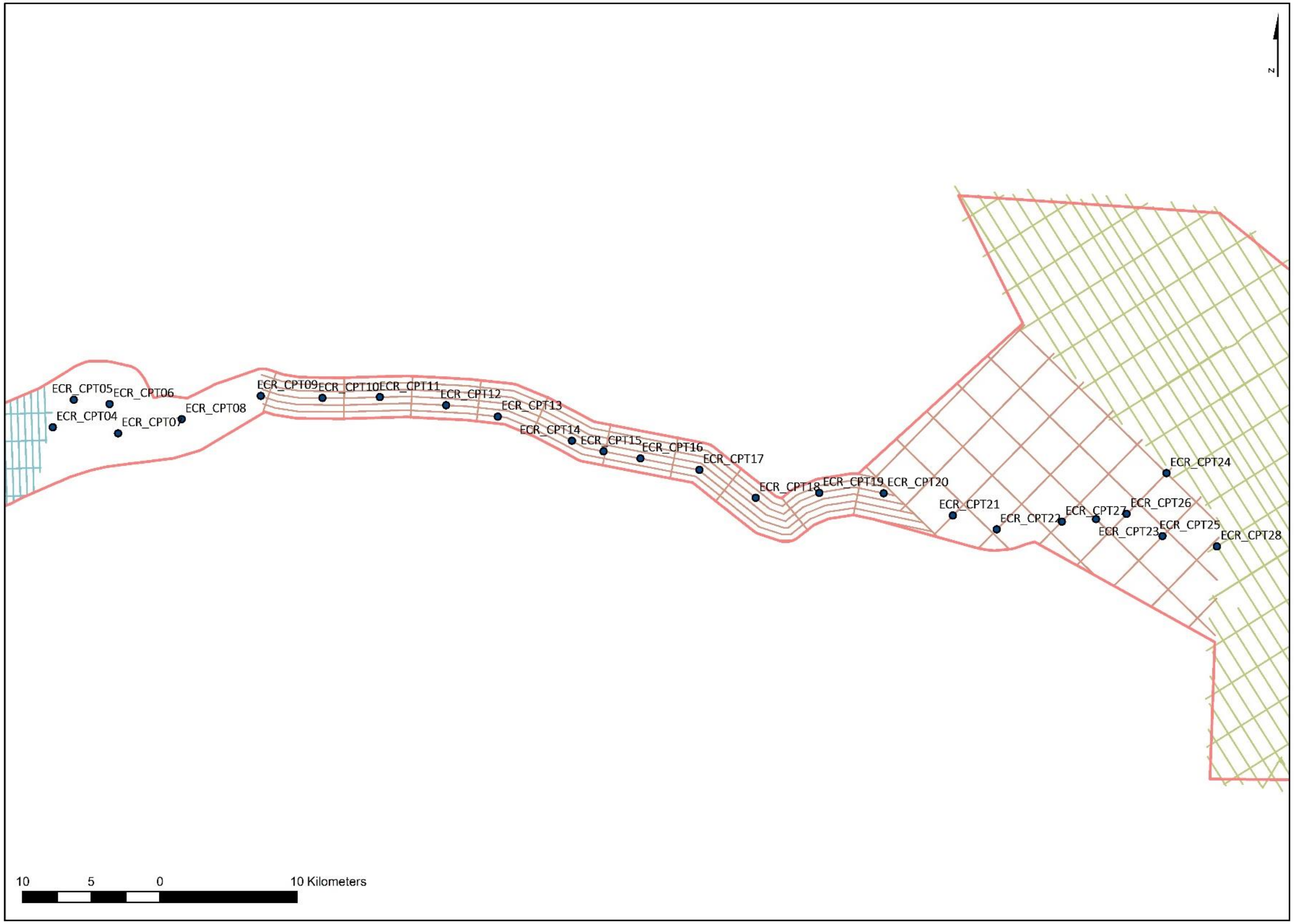

Figure 4: Possible CPT locations along the ECR

5.0 Archaeological Potential

5.1.1 This section contains preliminary indications of possible areas of higher and lower archaeological potential. Results are likely to be revised following the 2019 and later geotechnical campaigns, ongoing interpretations of seismic data, and refining of the ground model.

5.1.2 Quaternary deposits are thin within the western and northern part of the Hornsea Project Four Array area. The northern area in particular has <10m of Quaternary deposits. Quaternary deposits are thickest in the southern part of the array area and thus archaeological potential is highest in this zone.

5.1.3 Key deposits of interest are Holocene, Botney Cut, Eem Formation and Yarmouth Roads Formation. The extents of these deposits are shown by Figure 5 below.

5.1.4 Holocene deposits are represented by marine sands which are in some place underlain by possible palaeochannels. The North Sea Palaeolandscape project mapped a series of channel features within the southern part of the array area which may relate to Holocene channels. These features may contain palaeoenvironmental evidence and thus hold palaeoenvironmental and archaeological potential.

5.1.5 The southern part of the site includes evidence of the Eem formation and Yarmouth Roads, thus this part of the site has archaeological and palaeoenvironmental potential. Future geotechnical campaigns, and in particular the boreholes (table 2), will provide further insight into these deposits and their potential.

5.1.6 Yarmouth roads deposits in particular appear to be extensive and thick in places, with multiple different internal reflectors indicating different phases. These deposits are exceptionally thick within the Hornsea Project Four array area, and the sequence may be able to provide information which would allow a detailed understanding of the correlation between these deposits and the Cromer Forest Beds sequence.

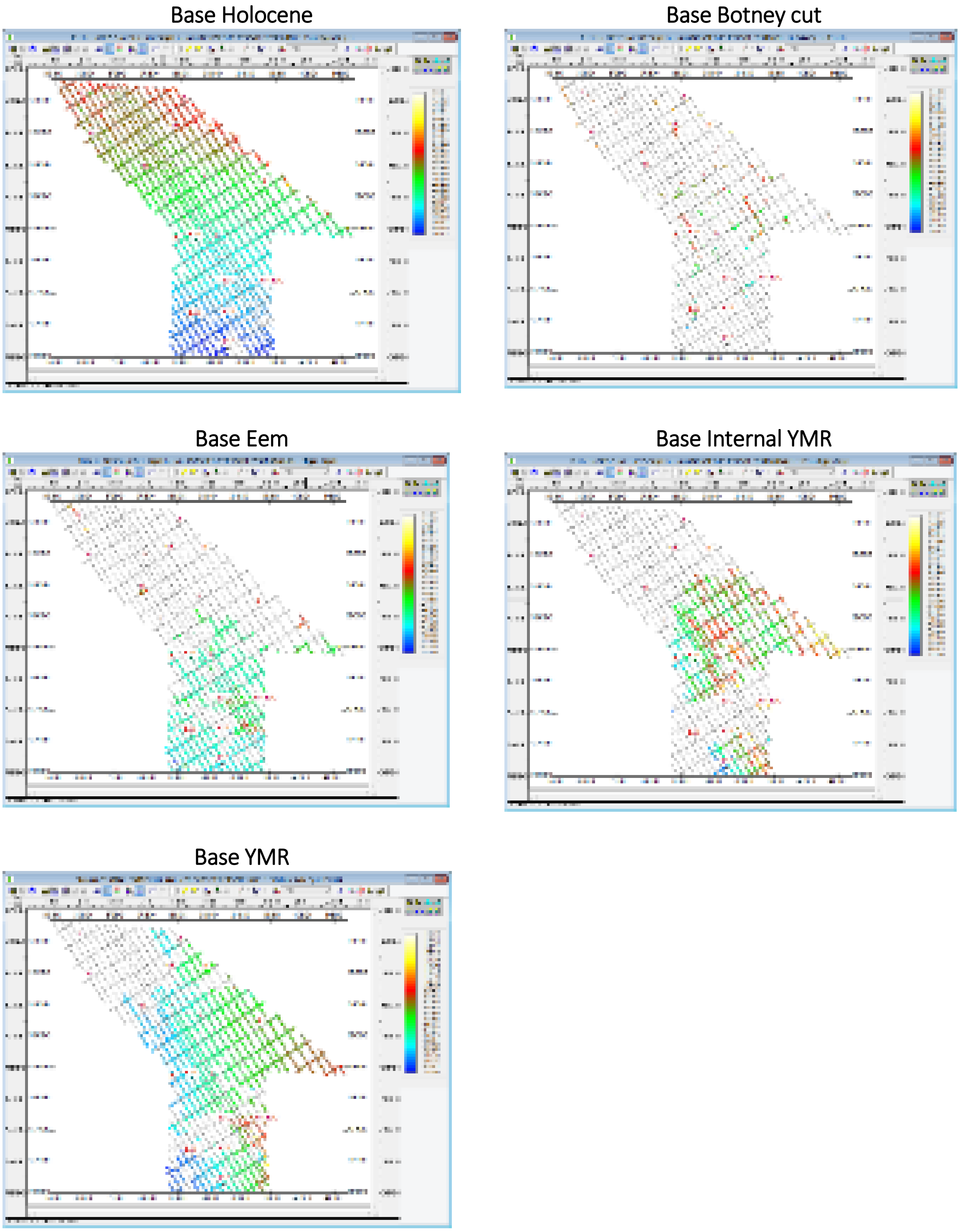

Figure 5: Distribution of deposits of archaeological interest within the HOW04 Array area

5.1.7 Along the export cable route preliminary indications of archaeological potential based on the interpretation of the seismic data to date indicate that fine grained sediments have been identified midway along the ECR at CPT locations 14 and 15 (see Table 3 and Figure 4). Additionally channel features or depressions have also been identified at CPT13, CPT 21, and CPT23-26.

5.1.8 Undulations at the base Holocene may reflect the underlying surface of moraines, whose depressions may be associated with Holocene fills potentially including fine grained or organic deposits, with palaeoenvironmental potential. Likewise, fluvioglacial features such as kettle holes, some of which later became meres, are also known along the Holderness coast and have been found to hold thickly stratified post-glacial deposits. There is potential for comparable remains offshore.

5.1.9 As the interpretation progresses further information on the archaeological potential will become available, however, at present it can be characterised according to the information in table 1, with deposits of potential archaeological interest including Holocene sediments, Botney cut, Eem formation and Yarmouth Roads.