Hornsea Project Four: Environmental Statement (ES)

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Volume A5, Annex 9.1: Marine Archaeology Technical Report

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Table of Contents

List of Tables

List of Figures

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 (NSIPs).
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.
Marine Heritage Receptor	Physical resources such as shipwrecks, aviation remains, archaeological sites, archaeological finds and material including pre-historic deposits as well as archival documents and oral accounts recognised as of historical/archaeological or cultural significance.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Order Limits	The limits within which Hornsea Four (the 'authorised project') may be carried out.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Outline Marine Written Scheme of Investigation (WSI)	Project specific document forming the agreement between the Applicant, the appointed archaeologists, contractors and the relevant stakeholders seaward of Mean High Water Springs (MHWS). The document sets out the methods to mitigate the effects on all the known and potential archaeological receptors within the Hornsea Four offshore Order Limits.
Outline Onshore Written Scheme of Investigation (WSI)	Project specific document forming the agreement between the Applicant, the appointed archaeologists, contractors and the relevant stakeholders landward of MHWS. The document sets out the methods to mitigate the effects on all the known and potential archaeological receptors within the Hornsea Four onshore Order Limits.

Acronyms

Acronym	Definition
AD	Anno Domini
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
dML	Deemed Marine Licence

Acronym	Definition
EIA	Environmental Impact Assessment
ECC	Export Cable Corridor
ES	Environmental Statement
FISH	Forum on Information Standards in Heritage
HE	Historic England
HERs	Historic Environment Records
HMD	His Majesty's Drifter
HMS	His Majesty's Ship
HMT	His Majesty's Trawler
HOB UID	NRHE Historical Object Unique Identifier (AMIE Primary Identifier)
JNAPC	Joint Nautical Archaeology Policy Committee
LAT	Lowest Astronomical Tide
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
NRHE	National Record of the Historic Environment
NSIP	Nationally Significant Infrastructure Project
NSPP	North Sea Palaeolandscapes Project
OD	Ordnance Datum
ORPAD	Offshore Renewables Protocol for Archaeological Discoveries
OS	Ordnance Survey
PEIR	Preliminary Environmental Information Report
PAD	Protocol for Archaeological Discoveries
RCZA	Rapid Coastal Zone Assessment
REC	Regional Environmental Characterisation
RSL	Relative Sea Level
SMR	Sites and Monuments Record (Now known as Historic Environment Records. HERs)
SSS	Side Scan Sonar
UKHO	United Kingdom Hydrographic Office
UXO	Unexploded Ordnance
WSI	Written Scheme of Investigation
WWI	World War One
WWII	World War Two

Units

Unit	Definition
km	Kilometres
m	Metres
nT	Nanotesla (magnetic induction)

1 Introduction

1.1 Introduction

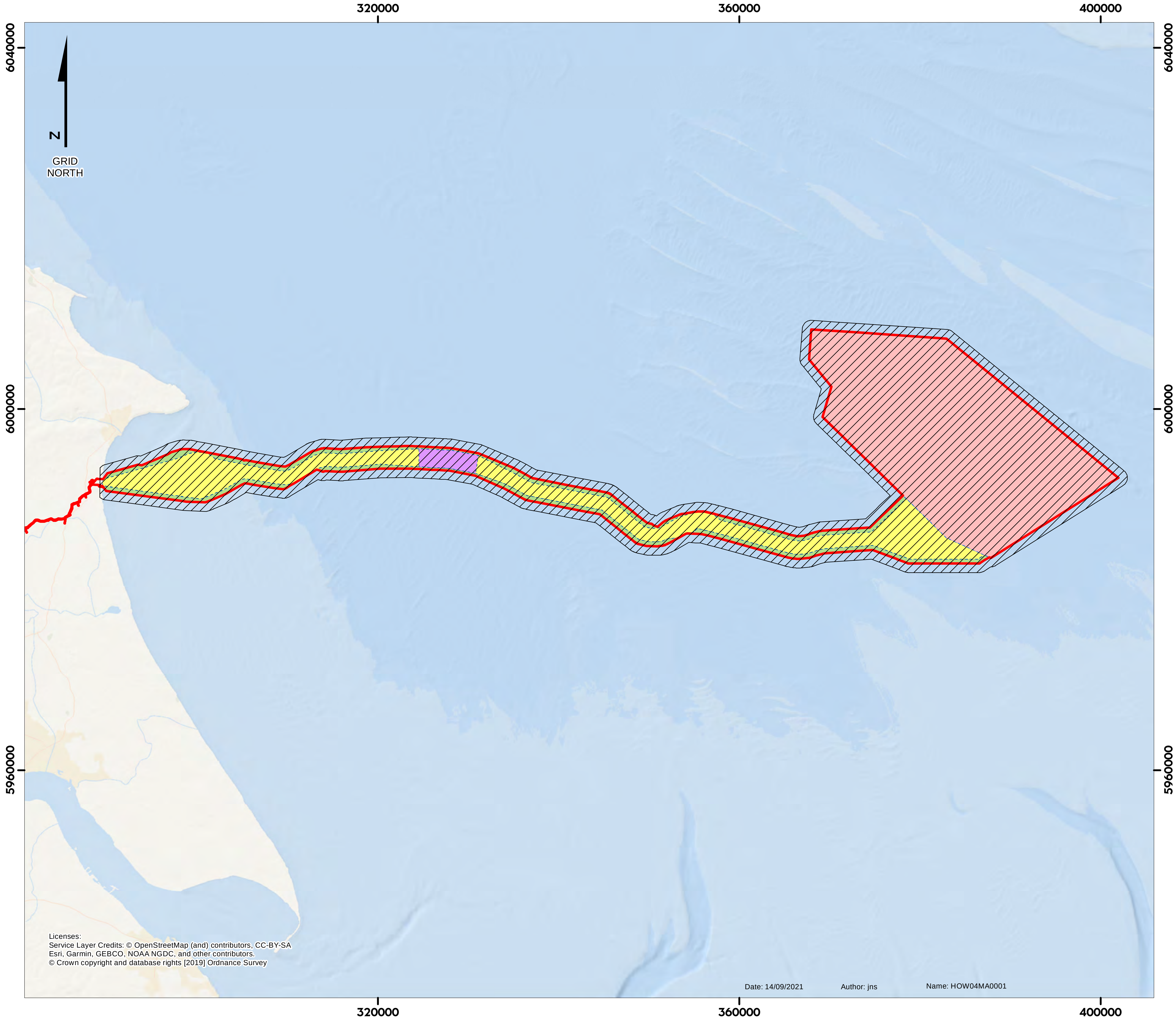
1.1.1 Project background

1.1.1.1 Orsted Hornsea Project Four Ltd (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore from Flamborough Head on the coast 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 (please see **Volume A1, Chapter 1: Introduction** for further details on the former 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 Order Limits combine the search areas for the onshore and offshore infrastructure.

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 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 has given due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) Application. 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.

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area Process has resulted in a marked reduction in the array area taken forward at the point of application (see **Figure 1**). Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

1.1.1.4 Maritime Archaeology Ltd. was commissioned by the Applicant to undertake an archaeological impact assessment study of the Hornsea Four Order Limits and surrounding area.



Hornsea Four

Figure 1

Marine Archaeology Study Area

- Marine Archaeology Study Area
- Order Limits
- Array Area
- HVAC Booster Station Works Area
- Offshore Temporary Works Areas
- Offshore Export Cable Corridor

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 7.5 15 Kilometres

0 3.5 7 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	14/09/2021

Archaeology Study Area
Document no: HOW04MA0001
Created by: CH
Checked by: BM
Approved by: GM

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 Hornsea Four Order Limits and wider marine archaeology study area.

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

- Undertake ongoing consultation with Historic England 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 Hornsea Four Order Limits and marine archaeology study area;
- Summarise the environmental context and archaeological potential;
- Assess 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 Outline Marine 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 of Hornsea Four for unexpected archaeological finds in accordance with 'Protocol for Archaeological Discoveries: Offshore Renewables Projects' (The Crown Estate, 2014).

1.1.2.3 The marine archaeological assessment is presented in **Chapter 9: Marine Archaeology**, with the Outline Marine WSI presented in **Document F2.4**.

2 Methodology

2.1 Introduction

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:

- Standard and guidance for historic environment desk-based assessment (CIfA 2017);
- Standard and guidance for the collection, documentation, conservation and research of archaeological materials (CIfA 2014a);
- Standard and guidance for commissioning work 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);
- Archaeological Written Schemes of Investigation for Offshore Wind Farm Projects (The Crown Estate 2021);
- Joint Nautical Archaeology Policy Committee (JNAPC) Code for Practice for Seabed Development (The Crown Estate 1998);

- Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy (Collaborative Offshore Wind Research into the Environment (COWRIE) 2008);
- Historic Environment Guidance for the Offshore Renewables Energy Sector (COWRIE 2007);
- Protocol for Archaeological Discoveries: Offshore Renewables Projects (ORPAD) (The Crown Estate 2014); and
- Commercial Renewable Energy Development and the Historic Environment, Historic England Advice Note 15 (Historic England 2021).

2.1.1.2 The marine archaeology study area was established to encompass the Hornsea Four Order Limits plus a 1 km buffer defining the zone where any potential effects on marine archaeology receptors may occur. The buffer was defined at the scoping phase, based on professional judgement, in order to capture baseline records of marine casualties for which positioning has historically been poor.

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 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 Mean High Water Springs (MHWS).	https://archaeologydataservice.ac.uk/archives/view/398/
UKHO	Spatial; full coverage seaward of MHWS.	Via https://www.oceanwise.eu/
Humber Historic Environment Record	Spatial and descriptive; landward of Mean Low Water Springs (MLWS) only.	http://www.hull.gov.uk/resident/planning-and-building-control/humber-historic-environment-record
Rapid Coastal Zone Assessment (RCZA): 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/

Database/ Source	Data type	Link
CITiZAN – Coastal and Intertidal Zone Archaeological Network	Descriptive; landward of MLWS only.	https://www.citizan.org.uk/

2.2.1.3 Data for known shipwrecks, obstructions and recorded shipping losses within the marine archaeology study area were obtained from the UKHO and the NRHE. The two datasets were compared, and duplicates removed. Where discrepancies were found in the spatial data between the different sources, the coordinates provided by UKHO were used.

2.2.1.4 Wrecks of all aircraft crashed in military service as well as designated vessels (protected places) are afforded statutory protection by the Ministry of Defence under the Protection of Military Remains Act 1986, meaning that 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.

2.2.1.5 Generally, known and identified seabed features in the marine environment fall into two categories: wrecks and obstructions. Definitions of these terms (as used by the UKHO) are provided below:

- **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.

2.2.1.6 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.

2.2.1.7 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.

2.2.1.8 Data contained within the NRHE database and reported as fishermen's fasteners (defined as places where fishermen have snagged their fishing gear) are included in this baseline assessment.

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 as **Appendix C: Archaeological review of geophysical and hydrographic data**. This technical report summarises the results from the assessment in **Section 4.1**.

2.3.1.2 To characterise the historic environment, all available survey data has been considered in the geophysical data assessment.

2.4 Geotechnical Data Assessment Methodology

2.4.1.1 The archaeological assessment of geotechnical data is ongoing although not complete at the time of the application. Methodologies for archaeological assessments for geotechnical data has been and will continue to be submitted to Historic England in form of Method Statements as per marine archaeology commitments Co140 and Co167 as detailed in **Table 2**.

2.5 Mitigation Methodology

2.5.1.1 Mitigation recommendations are formulated where archaeological receptors 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 Archaeological Written Schemes of Investigation for Offshore Wind Farm Projects (The Crown Estate 2021).

2.5.1.2 Hornsea Four has made several commitments as a part of the pre-application phase to avoid and reduce the potential for impacts to marine archaeological receptors. The relevant commitments in relation to marine archaeology are presented in **Table 2** below. All commitments and the mechanism within which the commitments are secured are detailed in Volume A4, Annex 5.2: Commitments Register.

Table 2: Marine archaeology commitments.

Commitment ID	Measure
Co46	Primary: All intrusive construction activities will be routed and microsited to avoid any identified archaeological receptors pre-construction, with buffers as detailed in the Marine Written Scheme of Investigation (WSI).
Co140	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 requirement for Archaeological Exclusion Zones (AEZs) to be established to protect any known / identified / unexpected marine archaeological receptors and the implementation of a Protocol for Archaeological Discoveries (PAD) in accordance with 'Protocol for Archaeological Discoveries: Offshore Renewables Projects' (The Crown Estate, 2014).
Co166	Secondary: An offshore geophysical survey (including an Unexploded Ordnance (UXO) survey) will be undertaken prior to construction and will be subject to a full archaeological review in consultation with Historic England.
Co167	Secondary: An offshore 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.
Co181	Tertiary: An Offshore Decommissioning Plan will be developed prior to decommissioning

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 Before Present (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.9,650 Before Christ (BC) - 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; 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. 2013; 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). 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 RSL, when areas of the marine zone were exposed as land surfaces. 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, such as Swarte Bank and Bolders Bank from these earlier periods are found within the lower levels of the seabed, the shallow sub-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 (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 RSL 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 (Sturt et al. 2013) 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 there is no local model for the Holderness coast, the impact on geomorphological change in this area is not clear (Sturt and Van de Noort 2013).

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). Bridlington Bay, 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).

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 (OS) 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).

3.1.2.8 In addition, in the medieval period. there was increased storm surge activity between Anno Domini (AD) 1300-1500 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 Second World War (WWII) artillery battery have been lost) (Brigham et al. 2008; Sistermans and Nieuwenhuis 2007). Brigham et al. (2008) note that *'most villages [now] lie further back, the original row of medieval settlements bordering the sea and shore having been lost'*. 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 intertidal context which subsequently became inundated; and,
- *Remains of aircraft crash sites*, either coherent assemblages or scattered material usually the result of 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 MHWS and 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 A6, 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), 'The UK Historic Environment Data Standard', MIDAS Heritage (English Heritage 2012), 'People and the Sea: A Maritime Archaeological Research Agenda for England' (Ransley et al. 2013), Forum on Information Standards in Heritage (FISH) 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.

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 land surfaces 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; Westley and Bailey 2013). 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 study area near Bridlington (Brigham et al. 2008). 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).

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). *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). The potential for the *in-situ* preservation in similar contexts within the marine archaeology study area is demonstrated by early Middle Palaeolithic flint tools, dated to 250-200,000 years ago, recovered from Area 240, an aggregate dredging site 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).

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. Further potential within the marine archaeology study area is demonstrated by the location and mapping of the Eem Formation deposits (**Appendix D: Palaeogeographic review of geophysical survey data**). The formation represents marine sands and intertidal deposits and is associated with the Ipswichian Interglacial (MIS 5e).

3.2.2.5 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; Westley and Bailey 2013). Material from earlier periods is more likely to be derived from secondary contexts.

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

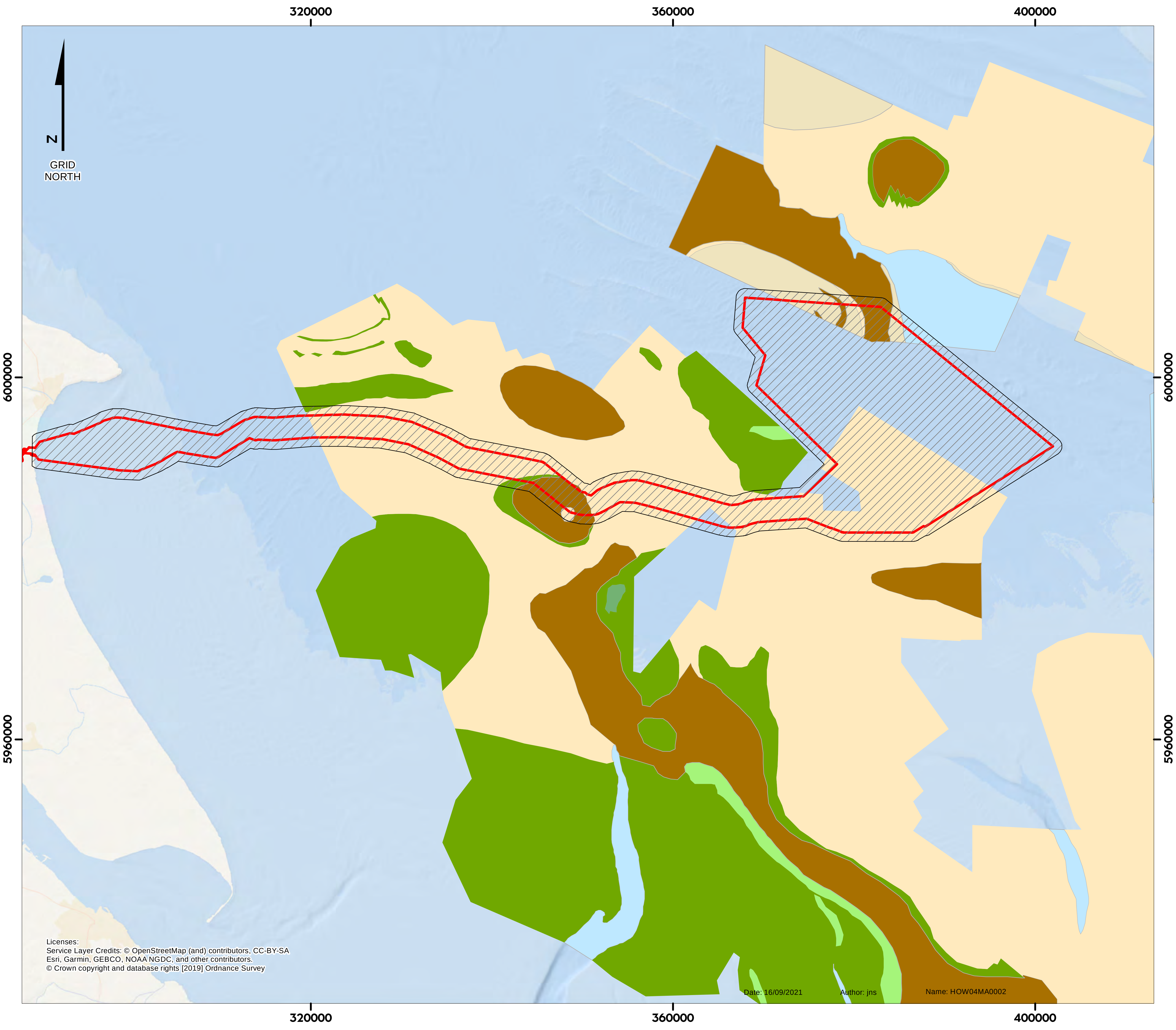
3.2.2.6 As further detailed in **Appendix D: Palaeogeographic review of geophysical survey data** the Eem formation and Yarmouth Roads have been identified within the marine archaeology study area, signifying further palaeoenvironmental and archaeological potential. The Yarmouth Roads Formation is associated with the onshore Cromer Forest Beds sequence which have produced evidence of in situ archaeological and palaeoenvironmental remains dating to the Lower Palaeolithic. Within the marine archaeology study area, the Yarmouth Roads deposits are exceptionally thick within the southern part of the Hornsea Four array area, further assessments to understand the archaeological potential are ongoing as detailed in **Appendix D: Palaeogeographic review of geophysical survey data**.

3.2.2.7 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 land surfaces (Tappin et al. 2011).

3.2.2.8 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. Archaeological assessments undertaken head of the Viking Link interconnector sub-sea cable's Environmental Impact Assessment found evidence of palaeochannels within 2 km of the Hornsea Four Order Limits (Wessex Archaeology 2017). Material collected within a previously mapped channel demonstrated a fluvial infill which was dated by Radiocarbon and showed that the upper channel fills were laid down during the Mesolithic, approximately 9000 BC, and lower fills dated to the Late Upper Palaeolithic with calibrated dates spanning 11,500-10,500 BC. This demonstrates the potential for channel systems and fills of a comparable Late Devensian/Early Holocene date to be present within the Hornsea Four Order Limits.

3.2.2.9 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. This is further discussed in **Section 4.3**.

3.2.2.10 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). 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 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; Brigham et al. 2008), 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). To the south at Hornsea, a barbed bone point was found in lacustrine peat (Sites and Monuments Record (SMR) number MHU3544), whilst a flint scraper was recovered south of Withernsea at Holmpton (Brigham et al. 2003). In addition, the post-glacial, infilled freshwater meres exposed along the coast are identified as having significant palaeogeoarchaeological potential (Brigham et al. 2003). 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 land surface deposits within the seabed of the marine archaeology study area.



Hornsea Four

Figure 2

North Sea Palaeolandscape Project topography

Order Limits
Marine Archaeology Study Area

North Sea Palaeolandscape Project Topography

High to Low

- High
- Mod/High
- Moderate
- Inter. Low
- Moderate Low
- Low
- V.Low

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 5 10 Kilometres

0 3.5 7 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	16/09/2021

NSPLP
Document no: HOW04MA0002
Created by: JNS
Checked by: BM
Approved by: GM

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).

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; 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 (RSL 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 NSPP (Gaffney et al. 2007) (**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 Export Cable Corridor (ECC) crosses areas mapped as harder geology intersected by fluvial systems, which may also have provided a focus for human exploitation of natural resources.

3.2.3.5 As noted above in **Section 3.2.2**, there are some gaps in the NSPP data within the marine archaeology study area (**Figure 2**), but given the proximity of the Humber 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', and sampling undertaken during the study has shown that these deposits generally lie close to the surface of the seabed.

3.2.3.6 As further detailed in **Appendix D: Palaeogeographic review of geophysical survey data** the marine archaeology study area demonstrates Holocene channels cut into the earlier glacial channels identified as the Botney Cut deposit. Botney Cut has been mapped showing a higher concentration in the southern parts of the array area with less evidence for these channels to the north. As mentioned above the Archaeological assessments undertaken head of the Viking Link interconnector sub-sea cable's Environmental Impact Assessment found evidence of palaeochannels within 2 km of the Hornsea Four Order Limits (Wessex Archaeology 2017). Material collected within a previously mapped channel demonstrated a fluvial infill which was dated by Radiocarbon and showed that the upper channel fills were laid down during the Mesolithic, approximately 9000 BC, associated with the Botney Cut deposit.

3.2.3.7 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), 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 Hornsea Four Order Limits (Brigham et al. 2008, SMR ID MHU15036 and MHU344), evidence of exploitation of Skipsea Withow Mere by hunter-gatherers during the early Mesolithic (Sitch and Jacob,1999; Brigham et al. 2008; Murphy 2009; 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 (NMR ID, NMN 910906).

3.2.3.8 In addition, there is a Mesolithic submerged forest at Withernsea, probably associated with the original Withernsea Mere (Brigham et al. 2008), 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 (Brigham et al. 2008; Brigham and Jobling 2011). 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), with the earliest organic lake deposits dating to 9880 BP (Brigham et al. 2008), and as a site of hunter-gatherer activity (Sitch and Jacobi 1999; Murphy 2009; Cadnam et al. 2018).

3.2.3.9 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). 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). 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). Many of the key research questions from 'People and the Sea' (Ransley et al. 2013) 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 (Bell et al. 2013), and, therefore, the potential importance of any Mesolithic *in-situ* deposits or archaeological finds.

3.2.3.10 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). These would likely be either logboats, skin/hide boats (Bell et al. 2013) 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; Brigham and Jobling 2011). There are also Neolithic submerged forests eroding from the intertidal zone at Hornsea as well as at Easington (Murphy 2009). 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; Sturt and Van de Noort 2013).

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). 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) (Brigham et al. 2008), an assemblage of late Neolithic / early Bronze Age flints at Newbegin, Hornsea (Brigham et al. 2008), a possible long barrow and pit at Roos (Brigham et al. 2008) and likely Neolithic occupation deposits eroding from Cliff at Withernsea (Brigham et al. 2008). Notably, there are plough stones among these finds indicating agricultural activity (Brigham et al. 2008) 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, Selkirk 2006). Along with the hearths, pits and postholes, over 650 pottery sherds and 750 worked flints were recovered during excavations (Selkirk 2006) and there is a palaeochannel exposed on the foreshore (Brigham and Jobling 2011).

3.2.4.4 Within the marine archaeology study area at Barmston, there are polished axe finds at Fraisthorpe (Brigham et al. 2008, SMR ID MHU8970), along with ploughed-out burial mounds at Watermill (now likely lost to erosion (Brigham and Jobling 2011)), which together suggest 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). 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; NMR ID 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; c.f. Mallon, 2005) or possibly sewn plank boats (Sturt and Van de Noort 2013), though there are no securely dated Neolithic boats from UK contexts (Sturt and Van de Noort 2013). 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 (Sturt and Van de Noort 2013; Murphy 2009; 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). Any Neolithic boat remains or associated artefacts, such as the examples found from Jaywick in Essex (Wilkinson and Murphy 1995), 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 Ordnance Datum (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).

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), 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; Van de Noort 2004; Coates 2005; 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).

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 (Brigham et al. 2008). 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) and a Late Bronze Age-Iron Age occupation site at Easington Cliff (Brigham et al. 2008). 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 (Brigham et al. 2008). 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 (Brigham et al. 2008; NMNs 1510522 (shown on **Figure 3**), 81091, 80999, 81183).

3.2.5.5 Within the marine archaeology study area at Barmston, there is a Bronze Age flint assemblage findspot (NMN1551072, shown on **Figure 3**). There is also a barrow eroding from the cliff (Brigham and Jobling 2011) 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).

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 (NMR ID NMN 910759) and also a possible Middle Bronze Age-Iron Age 'lake dwelling' at Round Hill just inland (Brigham et al. 2008). 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 (Brigham et al. 2008; 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; 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; Murphy 2009) 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; Murphy 2009).

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).

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 RCZA 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). 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). 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 (Roskams and Whyman 2007) and staters (coins) at Hollym (Roskams and Whyman 2007) 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 (Roskams and Whyman 2007), whilst a number of features suggest continued activity through the Iron Age and into the Romano-British period at Flamborough Head (Roskams and Whyman 2007). 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 (Roskams and Whyman 2007). At Rolston, there is a pit dwelling with assemblage of flint, bones, pottery (Roskams and Whyman 2007) 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) (Roskams and Whyman 2007).

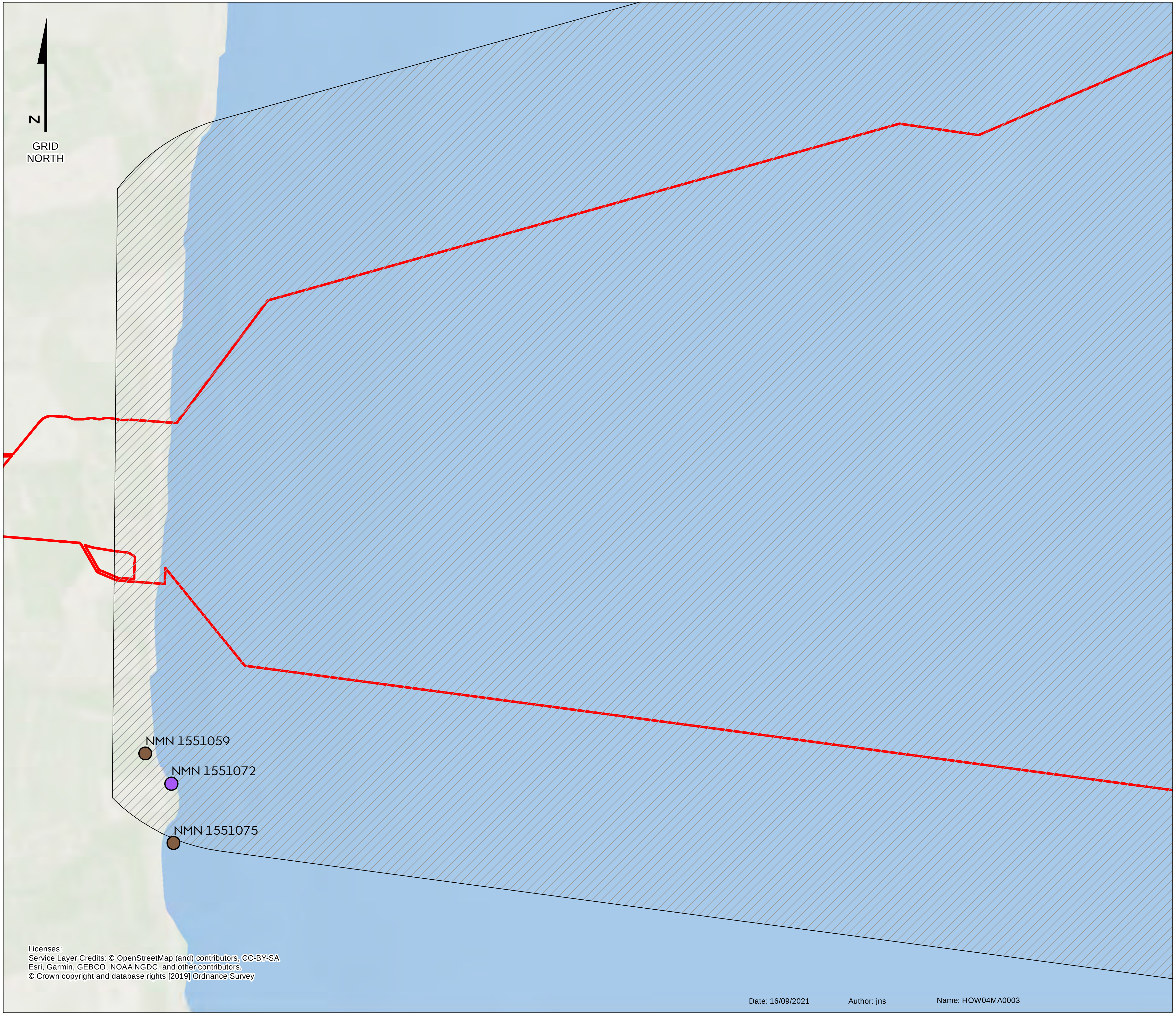
3.2.6.4 More specifically, within the marine archaeology study area, there is continuity of occupation from the Bronze Age through the Iron Age into the Romano-British period at Barmston. The Middle Bronze Age occupation site on the edge of a mere has a later phase of Late Bronze Age-Iron Age activity (Van de Noort et al. 1995) 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; NMNs 1551059 and 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 (Brigham et al. 2008) 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 (Brigham et al. 2008). Whilst just inland at Ulrome there is a probably Middle Bronze Age-Iron Age 'lake dwelling' at Round Hill (Brigham et al. 2008) 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 (Brigham et al. 2008; NMNs 1546940 and 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), 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). 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). There is even evidence of developing cosmological connections to the sea with the development of coastal shrines (Hill and Willis 2013). 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). 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). 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). 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 (Hill and Willis 2013), and potentially even visiting Greco-Roman vessels from the Mediterranean (see Boon 1977; Cowell 2007). 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.



Hornsea Four

Figure 3

Bronze Age and Iron Age sites included within the Marine Archaeology Study Area

Order Limits

Marine Archaeology Study Area

Sites included within the baseline archaeology review

Bronze Age

Iron Age

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:20,000

0 0.5 Kilometres

0 0.2 0.4 Nautical Miles

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Neolithic, Bronze Age and Iron Age sites
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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 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). 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 un-investigated. 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). 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 (NMR ID 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 ID 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

ID MHU3141, marked on Figure 4), and other pottery fragments). 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).

3.2.7.6 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 fourth 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 RSLs 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). Loveluck references the Holderness sites of Flamborough, Sewerby, Bridlington, Aldbrough and Easington in this work (Loveluck et al. 2013) and highlights the potential for landing places, beach markets and interactions with traders moored along the coast or in the Humber Estuary. However, the RCZA 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; see also the Yorkshire Archaeological Research Framework, Roskams and Whyman 2007). 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). 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 (Brigham et al. 2008). 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 (Brigham et al. 2008). 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 (Brigham et al. 2008). 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 (Brigham et al. 2008).

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.

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), 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), along with other UK examples including the Langstone and Hamble River logboats, dated sixth and seventh century respectively (Loveluck et al. 2013; 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). 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 AD 1000 to AD 1250), 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). Towards the end of the Early Medieval period, from the tenth 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).

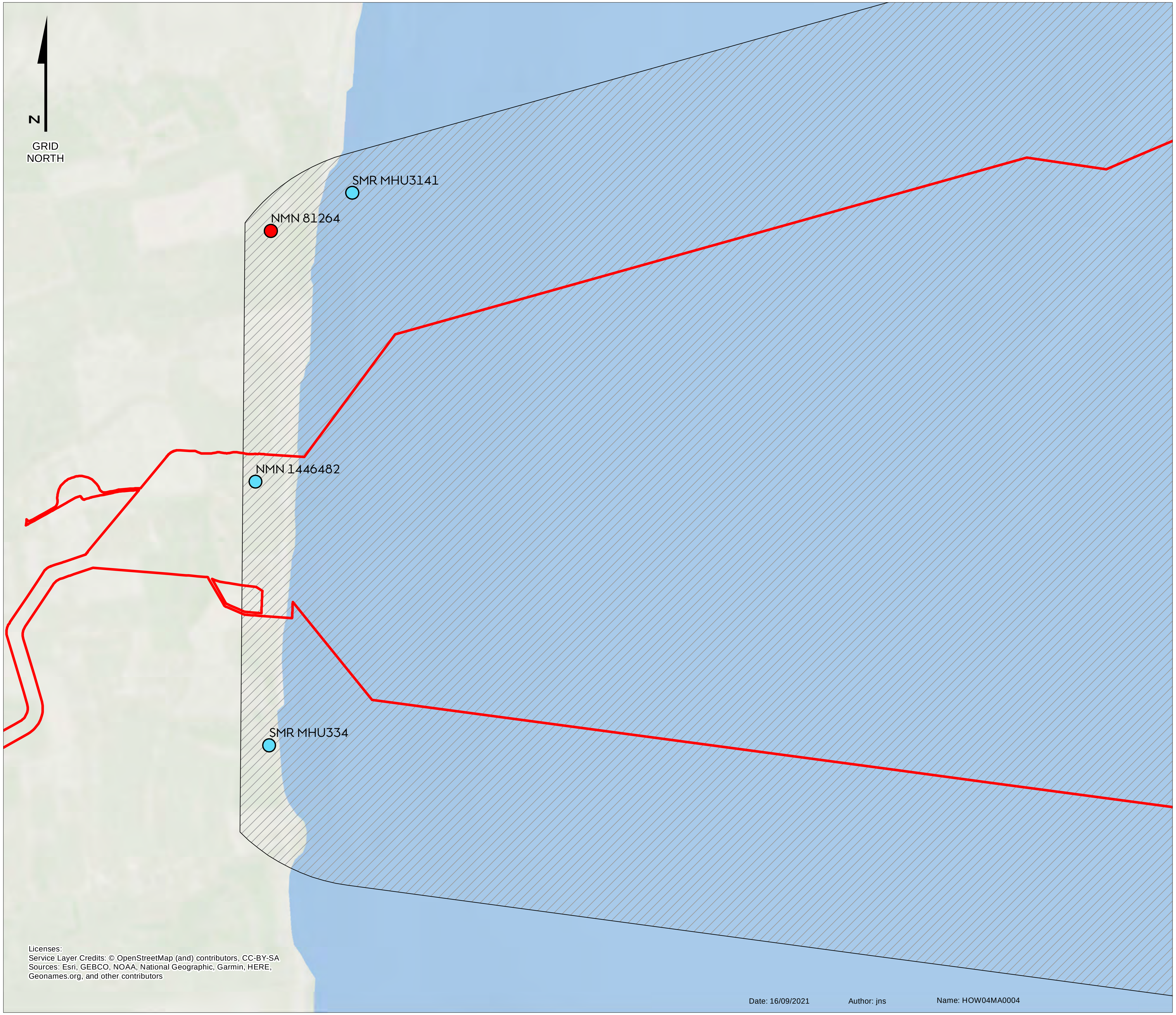
3.2.9.4 The coastal archaeological record within the marine archaeology study area has been impacted by the rapid erosion of the coastline and a notable increase in storm surges between c. AD 1300-1500 in the North Sea region; the nature of coastal and maritime activity would have adapted in response (Long et al. 1998). As with the Early Medieval period, the High Medieval period has been identified in the RCZA 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. 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 (NRHE monument numbers 1446399; 1445415; 1445422). Casual finds include: a spindle whorl found on the beach south of Bridlington; and 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 (NMR ID 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 fifteenth 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 eleventh or twelfth 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 fourteenth century, though a large mound over an infilled mere is still extant (Brigham et al. 2008).

3.2.9.8 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 fourteenth century, extensive documentary evidence and isolated vessel-related finds (e.g. a thirteenth century steerboard from Rye Bay, and hull planks from a thirteenth 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 fourteenth century (Historic England 2016a). From the late thirteenth 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 fifteenth 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.



Hornsea Four

Figure 4

Roman and Medieval sites included within the Marine Archaeology Study Area

Order Limits

Marine Archaeology Study Area

Sites included within the baseline archaeology review

Roman

Medieval

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:20,000

0 0.4 0.8 Kilometres

0 0.15 0.3 Nautical Miles

REV	REMARK	DATE
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Roman, Anglo Saxon and Medieval sites
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Checked by: CH
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MARITIME ARCHAEOLOGY

Ørsted

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 nineteenth 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-seventeenth 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 sixteenth 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 sixteenth century before being entirely breached by the sea in the late seventeenth century (Brigham et al. 2008).

3.2.10.7 In Ulrome, there are a few extant buildings from the nineteenth 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 nineteenth 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 nineteenth century only a farm remains; Great

Colden (Cowden), which lay between Hornsea and Mappleton, was mapped in c.1850 but lost by the mid-twentieth century.

3.2.10.8 The *Adventure* which sunk in 1882 is located within the marine archaeology study area but outside the Order Limits. No features of archaeological potential were discovered at the position during the geotechnical survey as detailed in **Appendix C: Archaeological Review of Geophysical and Hydrographic Data**, the wreck is recorded as DEAD.

3.2.10.9 There are also several wrecks of unknown name and date, both DEAD and LIVE – these are discussed further in **Section 3.4** and illustrated on **Figure 6**.

3.2.10.10 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 His Majesty's Ship (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 twentieth 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 marine archaeology study area, Bridlington underwent extensive urbanisation during the twentieth century; the harbour was also substantially rebuilt at this time. Immediately after WWII, 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 (NMR ID NMN 1446479). There are also several anti-tank cubes (NMR IDs NMN 1445209; and NMN 1445214), though these have often been moved or slipped from their primary context as the cliff has eroded. These features are shown on **Figure 5**.

3.2.11.5 Just to the north of the marine archaeology study area, the area of Auburn Sands was strategically important to Bridlington's WWII defences: there are concentrations of features here. These include: a pillbox and heavy machine gun emplacement (NMR ID NMN 1418845); two pillboxes at 100 m intervals to the north and three similarly spaced to the south (SMR IDs MHU9986, MHU9985, MHU9983, MHU9982, MHU9981).

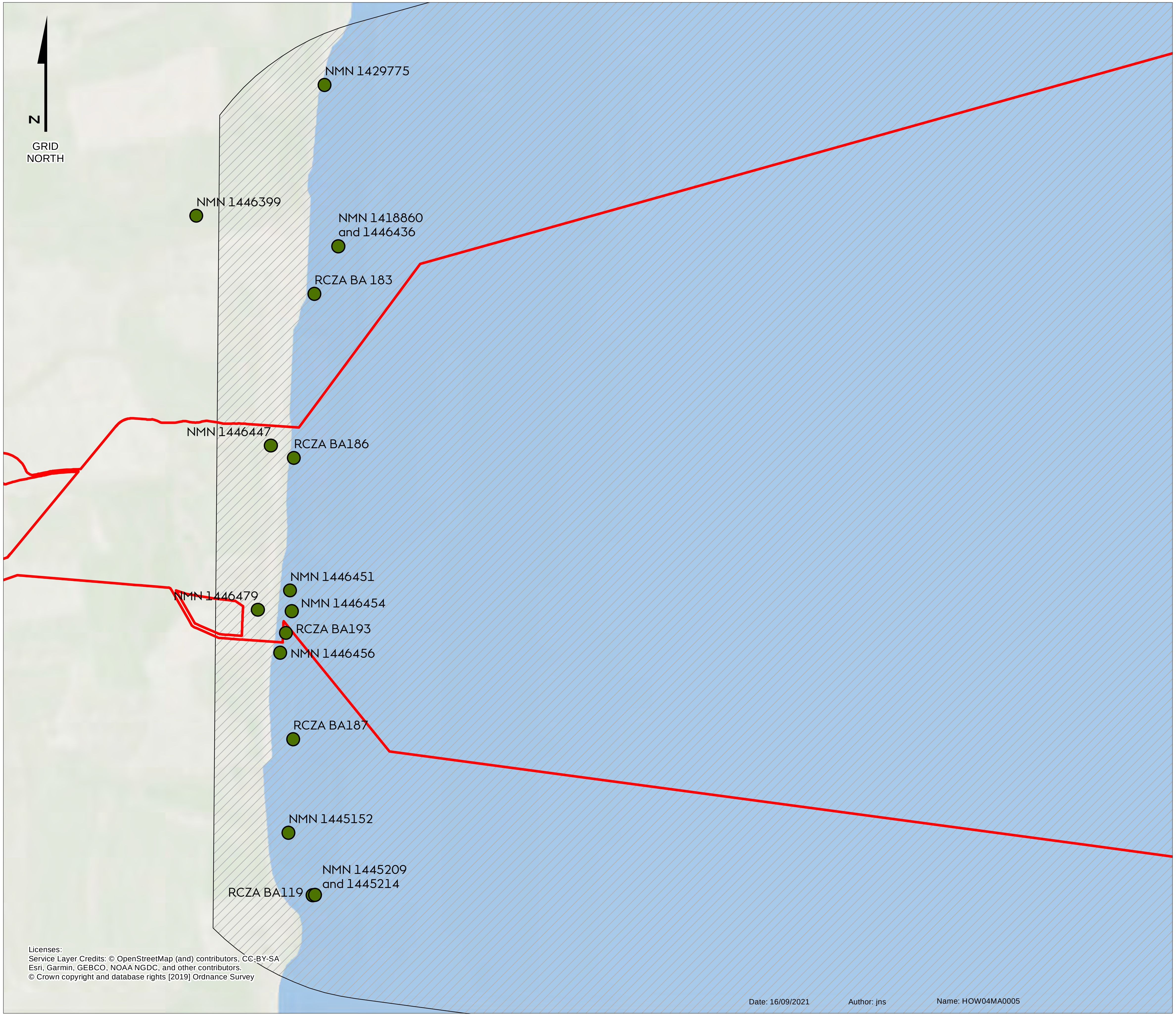
3.2.11.6 Within the marine archaeology study area there are numerous features stretching from the beach below Aurbun Farm to the north edge of Ulrome Sands, though many of these are no longer *in-situ* due to coastal erosion. These all date to WWII and are also shown on **Figure 5**. From north to south:

- An anti-tank wall and twin machine gun emplacements (NMR ID NMN 1429775);
- Two possible beach defence lights (NMR ID NMN 1418860 and 1446436);
- Anti-tank defences and a minefield extending along the beach (NMR ID NMN 1446399);
- A pillbox designed to house a six-pounder quick-firing gun (RCZA ID BA119);
- Anti-tank cubes (RCZA ID BA183);
- A pillbox (RCZA ID BA186);
- A pillbox (NMR ID NMN 1446479);
- Searchlight battery and associated buildings (NMR ID NMN 1446447);
- Weapons pits (NMR ID NMN 1446451);
- Military buildings (NMR ID NMN 1446454);
- Beach defence light (RCZA ID BA193);
- Pillbox and surrounding barbed wire obstructions (NMR ID NMN 1446456);
- Pillbox (RCZA ID BA187);
- Barbed wire obstructions and trackways (NMR ID NMN 1445152);
- Anti-tank cubes (NMR ID NMN 1445209); and
- Anti-tank cubes (NMR ID NMN 1445214);

3.2.11.7 To the south of Order Limits, but within the marine archaeology study area, there is a similar distribution pattern. At Spurn Head, there is a WWII observation post (NMN 1429773).

3.2.11.8 Deriving from the Modern period (1900-present) there are a total of 15 known and possibly identified remains of ships or boats within the marine archaeology study area, and the potential for more yet to be found. Nine of these wrecks are within the Order Limits.

3.2.11.9 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.



Date: 16/09/2021 Author: jns Name: HOW04MA0005

Hornsea Four

Figure 5

Second World War sites included within the Marine Archaeology Study Area

Order Limits

Marine Archaeology Study Area

Sites included within the baseline archaeology review

Second World

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:15,000

0 0.3 0.6 Kilometres

0 0.1 0.2 Nautical Miles

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Checked by: CH
Approved by: GM

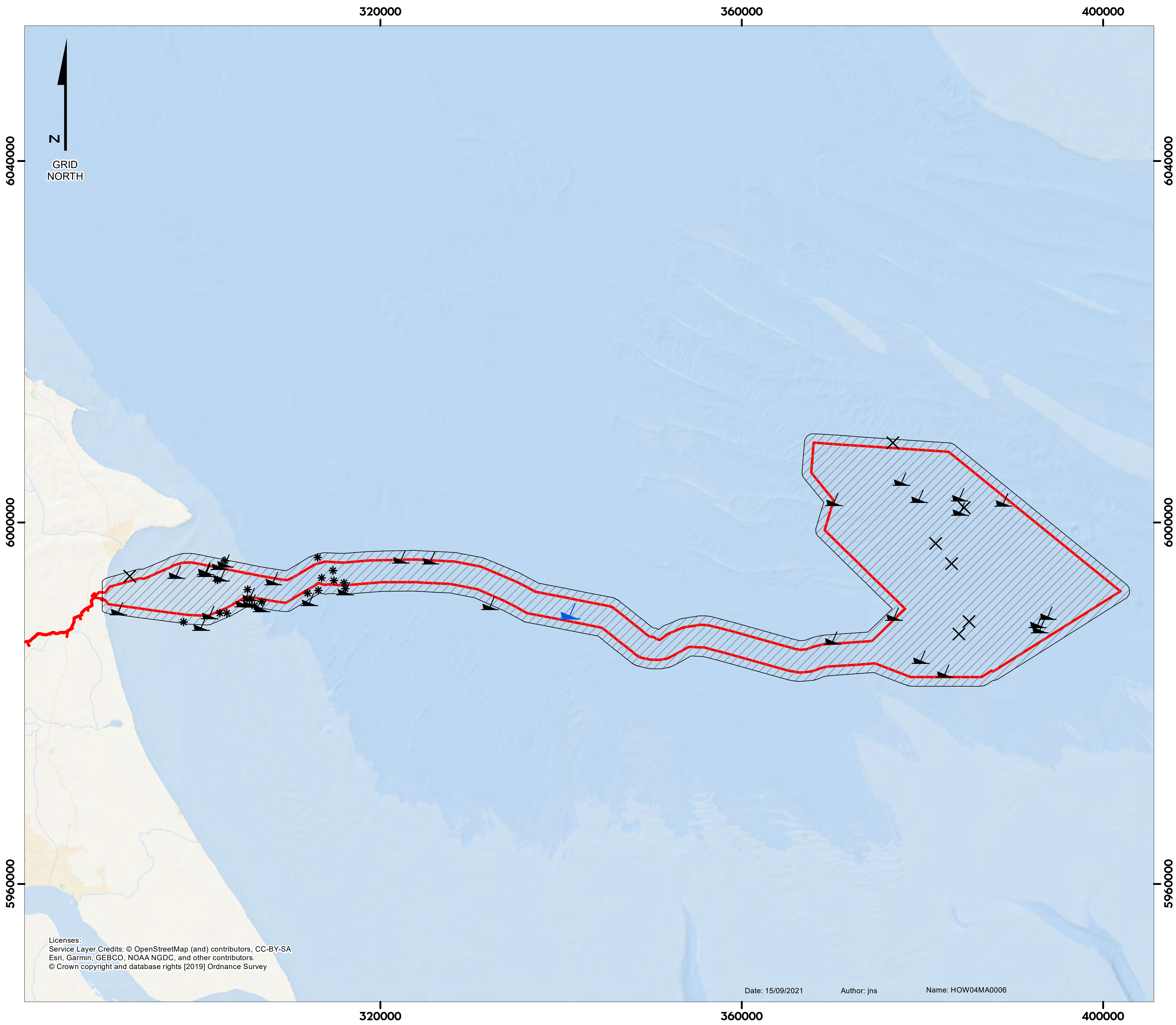

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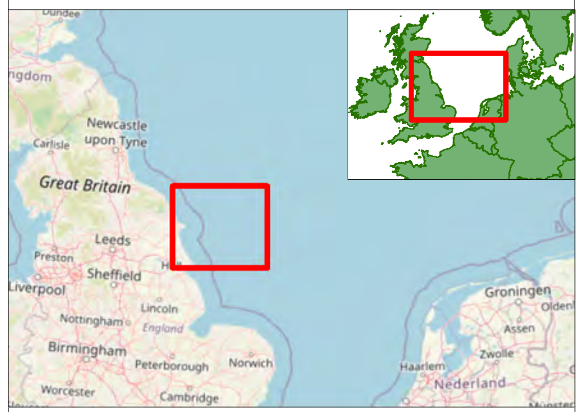
Figure 6

Known wrecks or obstructions within the Marine Archaeology Study Area

- Order Limits
- Marine Archaeology Study Area
- Known wrecks (UKHO)
- Obstruction, Foul ground (UKHO)
- Fishermen's fastener (NRHE)
- Known wrecks (NRHE)



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 8 16 Kilometres

0 3 6 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
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Known wrecks or obstructions
Document no: HOW04MA0006
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Checked by: BM
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3.2.11.10 There is one known vessel within the Order Limits with a UKHO record and corresponding geophysical anomaly (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 anomaly for this vessel is discussed in **Section 4.1.6.3**, and its significance in **Section 3.4.8**.

3.2.11.11 Outside of the Order Limits, but within the survey data extent, there are five known wrecks recorded by the UKHO that correlate with anomalies identified in the archaeological assessment, as summarised in **Table 3** and nine records where no features of archaeological potential were identified as further detailed in **Appendix C: Archaeological Review of Geophysical and Hydrographic Data**.

3.3 Aviation Remains

3.3.1.1 Aviation remains include aircraft, airships, and other dirigibles deriving from crash sites as either coherent assemblages or scattered material. Remains located in the offshore environment are often the result of WWII military conflict but may also be associated with early aircrafts from WWI or passenger air casualties, particularly during the peak of seaplane activity during the inter-war period.

3.3.1.2 Despite the low number of known aviation remains located on the seafloor, the east coast of England and the Southern North Sea has been identified as a region with high levels of aviation activity with WWII losses clustered along the southern and eastern margins of England (Wessex Archaeology 2008).

3.3.1.3 There are no reported or known aviation sites or remains within the marine archaeology study area, however considering the high number of unidentified seabed obstructions and geophysical anomalies identified within the Order Limits, the potential to locate aviation remains is high.

3.3.1.4 Wrecks of all aircraft crashed in military service are afforded statutory protection by the Ministry of Defence under the Protection of Military Remains Act 1986. Potential aviation remains located during all project phases should be reported as per the Outline Marine WSI (**F2.4: Outline Marine Written Scheme of Investigation**).

Table 3: Known wrecks that correlate with geophysical anomalies outside the Order Limits.

UKHO ID	Description	Archaeological Potential	Geophysical assessment ID
9410	Unknown Wreck	High	MSDS_HOW04_2019_ARCH_0015
9377	Wreck *Flirt* (Possibly)	High	MSDS_HOW04_2019_ARCH_0073
9401	Unknown Wreck	High	MSDS_HOW04_2019_ARCH_0113
5805	Wreck, *Sote* Aft part	High	MSDS_HOW04_2019_ARCH_0178
9403	Unknown wreck (possibly)	Medium	MSDS_HOW04_2019_ARCH_0096

3.4 Known Wrecks – Archaeological Significance

3.4.1.1 There are 33 wrecks within the marine archaeology study area. of the 33 wrecks 18 wrecks are within the Order Limits. The 33 wrecks are contained within both the UKHO and the NRHE datasets. 16 of them are named and 17 of them are unknown, 14 of these are recorded as DEAD.

3.4.1.2 There are also seven obstructions contained in the UKHO data set within marine archaeology study area (**Appendix A**).

3.4.1.3 There are 15 records classed as fishermen's fasteners within the marine archaeology study area, six are within the Order Limits, all 15 are described as 'Unidentified seabed obstruction reported by fishermen. Possibly indicative of wreckage or a submerged feature'. No other baseline information is available for any of these records, while they may well represent archaeological remains, this is not possible to ascertain from the existing sources. the records are not associated with vessel or structural remains (including records classified as DEAD by the UKHO), however two of the fishermen's fasteners located outside the Order Limits but within the marine archaeology study are located within 500 m of records identified as wrecks in the UKHO and NRHE data as detailed in **Appendix A**.

3.4.1.4 The archaeological significance of eleven wrecks within the marine archaeology study area are described in the following sections, with their locations illustrated in **Figure 7**. The wreck data assessed contained enough information to undertake the archaeological significance assessment as per the matrix based on the 'Criteria for the assessment of archaeological significance', as set out by the Department for Culture Media and Sport (DCMS 2011).

3.4.1.5 The archaeological significance of four wrecks, the fishing vessels *Linda Louise* (1983) and *Zephr* (1960), *Adventure* (1882), Ross Curlew (unknown date) have not been considered further due to their modern sinking dates and the absence of detailed information on these wrecks.

3.4.1.6 The archaeological significance has not been considered for known wrecks, included in the UKHO and NRHE data search with an approximate sinking position within the marine archaeology study area but identified as wreck remains outside the marine archaeology study area as detailed in **Appendix A**.

3.4.2 Brabant

3.4.2.1 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 three lives.

3.4.2.2 *Baseline Archaeological Significance:* while itself not well documented, *Brabant* represents a type of vessel common throughout the early twentieth 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***

3.4.3 Nitedal

3.4.3.1 The *Nitedal* is recorded as LIVE by the UKHO, but its position is also recorded further north outside the marine archaeology study area. The position as received from UKHO and NMRHE refer to a second vessel on this position, *Leka*, a Norwegian cargo vessel sunk in 1917. The archaeological assessment of geopgysical data did not identify any anomalies in the area. The *Nitedal* was 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 21 crew were lost as the vessel sank within three minutes. The wreck was positively identified by the discovery of a bell inscribed 'HERO'.

3.4.3.2 *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 nineteenth and early twentieth 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***

3.4.4 Biesbosch

3.4.4.1 *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.

3.4.4.2 The vessel was seized by the U.S. Government towards the end of WWI 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.

3.4.4.3 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.

3.4.4.4 *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***

3.4.5 Feltre

3.4.5.1 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.

3.4.5.2 At the outbreak of WWI, *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.

3.4.5.3 *Baseline Archaeological Significance:* The *Feltre*'s story is similar to many other vessels operating in WWI: 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*
Potential	*Medium*
Overall	***MEDIUM***

3.4.6 Resercho

3.4.6.1 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 WWI, 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 *Resercho* was sunk by a mine laid by *U-15*, but all ten crew were rescued.

3.4.6.2 *Baseline Archaeological Significance:* The *Resercho* 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 His Majesty's Drifter (HMD) *John Mitchell* (1917) and the Protected Wreck His Majesty's Trawler (HMT) *Arfon* (1918), both located on the south-coast.

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

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***

3.4.7 Syrian

3.4.7.1 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.

3.4.7.2 *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***

3.4.8 *Lapwing*

3.4.8.1 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.

3.4.8.2 *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***

3.4.9 Leka

3.4.9.1 The wreck of the *Leka* is listed as DEAD by the UKHO. Built by Richardson, Duck & Co., Stockton in 1892 and owned at the time of her loss by C. T. Gogstad & Co., Christiania, was a Norwegian steamer that on September 24th, 1917 was on a voyage from Santander to Sunderland with a cargo of iron ore when it was sunk by the German submarine UC-71, 7 miles east of Flamborough Head with the loss of 17 people.

3.4.9.2 The wreck is located within the Order Limits on the same position as *Nitedal* (see above) and has not been seen during previous surveys or within the geophysical data assessed for archaeological potential (**Appendix C: Archaeological review of geophysical and hydrographic data**).

3.4.9.3 *Baseline Archaeological Significance*: Leka represents a type of vessel common throughout the early twentieth 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. Should the wreck be located, it would be deemed to be of medium archaeological significance.

Table 11 Significance assessment matrix for the wreck of Leka

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

3.4.10 Coronation

3.4.10.1 The wreck site is outside the order Limits but within the marine archaeology study area. It is recorded as DEAD by the UKHO.

3.4.10.2 The *Coronation* was a British trawler that sunk approximately 13 miles ESE of Flamborough Head in 1918, it was reported that it sunk by gunfire from an unidentified German submarine after being ordered to stop and the crew to abandon ship.

3.4.10.3 The *Coronation* is of a vessel type that is well served by other sources, both documentary evidence and in other surviving examples. Should the wreck be located, it is deemed to be of medium archaeological significance.

Table 12 Significance assessment matrix for the wreck of Coronation

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

3.4.11 Sote

3.4.11.1 The wreck site is outside the order Limits but within the marine archaeology study area, It is recorded as a LIVE obstruction, foul ground by the UKHO and was identified in the archaeological assessment of geophysical data as MSDS_HOW04_2019_ARCH_0178 (**Appendix C: Archaeological review of geophysical and hydrographic data**).

3.4.11.2 The *Sote* was a Swedish cargo ship powered by steam and built in 1883. On May 25, 1918, the ship was torpedoed off Bridlington by the German submarine UC-64. *Sote* was quickly taken in tow and an effort was made to beach her, but she sank in 13 metres of water.

3.4.11.3 *Baseline Archaeological Significance*: *Sote* represents a type of vessel common throughout the early twentieth 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 some of the wreck survives, it is deemed to be of medium archaeological significance.

Table 13 Significance assessment matrix for the wreck of Sote

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

3.4.12 Ville De Valenciennes

3.4.12.1 *Ville De Valenciennes* lies outside the order Limits but within the marine archaeology study area. It is recorded as a LIVE by the UKHO.

3.4.12.2 The French owned steam powered cargo ship was built for Cie des Bateaux a Vapeurs du Nord, Dunkirk. While en rute from Bordeaux from the Tyne, with a cargo of coal on 22/09/1917 it was torpedoed and sunk by the German submarine UC-64. The wreck has been identified by the recovery of the ship's bell inscribed with VILLE DE VALENCIENNES - DUNKERQUE - 1897.

3.4.12.3 *Baseline Archaeological Significance*: A fairly intact wreck, the *Ville De Valenciennes* 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 14 Significance assessment matrix for the wreck of Ville De Valenciennes

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***

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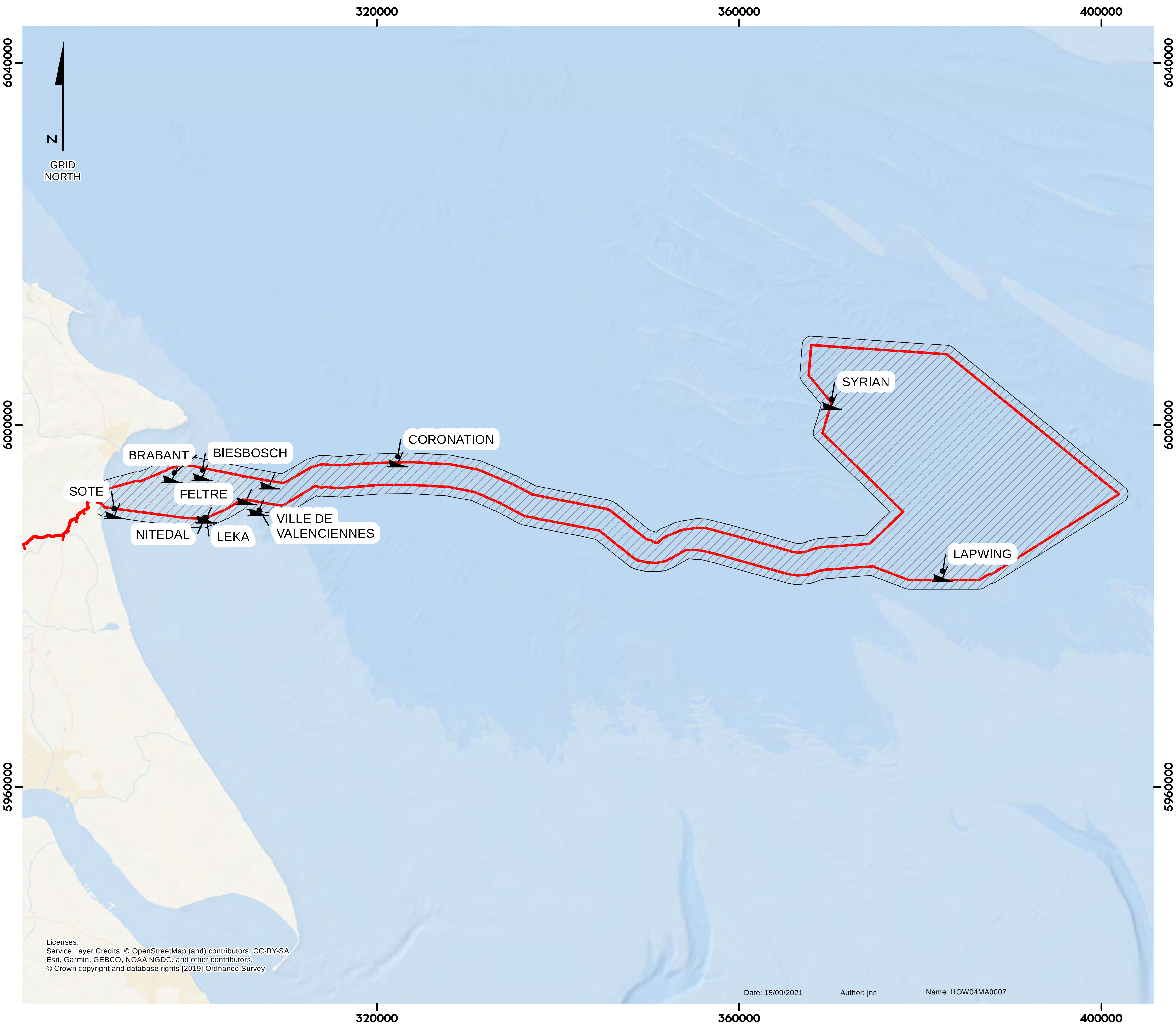
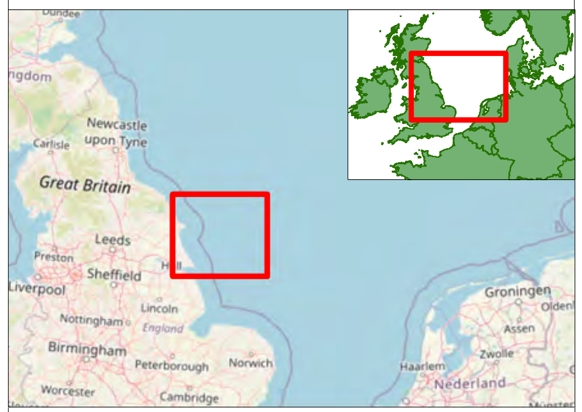
Figure 7

Wrecks of archaeological significance within the Marine Archaeology Study Area



Order Limits
Marine Archaeology Study Area
Wrecks of Archaeological Significance



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 8 16 Kilometres

0 3 6 Nautical Miles

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Wrecks of archaeological significance
Document no: HOW04MA0007
Created by: JNS
Checked by: CH
Approved by: GM

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4 Geophysical Assessments

4.1 Archaeological Assessment of Geophysical Data

4.1.1.1 The geophysical assessment was undertaken by MSDS Marine Ltd. and is summarised here; further information can be found in **Appendix C: Archaeological review of geophysical and hydrographic data**. The archaeological potential of the anomalies was determined following the criteria as stated in **Table 15**.

Table 15: Criteria for assessment of archaeological potential.

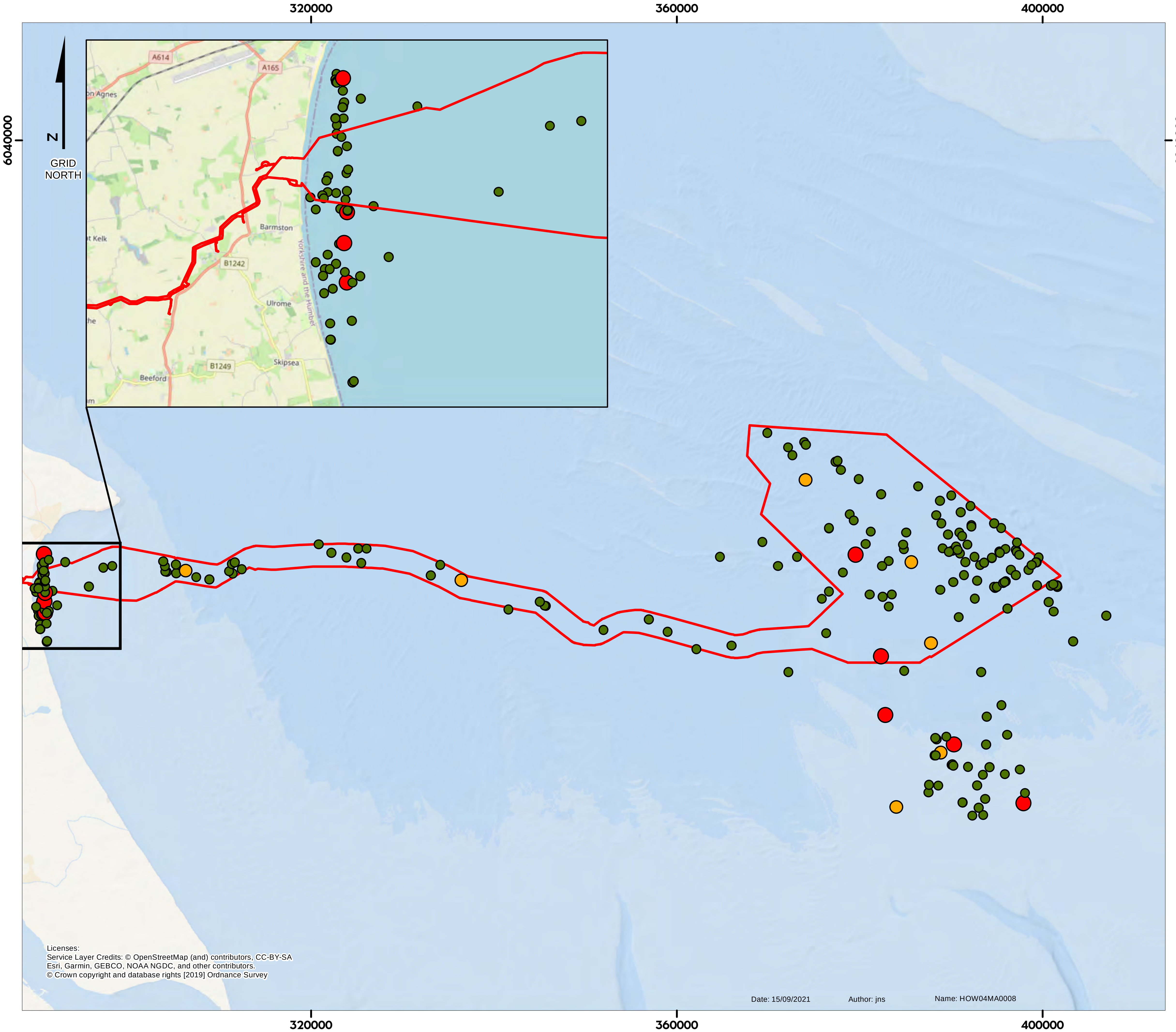
Potential	Criteria
Low	An anomaly potentially of anthropogenic origin but that is unlikely to be of archaeological significance – Examples may include; discarded modern debris such as rope, cable, chain or fishing gear, small isolated anomalies with no wider context or small boulder-like features with associated magnetometer readings.
Medium	An anomaly 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	An anomaly almost certainly of anthropogenic origin and with a high potential of being of archaeological significance – high potential anomalies 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 256 anomalies of potential anthropogenic origin within the survey data extent (AfL), 146 of these are located within the Order Limits as summarised in **Table 16.** All anomalies are shown on **Figure 8**.

Table 16: Summary of anomalies with archaeological potential.

Potential	Order Limits	Data Extents	Total
Low	139	101	240
Medium	5	2	7
High	2	7	9
Total	**146**	**110**	**256**

4.1.1.3 Identified magnetic anomalies not correlating with known features or associated with anomalies of archaeological potential are summarised in **Table 17** and further discussed in **Section 4.2**.



Date: 15/09/2021 Author: jns Name: HOW04MA0008

Hornsea Four

Figure 8

Anomalies of archaeological potential identified in the geophysical data

Order Limits

Anomalies of archaeological potential

- High
- Medium
- Low

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 7.5 15 Kilometres

0 3 6 Nautical Miles

REV	REMARK	DATE
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Anomalies of archaeological potential
Document no: HOW04MA0008
Created by: JNS
Checked by: CH
Approved by: GM

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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 data and the ongoing geoarchaeological programme prior to DCO 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 A4, Annex 5.2: Commitments Register** and these commitments will be delivered through the mechanism of the resulting DCO and associated deemed Marine Licences (dMLs) (**C1.1: Draft DCO including Draft DML**).

4.1.2.3 Impact on all known and identified archaeological receptors outlined in the existing baseline assessment (**Sections 3** and **4**) will be mitigated by utilising the embedded mitigation methodology as outlined in **Section 5**.

4.1.3 Low Potential Anomalies

4.1.3.1 Of the 240 anomalies identified as of low archaeological potential, 139 are located within the Order Limits. The low potential anomalies 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. For a full list and board categories refer to **Appendix C: Archaeological review of geophysical and hydrographic data**.

4.1.4 Medium Potential Anomalies within the Order Limits

4.1.4.1 Five anomalies of archaeological potential are located within the Order Limits and range from as summarised below and as detailed in **Appendix C: Archaeological review of geophysical and hydrographic data**.

4.1.4.2 MSDS_HOW04_2019_ARCH_0079: A square feature measuring 4.1 m x 4.7 m, with a measurable height of 0.3 m. The feature has raised edges with a depression in the middle which corresponds to the surrounding seabed. The anomaly is not associated with a magnetic anomaly but lies c.30 m 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.

4.1.4.3 MSDS_HOW04_2019_ARCH_0088: A dense cluster of boulder-like features over an area of 22.0 m x 12.3 m. The coverage is uniform with a few small bare areas of seabed. The anomaly is associated with a magnetic anomaly of 135.9 nT indicating the presence of ferrous material. The anomaly could potentially be interpreted as a ballast mound.

4.1.4.4 MSDS_HOW04_2019_ARCH_0234: A cluster of features concentrated within an area measuring 10.3 m x 3 m x 7.7 m and associated with a large magnetic anomaly of 1653.8 nT. 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.

4.1.4.5 MSDS_HOW04_2019_ARCH_0244: A 'L' shaped feature with prominent shadow associated with a magnetic anomaly of 291.4 nT. The form and the size of the magnetic anomaly may indicate maritime debris such as a lost anchor.

4.1.4.6 MSDS_HOW04_2019_ARCH_0257: A largely buried anomaly of incoherent form, visible element measures 6.7 m x 7 m x 3.7 m. The anomaly is likely to represent partially buried anthropogenic material of unknown type.

4.1.5 Medium Potential Anomalies within the survey data extent but outside of the Order Limits

4.1.5.1 Two further anomalies of medium archaeological potential were identified outside the Order Limits as described below and detailed in **Appendix C: Archaeological review of geophysical and hydrographic data**.

4.1.5.2 MSDS_HOW04_2019_ARCH_0072: A prominent mound which may represent anthropogenic material. The mound measures 12.3 m x 5.8 m, with a maximum height of 0.9 m. There is no associated magnetic anomaly, potentially due to being 50 m from the magnetometer survey line.

4.1.5.3 MSDS_HOW04_2019_ARCH_0096: A distribution of features over an area of 70.2 m x 16.8 m with a height of 0.2 m and an associated magnetic anomaly of 7 nT. This feature corresponds with UKHO record 9403, an area of debris swept clear at 29 m in 1986. The extent of the features as indicated by the Side Scan Sonar (SSS) and multibeam data could possibly indicate a broken-up wreck.

4.1.6 High Potential Anomalies within the Order Limits

4.1.6.1 Two anomalies within the Order Limits have been assessed as of high archaeological potential as summarised below and detailed in **Appendix C: Archaeological review of geophysical and hydrographic data**.

4.1.6.2 MSDS_HOW04_2019_ARCH_0086: A spread of potential debris and an associated magnetic anomaly of 1960.4 nT. The debris covers an area of 34.1 m 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 SSS data it is characterised as a rectangular feature with associated features to the north and south-east. The anomaly is not associated with a known wreck.

4.1.6.3 MSDS_HOW04_2019_ARCH_0224: The semi-coherent remains of a wreck with a significant associated magnetic anomaly of 1938.4 nT. 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 3.4.8**.

4.1.7 High Potential Anomalies within the survey data extent but Outside of the Order Limits

4.1.7.1 Seven further anomalies assessed as high archaeological potential were located outside the Order Limits as summarised below and detailed in **Appendix C: Archaeological review of geophysical and hydrographic data**.

4.1.7.2 MSDS_HOW04_2019_ARCH_0015: The semi-coherent remains of a wrecked vessel measuring 21.1 m 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 anomaly corresponds to UKHO record 9410, an unknown wreck located in 1986. The wreck is associated with a significant magnetic anomaly of 8940 nT. The size of the magnetic anomaly and the coherent form likely indicate a steel vessel.

4.1.7.3 MSDS_HOW04_2019_ARCH_0073: The coherent remains of a wreck measuring 32.4 m x 9.6 m, with a height of 2.8 m. There is no magnetic anomaly associated with the wreck, likely due to the distance of c.40 m from the magnetometer track. This anomaly 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*.

4.1.7.4 MSDS_HOW04_2019_ARCH_0113: The coherent remains of a wreck lying within an area of sandwaves. The wreck is associated with a magnetic anomaly of 23.5 nT and UKHO record 9410, which was identified in 1985 but has no known identity. The vessel measures 21.1 m x 7.7 m with a height of 1.8 m.

4.1.7.5 MSDS_HOW04_2019_ARCH_0171: A likely wreck measuring 12.4 m x 4.1 m but with no corresponding magnetic anomaly. The anomaly measures 13.4 m 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.

4.1.7.6 MSDS_HOW04_2019_ARCH_0173: Likely remains of a wrecked vessel measuring 15.5 m x 4.2 m and with a measurable height of 0.1 m. The wreck is partially ensonified within the multibeam data appearing as a mound within a slight depression, there is no associated magnetic anomaly. The SSS data characterises the wreck by a number of relatively regular features forming the outline of a vessel, potentially frames, a flat stern and a more pointed bow.

4.1.7.7 MSDS_HOW04_2019_ARCH_0178: The remains of a wrecked vessel covering an area of 77.3 m x 33.8 m with a height of 0.1 m. The anomaly has an associated magnetic anomaly of 9581.4 nT and UKHO record 5805, the aft section of *Sote* a Swedish steamship built in 1883 and sunk by a torpedo in 1918.

4.1.7.8 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 anomaly of 790.8 nT indicate material of anthropogenic origin in the vicinity of the mound which could be related to a vessel.

4.2 Archaeological Assessment of Magnetometer Data

4.2.1.1 The magnetometer assessment was undertaken by MSDS Marine Ltd. and is summarised here; further information can be found in **Appendix C: Archaeological Review of Geophysical and Hydrographic Data**.

4.2.1.2 There were 2363 magnetic anomalies, not correlating with known features or associated with anomalies of archaeological potential, identified within the survey extents, 1582 of which lie within the Order Limits as summarised in **Table 17**.

Table 17: Magnetic anomalies.

Intensity (nT)	Order Limits	Data extents	Total
5 - 50	1477	682	2159
50 - 100	64	54	118
100 - 200	29	31	60
200+	12	14	26
Total	**1582**	**781**	**2363**

4.2.1.3 Within the Order Limits, 41 large magnetic anomalies (over 100 nT) were identified, with another 45 large anomalies located outside the Order Limits but within the data extents. The large magnetic anomalies have the potential to represent material of anthropogenic origin and of archaeological potential.

4.3 Palaeogeographic Assessment of Geophysical Data

4.3.1.1 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: Palaeogeographic review of geophysical survey data**). The interpretations within this summary are based on MBES data, SBP data and UHRS data supported by knowledge gained from other Hornsea project areas and previous geotechnical work.

4.3.1.2 Quaternary formations identified within the site on the basis of current evidence consist of Holocene marine sands, Botney Cut, Bolders Bank, Eem, Egmond Ground, Swarte Bank and Yarmouth Roads Formations. Pre-quaternary formations include the chalk and pre-chalk bedrock which are not of archaeological interest. The distribution of these formations within the Order Limits is set out within **Appendix D: Palaeogeographic review of geophysical survey data**.

4.3.1.3 Quaternary deposits extend across the Order Limits, although they are thickest within the southern part of the array area demonstrating a higher palaeoenvironmental and archaeological potential within this zone. The southern part of the array area demonstrates deposits of the Eem and Yarmouth Roads formations, with the latter extending to the north-eastern part of the array area. The Upper Yarmouth Roads deposits are thought to equate to the onshore Cromer Forest Beds, which contain evidence of in situ archaeological and palaeoenvironmental remains dating to the Lower Palaeolithic. Botney cut channels are mapped across the array area, though with a greater concentration in the south.

4.3.1.4 Ongoing and geotechnical and future survey campaigns will target all formations identified within the Order Limits and geoarchaeological assessment which will follow will provide further insights into the palaeoenvironmental and archaeological potential of Hornsea Four. A summary of the sedimentary sequence of the site is provided in **Table 18**.

Table 18: 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 moraines and other glacial features along the export cable route may hold organic deposits of Holocene date.
Botney Cut	Related to the Late Devensian and Early Holocene period. Predominantly glacio-fluvial channel 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.
Eem Formation	Related to the Ipswichian interglacial. Fine to medium grained shelly marine sands, or intertidal/sub-tidal deposits.
Egmond Ground	Fine grained marine sands interbedded with clays
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

Deposit	Description
	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

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 Order Limits. This approach is further detailed in the Hornsea Four Outline Marine WSI document (**F2.4: Outline Marine Written Scheme of Investigation**) and follows the methodology detailed in 'Archaeological Written Schemes of Investigation for Offshore Wind Farm Projects' (The Crown Estate 2021).

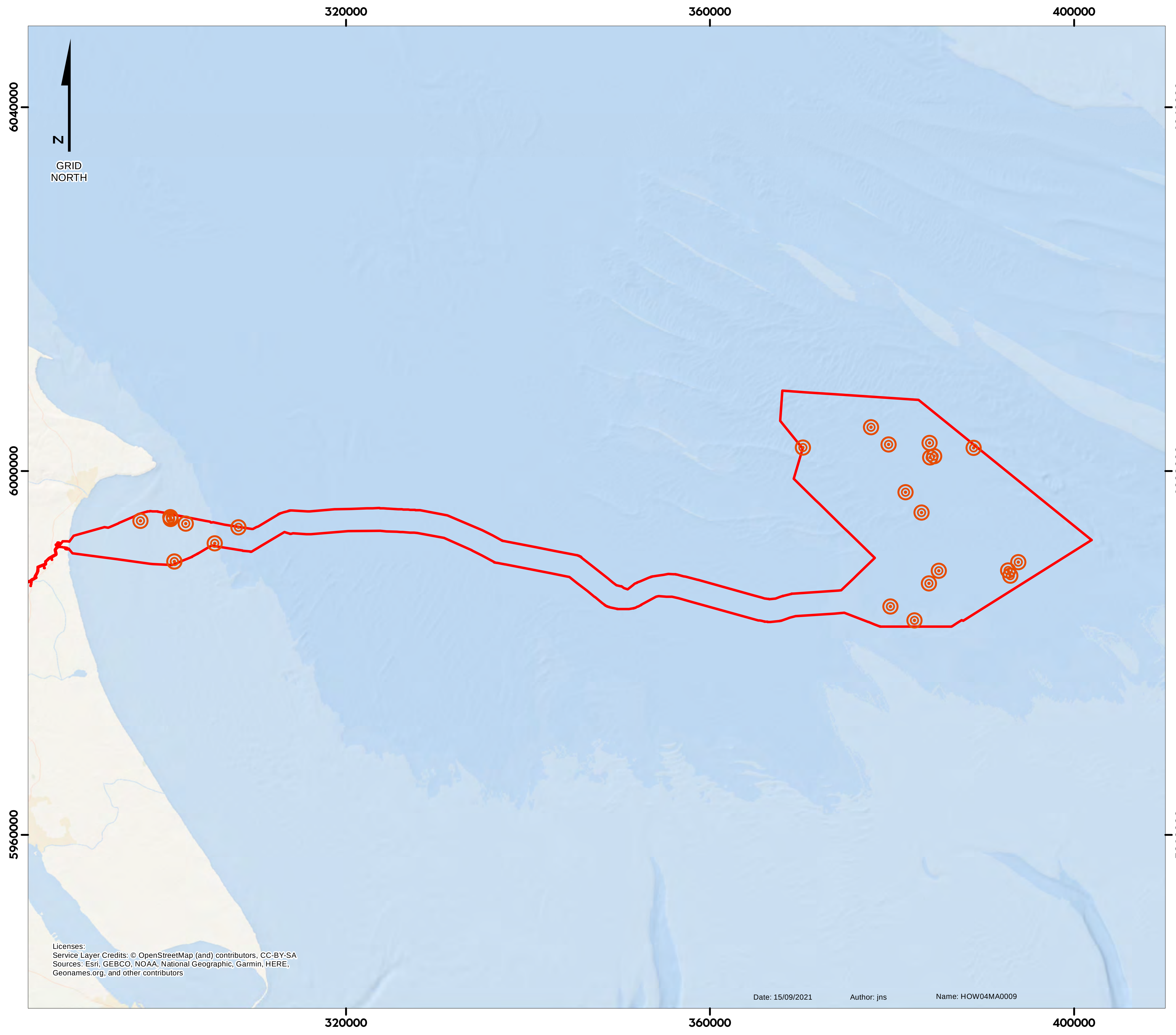
5.1.1.3 As per commitments Co166 and Co167 outlined in **Table 2,** further geophysical and geotechnical surveys prior to and during construction will be subject to a full archaeological review as further detailed in the Outline Marine WSI (**F2.4: Outline Marine Written Scheme of Investigation**).

5.1.1.4 As per commitment Co181 outlined in **Table 2,** an Offshore Decommissioning Plan will be developed prior to decommissioning ensuring that all potential impact on marine archaeology receptors will be mitigated.

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 Order Limits. Of the 18 wrecks, 13 are classed as LIVE. In addition, there are five foul and seabed obstructions within the Order Limits. The six fishermen's fasteners included in the NRHE data have not been assigned exclusion zones.

5.2.1.2 As per commitments Co46 and Co140 in **Table 2**, precautionary AEZs of 50 m are recommended for all 23 known heritage receptors (18 wrecks plus five foul and seabed obstructions), as illustrated in **Figure 9**, and the Historic Environment Plan (**Volume D1, Annex 8.1: Offshore Historic Environment Plan**). Full details of which are provided in **Appendix A** of this document.



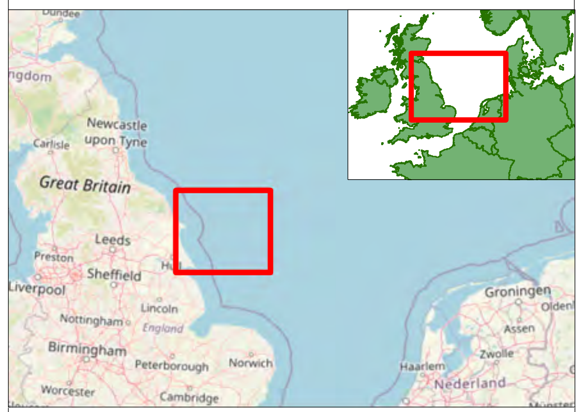
Hornsea Four

Figure 9

Archaeological Exclusion Zones assigned to known wrecks and obstructions

Order Limits

AEZs for known wrecks and obstructions



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 8 16 Kilometres

0 3 6 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	15/09/2021

AEZs for known wrecks and obstructions
Document no: HOW04MA0009
Created by: JNS
Checked by: CH
Approved by: GM

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5.3 Mitigation for Geophysical Anomalies of Archaeological Potential

5.3.1.1 The combined geophysical data assessments undertaken to identify material of anthropogenic potential identified 187 features within the Order Limits as outlined in **Table 19**.

Table 19: Anomalies with archaeological potential identified within the Order Limits.

Potential	Anomalies (no.)
Low	139
Medium	5
High	2
High magnetic (over 100 nT)	41
Total	**187**

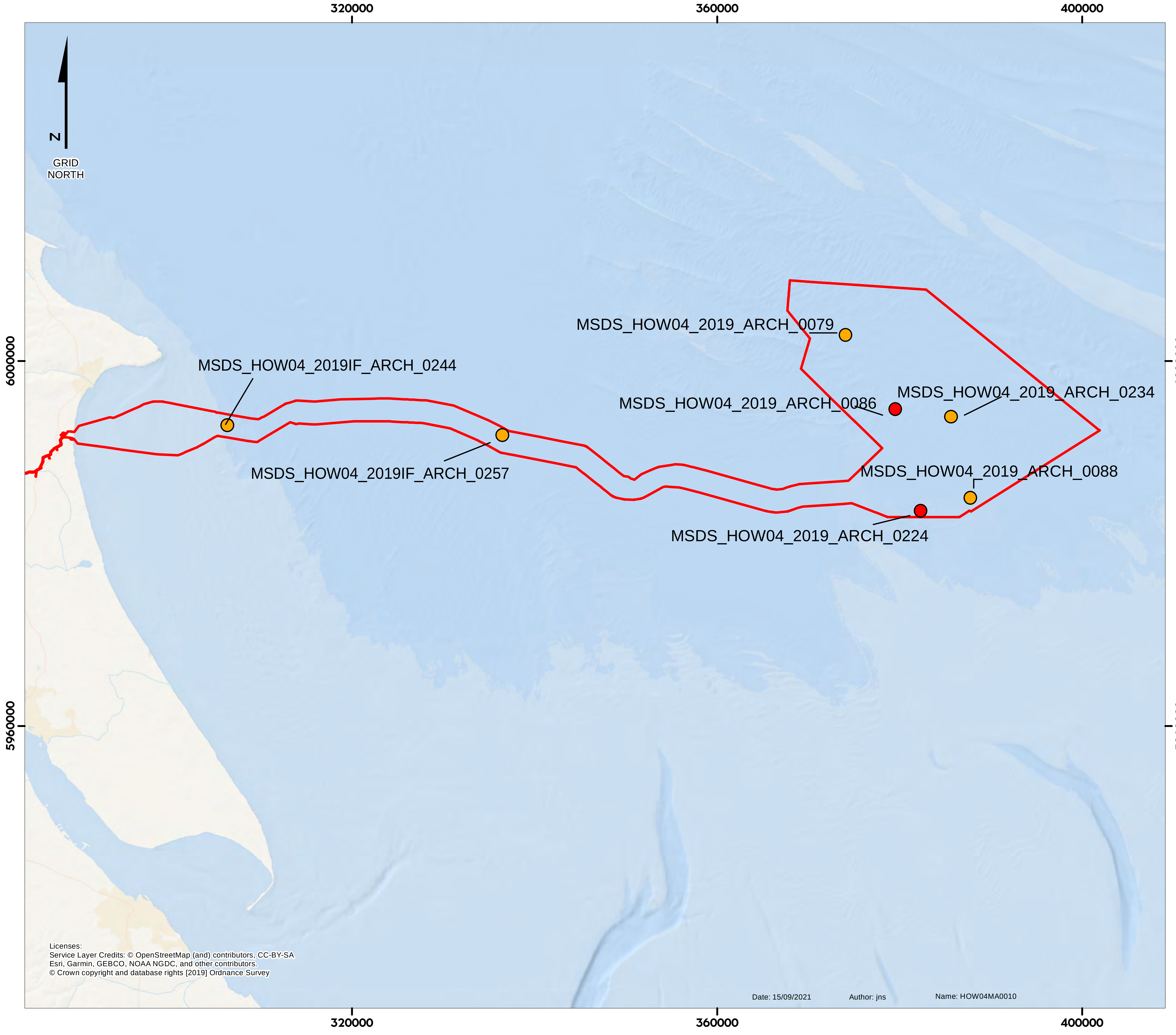
5.3.1.2 Anomalies of low archaeological potential (see **Table 19** above) and high magnetic anomalies > 100 nT (also see **Table 17**) without correlating seabed feature are detailed in **Appendix C: Archaeological review of geophysical and hydrographic data**. Due to the uncertainty of their archaeological potential, the 139 low anomalies and the 41 high magnetic anomalies have not been assigned AEZs.

5.3.1.3 As per commitment Co140 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 Investigation**) should be observed and any objects of archaeological potential should be reported as outlined in **F2.4: Outline Marine Written Scheme of Investigation**.

5.3.1.4 As per commitments Co46 and Co140 in **Table 2,** anomalies 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 the size of the anomaly, any outlying debris, the potential significance of the anomaly, the likely impact of the development and the seabed dynamics within the area. The AEZ has been placed as a radius from the centre point of the feature, as detailed below and in **Appendix C: Archaeological review of geophysical and hydrographic data**. In total, seven AEZs have been assigned within the Order Limits, for two high potential and five medium potential anomalies as per **Table 20** and **Figure 10**.

Table 20: 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
MSDS_HOW04_2019IF_ARCH_0244	Medium	Potential anthropogenic debris with large magnetic anomaly	306336.1	5992925.3	15
MSDS_HOW04_2019IF_ARCH_0257	Medium	Potential anthropogenic debris	336477.5	5991865.6	15



Hornsea Four

Figure 10

Archaeological Exclusion Zones assigned to anomalies of archaeological potential

Order Limits

AEZ's for High and Medium

High

Medium

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 8 16 Kilometres

0 3 6 Nautical Miles

REV	REMARK	DATE
	First Issue for ES	15/09/2021

AEZs for anomalies of archaeological potential
Document no: HOW04MA0010
Created by: CH
Checked by: JNS
Approved by: BM

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 Order Limits. 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 Investigation**.

5.5 Mitigation for Unexpected Archaeological Discoveries

5.5.1.1 As per commitment Co140 in **Table 2**, it is proposed that any finds believed to be of archaeological potential recovered by any Hornsea Four operating vessels during construction, operation or decommissioning will be reported using the methodology outlined in the project-specific PAD (**Appendix A** of **F2.4: Outline Marine Written Scheme of Investigation**).

5.5.1.2 The Hornsea Four 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 will familiarise themselves with the PAD and the reporting procedures it describes, which is further detailed in **F2.4: Outline Marine Written Scheme of Investigation**.

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Appendix A: Known shipwrecks, fouls, and obstructions within the marine archaeology study area

Table A.1: Shipwrecks.

Name	MSDS ID	UKHO ID	NRHE ID (HOB UID)	Latitude	Longitude	Status	Location accuracy	Notes
Adventure		5805		54.033567	0.01825	DEAD	Unreliable	Outside OL No information
Biesbosch		5808	907942	54.062183	0.046733	LIVE	~25 m	
Brabant		5807	907941	54.058917	0.09695	LIVE	~3 m	
Feltre		6470	907939	54.039967	0.029083	LIVE	~25 m	
HMS Falcon		6687	1456911	54.02083	0.34472	LIVE	~13 m	Confirmed location outside OL
Lapwing	0224	9400		53.987217	1.205633	LIVE	~13 m	
Leka			1454594	54.02025	0.037283	LIVE	Approximate	Identity and location unreliable
Linda Louise		6845		54.038883	1.360883	LIVE	~13 m	Sank 1983
Manchester Engineer (Possibly)		66241		54.033567	0.031583	Dead	Unreliable	Identified outside marine archaeology study area
Nitedal		6493	978621	54.02025	0.037283	LIVE	~13 m	Possibly located outside marine archaeology study area
Resercho (possibly)		6586	907940	54.056633	0.067417	DEAD	Unreliable	
Ross Curlew (Probably)	89754	6162		54.033567	0.031583	Dead	Unreliable	Located 145m from Fisherman's fastener
Sote (Aft Part)	0178	5805		54.02035	0.1916	LIVE	~3 m	Located during the geophysical survey 2019
Syrian		6741		54.154967	1.010633	LIVE	~4 m	
Unknown		6163	908402	54.06385	0.047283	DEAD	Unreliable	Recorded as natural feature
Unknown		6165	908401	54.0583	0.0209	LIVE	Unreliable	
Unknown		6721		54.000267	1.164767	DEAD	Unreliable	
Unknown		6728		54.047217	1.37755	LIVE	~13 m	
Unknown	0233	6830		54.176917	1.124233	LIVE	~13 m	
Unknown		6846		54.16025	1.154783	DEAD	Approximate	
Unknown		6833		54.16275	1.223383	LIVE	~13 m	
Unknown		6735		54.148583	1.225333	LIVE	~13 m	

Unknown		6736		54.158867	1.2981	LIVE	~13 m	
Unknown		6164	908392	54.008583	0.051183	LIVE	Unreliable	Outside OL
Unknown		6161	908404	54.072467	0.015633	LIVE	Precicely known	Outside OL
Unknown		6587	908400	54.049683	0.18935	DEAD	Unreliable	Outside OL
Unknown		6588		54.037467	0.129917	DEAD	Unreliable	Outside OL
Unknown		6685		54.040533	0.4346	LIVE	~13 m	Outside OL
Unknown		6847		54.0172	1.01535	LIVE	~13 m	Outside OL
Unknown		6848		54.042483	1.117833	LIVE	~13 m	Outside OL
Unknown		6696		54.083567	0.33155	LIVE	Unreliable	Outside OL
Ville De Valenciennes		6469	908397	54.029683	0.049917	LIVE	~25 m	Outside OL
Zephr		6725		54.0336	1.364767	DEAD	Unreliable	Sank 1960

Table A.2: Fouls and other obstructions.

UKHO ID	Latitude	Longitude	Status	Location Accuracy
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
5806	54.052717	-0.174983	LIVE	~3 m Outside OL
6861	54.212467	1.108117	LIVE	~13 m Outside OL

Table A.3: Fishermen's fasteners (NRHE).

Description	MSDS ID (within 100m)	HOB UID	Easting	Northing	Location
Unidentified seabed obstruction reported by fishermen.		1003367	529778	460059	Outside OL
Unidentified seabed obstruction reported by fishermen.		1003369	530560	460112	Outside OL
Unidentified seabed obstruction reported by fishermen.	MAG_2525	1003371	529276	463693	Within OL
Unidentified seabed obstruction reported by fishermen.		1003378	532970	461788	Outside OL
Unidentified seabed obstruction reported by fishermen.		1003380	533553	461124	Outside OL
Unidentified seabed obstruction reported by fishermen.	0240 (Low)	1003381	532666	462862	Within OL
Unidentified seabed obstruction reported by fishermen.		1003385	534321	461641	Outside OL
Unidentified seabed obstruction reported by fishermen.		1003407	539325	462933	Outside OL
Unidentified seabed obstruction reported by fishermen.		1003413	540478	463308	Outside OL
Unidentified seabed obstruction reported by fishermen.		1003422	540744	464739	Within OL
Unidentified seabed obstruction reported by fishermen.		1003428	540168	466948	Outside OL
Unidentified seabed obstruction reported by fishermen.		1003431	542133	464534	Within OL
Unidentified seabed obstruction reported by fishermen.		1003436	541954	465642	Within OL
Unidentified seabed obstruction reported by fishermen.		1003437	543267	464352	Within OL
Unidentified seabed obstruction reported by fishermen.		1003416	525880	458776	Outside OL

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

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

NMR, SMR or RCZA 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
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 1551072,	Bronze Age	Potsherds	+54.018230	-0.214238
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 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
SMR MHU334	Roman	A substantial trackway cropmark of approx. 100 m in length.	+54.021640	-0.216916
SMR MHU3141	Roman	Roman coins and 4^{th} Century Signal Station type pottery	+54.048312	-0.212185
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

NMR, SMR or RCZA record number	Era	Description	Latitude	Longitude
RCZA BA119	Second World War	A pillbox designed to house a 6-pounder quick-firing gun	+54.018750	-0.212995
RCZA BA183	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
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
NMN 1429773	Second World War	Observation post	+53.979351	-0.199127

Appendix C: Archaeological review of geophysical and hydrographic data

Hornsea Project Four: Environmental Statement (ES)

Appendix C of ES Annex 9.1: Archaeological Review of Geophysical and Hydrographic Data

Prepared MSDS Marine. April 2021
Checked MSDS Marine. August 2021
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Approved Julian Carolan, Orsted. September 2021

A5.9.1
Version B

Hornsea Project Four Offshore Wind Farm

Archaeological Review of Geophysical and Hydrographic Data

DOCUMENT CONTROL GRID	
Project Name	Hornsea Project Four Offshore Wind Farm: Archaeological Review of Geophysical and Hydrographic Data
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MSDS Marine Project Number	MSDS19103
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Summary of changes	Review of additional data and DCO boundary change, addressing client comments, further DCO boundary change

Contents

Acronyms

AAP	Areas of Archaeological Potential
AEZ	Archaeological Exclusion Zone
AfL	Agreement for Lease
ASCII	American Standard Code for Information Interchange
c.	Circa (approximately)
CUBE	Combined Uncertainty and Bathymetry Estimator
DCO	Development Consent Order
Decca	Hyperbolic Radio Navigation System
ECC	Export Cable Corridor
EGN	Empirical Gain Normalisation
EIA	Environmental Impact Assessment
ETRS	European Terrestrial Reference System
ES	Environmental Statement
GIS	Geographical Information System
GNSS	Global navigation Satellite System
GPS	Global Positioning System
HE	Historic England
Hornsea Four	Hornsea Project Four Offshore Wind Farm
HF	High Frequency
IAKAR	Inertially Aided Kinematic Ambiguity Resolution
ID	Identification
IHO	International Hydrographic Organisation
INS	Inertial Navigation System
LAT	Lowest Astronomical Tide
LF	Low Frequency
MAG	Magnetometer
MBES	Multibeam Echo Sounder
MMO	Marine Management Organisation
nT	Nanotesla
OSS	Offshore Sub-station
PAD	Protocol for Archaeological Discoveries
PEIR	Preliminary Environmental Information Report
PPM	Pixels Per Meter
PPP	Precise Point Positioning
PPVRS	Post Processed Virtual Reference Station
pUXO	potential Unexploded Ordnance
QC	Quality Control
RCS	Reactive Compensation Station
SBET	Smoothed Best Estimated Trajectory
SBP	Sub-bottom Profiler
SEGY	Society of Exploration Geophysicists ‘Y’ Format
SSS	Sidescan Sonar
SVS	Sound Velocity Sensor
TAEZ	Temporary Archaeological Exclusion Zone
UKHO	United Kingdom Hydrographic Office
USBL	Ultra Short Baseline
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
VORF	Vertical Offshore Reference Frames

VRS	Virtual Reference Stations
WSI	Written Scheme of Investigation
WTG	Wind Turbine Generator
WWI	World War One
WWII	World War Two
XTF	eXtended Triton Format

1.0 Non-Technical Summary

1.0.1 MSDS Marine Ltd (MSDS Marine) have been commissioned by Ørsted Hornsea Project Four Limited (hereafter 'the Applicant'), 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 (hereafter 'Hornsea Four') in 2018, 2019 and 2020 as part of the geophysical survey works to support Hornsea Four pre-application activities for their application for a Development Consent Order (DCO). The archaeological review is to establish the archaeological potential of the area and identify known and unknown anomalies of archaeological potential within the datasets. The data has been reviewed to identify anomalies of potential archaeological significance, to characterise potential for material of archaeological significance and to recommend appropriate mitigation strategies.

1.0.2 Each 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. A second campaign was undertaken on the ECC by Bibby Hydromap between 1st March and 10th April 2019 and 15th May and 14th July 2019 to acquire infill data. A third campaign was undertaken by GEOxyz between 24th March and 1st April 2020 to acquire data over eighteen locations identified for geotechnical investigations within the Array Area.

1.0.3 The survey data extends to the pre-DCO boundary submitted at Scoping, however the area taken forward at the DCO application stage, referred to as the Order Limits, 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 DCO Order Limits.

1.0.4 The data were processed and interpreted to identify anomalies 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.

1.0.5 256 anomalies of potential archaeological significance were identified within the geophysical data extents across all years. These can be broken down as 240 low potential, seven medium potential and nine high potential. 146 of the anomalies lie within the Order Limits, broken down as 139 low potential, five medium potential and two high potential. The anomalies 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 anomalies identified on the seabed.

1.0.6 The recommended mitigation strategy for the medium and high potential anomalies is in the form of archaeological exclusion zones. The low potential anomalies 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 during construction and site preparation activities through an appropriate protocol for reporting archaeological discoveries. Seven archaeological exclusion zones within the Order Limits have been recommended for anomalies identified as of medium or high archaeological potential. 41 magnetic anomalies with no significant correlating seabed anomalies have been identified within the Order Limits 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

1.0.7 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 during construction and site preparation activities.

1.0.8 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 anomalies so that further archaeological assessment can be undertaken, and interpretations revised as appropriate.

2.0 Introduction

2.0.1 MSDS Marine Ltd (MSDS Marine) have been commissioned by Orsted Hornsea Project Four Limited (hereafter 'the Applicant'), to undertake an archaeological review of the geophysical and hydrographic data collected along the Export Cable Corridor (ECC) and Array of the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four') between 2018 and 2020 as part of the pre-application survey works. The archaeological review is to establish the archaeological potential of the area and identify known and unknown anomalies of archaeological potential within the dataset. The data has been reviewed to identify anomalies of potential archaeological significance, to characterise potential for material of archaeological significance and to recommend appropriate mitigation strategies.

3.0 Project Location and Status

3.0.1 The Applicant is proposing to develop Hornsea Four, which is located approximately 69 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 Four is illustrated in Figure 1. Of the other Hornsea projects, Hornsea Project Two lies in closest proximity, and is currently undergoing offshore construction works. 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 at Creyke Beck. The DCO Order Limits combine the search areas for the onshore and offshore infrastructure.

3.0.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In keeping with the Hornsea Four approach to Proportionate EIA, the project gave due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. 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 factors with technical feasibility for construction.

3.0.3 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 DCO application. Hornsea Four adopted a major site reduction from the AfL presented at Scoping (846km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback (Figure 1). The evolution of the AfL is captured in Volume A1, Chapter 3: Site Selection and Consideration of Alternatives and Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure.

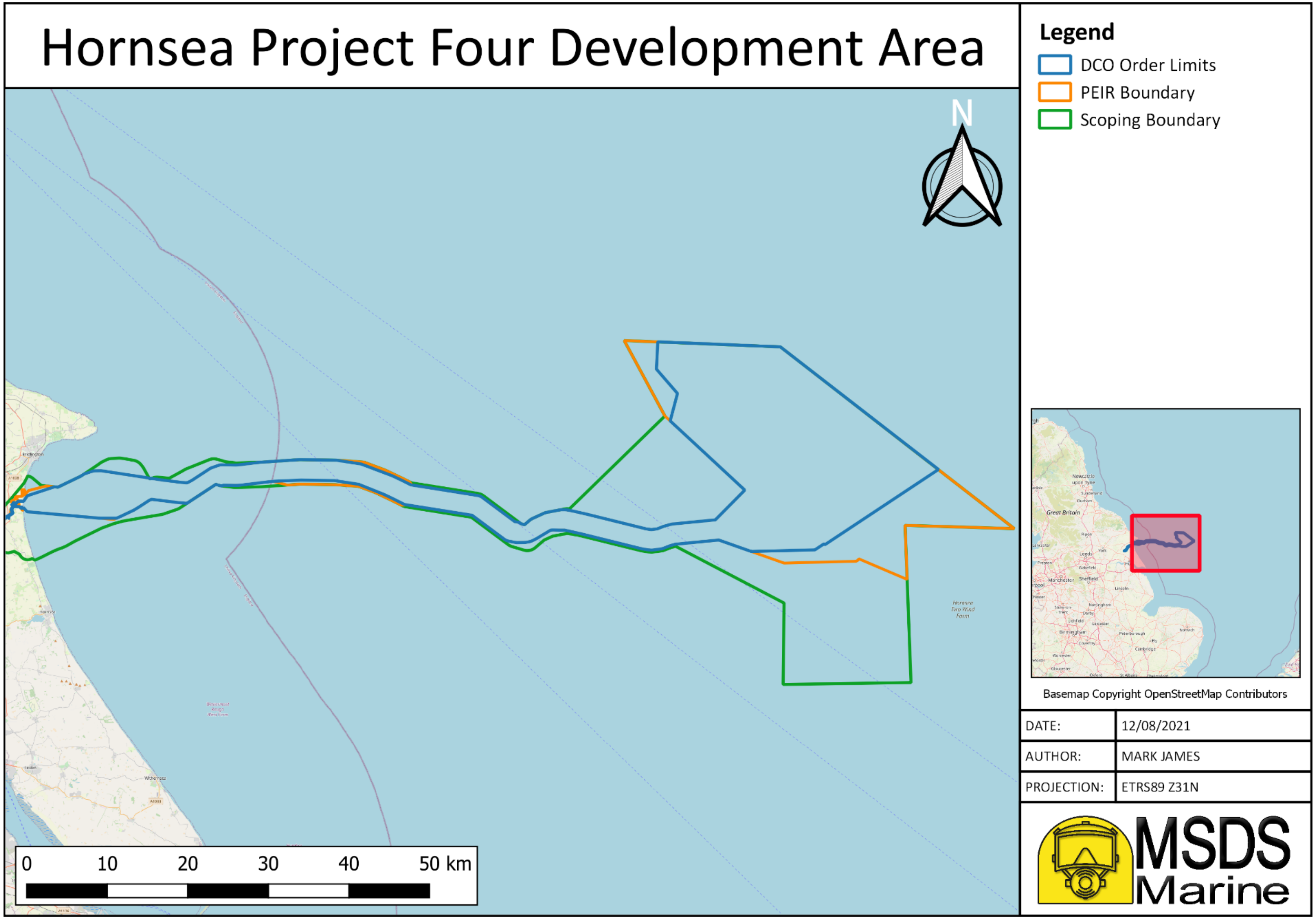

Figure 1. Hornsea Four Development Area and Location

4.0 Previous Archaeological Work

4.0.1 Hornsea Four is currently in the pre-application phase of development and is engaged in the production of the Written Scheme of Investigation (WSI), the Protocol for Archaeological Discoveries (PAD), Environmental Statement (ES) and marine archaeological Technical Report (Volume 5, Annex 9.1) which this report will inform.

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

4.0.3 An Environmental Impact Assessment, Scoping Report was produced in October 2018 (Ørsted, 2018) which aimed to establish relevant cultural heritage assets and the potential impacts from construction, operation, and decommissioning of Hornsea Four. A Preliminary Environmental Information Report (PEIR) was submitted in August 2019, which included an initial assessment of archaeological receptors and an outline WSI.

4.0.4 A significant amount of archaeological work has been undertaken in the adjacent Hornsea Projects (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.

5.0 Aims and Objectives

5.1 Archaeological Review of Geophysical and Hydrographic Data

5.1.1 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.

5.1.2 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 anomalies as to their potential to be of archaeological significance
3. To recommend mitigation strategies for the anomalies appropriate to their archaeological potential
4. To recommend further works that may be required and their specifications

5.1.3 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.

6.0 Methodology

6.1 Data Collection

6.1.1 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).

6.1.2 The first survey campaign (GP1A) (2018) 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.

6.1.3 Data were collected by Bibby Hydromap between 17th October and 5th December 2018 and by Gardline between 16th August and 18th September 2018. A second survey campaign (GP1A) was undertaken on the ECC by Bibby Hydromap between 1st March and 10th April 2019 and 15th May and 14th July 2019 to acquire infill data.

6.1.4 A third campaign (GP1C) was undertaken by GEOxyz between 24th March and 1st April 2020 to acquire data over eighteen locations identified for geotechnical investigations within the Array Area.

6.1.5 The data collected varied in specification across the two lots, and each campaign, however the data from each lot is considered comparable and appropriate to characterise the marine archaeological potential of the Hornsea Four development site. Mobilised sensors are detailed in Table 1, Table 2, Table 3 and Table 4.

6.1.6 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. Data collected over the geotechnical locations was to a specification to ensure 100% coverage of a 10m radius of the location. Coverage is presented in Figure 2.

Vessel	Sidescan Sonar	Multibeam	Magnetometer	Sub-bottom
Bibby Tethra	Edgetech 4200 (300/600/900 kHz)	Kongsberg 2040 Dual head (400 kHz)	Geometrics G-882	Innomar SES-2000 Medium

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

Vessel	Sidescan Sonar	Multibeam	Magnetometer	Sub-bottom
MV *Proteus*	Edgetech 4200 (300/600 kHz)	Reson SeaBat T20 (400 kHz)	Geometrics G-882	Innomar SES-2000 Medium

Table 2. Survey Specification - Export Cable Corridor, nearshore (Bibby Hydromap)

Vessel	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

Table 3. Survey Specification - Array (Gardline)

Vessel	Sidescan Sonar	Multibeam	Magnetometer	Sub-bottom
Geo Ocean IV	Edgetech 4200 (300/900 kHz)	Kongsberg 2040 Dual Head (400 kHz)	Geometrics G-882	Innomar SES-2000 Medium

Table 4. Survey Specification - Geotechnical Locations (GEOxyz)

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

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

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

6.1.9 The towed sensors, Sidescan Sonar (SSS) 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.

6.1.10 Positional accuracy is further increased through the correlation of SSS and Magnetometer datasets with the Multibeam Echo-Sounder (MBES) dataset.

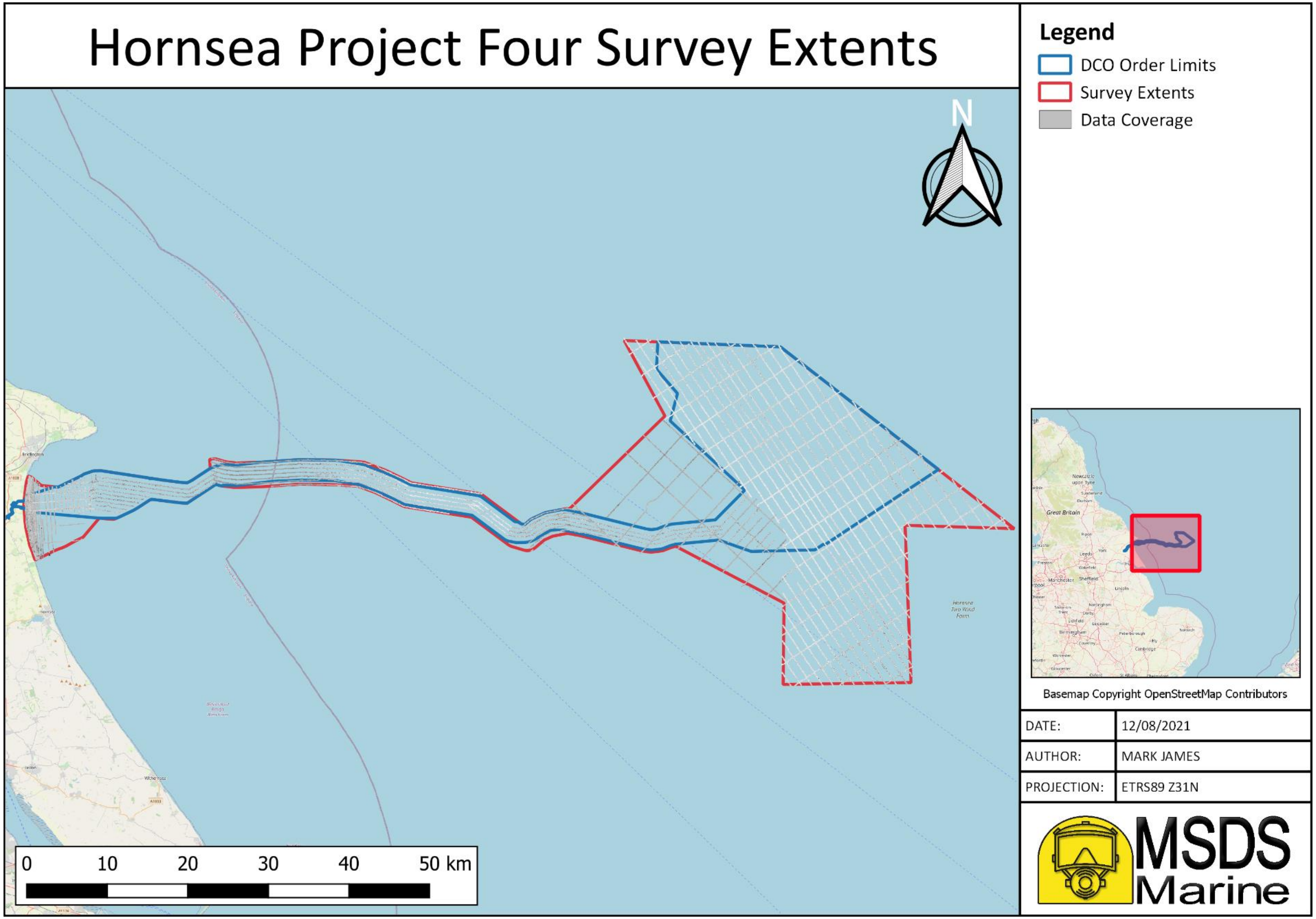

Figure 2. Hornsea Four Data Coverage

6.2 Data Processing

6.2.1 Data collected during the 2018 and 2019 survey campaigns were processed by Bibby Hydromap and Gardline, data from the 2020 survey campaign were processed by GEOxyz. 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 Global Navigation Satellite System (GNSS) Data

6.3.1 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).

6.3.2 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.

6.3.3 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

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

6.4.2 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.

6.4.3 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.

6.4.4 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

6.5.1 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.

6.5.2 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.

6.5.3 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.

6.5.4 Predefined spline and International Hydrographic Organisation (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.

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

6.5.6 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.

6.6 Bathymetric Quality Assurance

6.6.1 All bathymetry processing followed a structured workflow with clearly defined Quality Control (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.

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

6.6.3 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.

6.6.4 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.

6.6.5 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.

6.6.6 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.

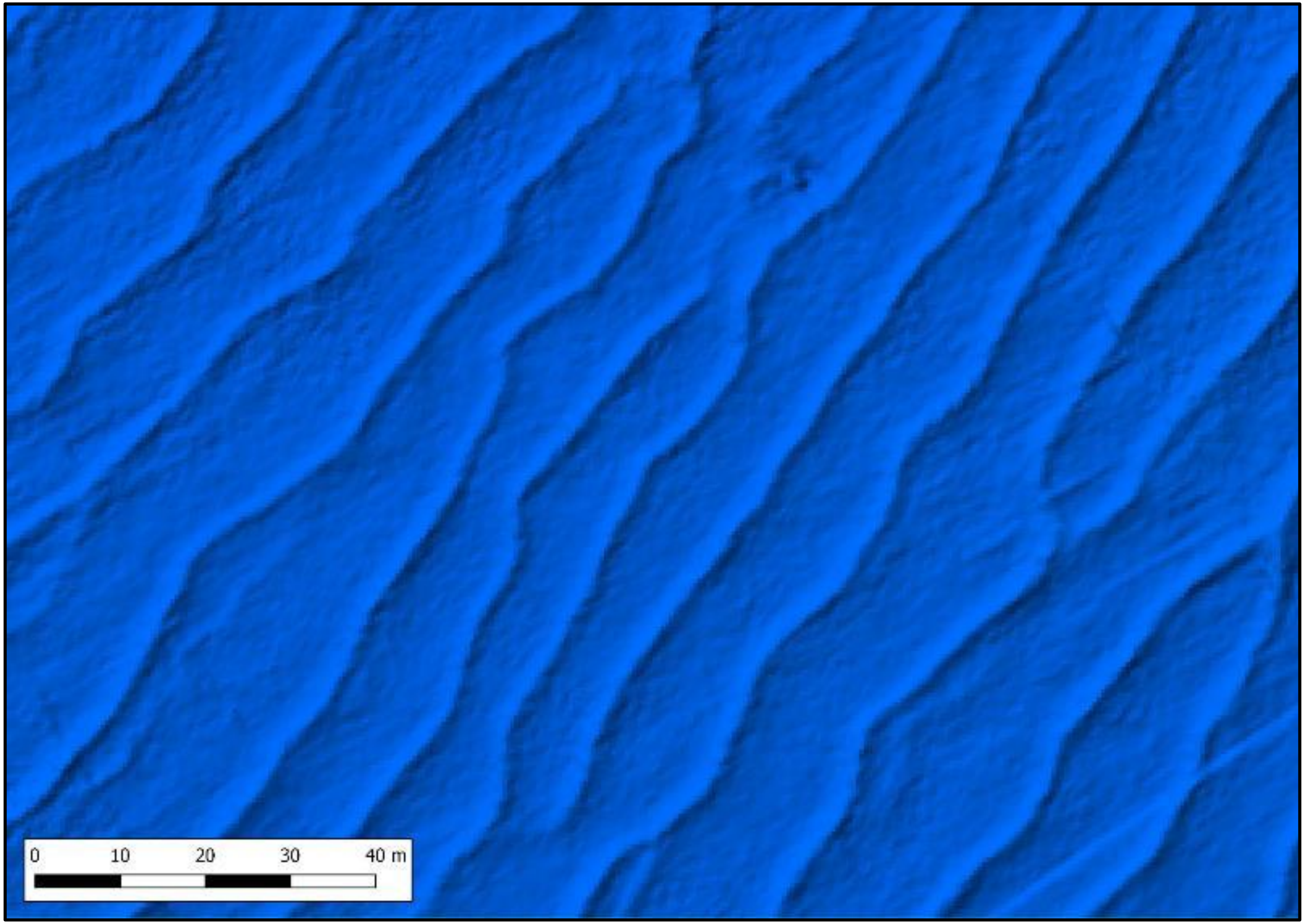

Figure 3. MBES Data Example

6.7 Sidescan Sonar

6.7.1 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 into a mosaic.

6.7.2 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.

6.7.3 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.

6.7.4 The Geographical Information System (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.

6.7.5 Confidence intervals were assigned to the buried anomalies 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, anomalies 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.).

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

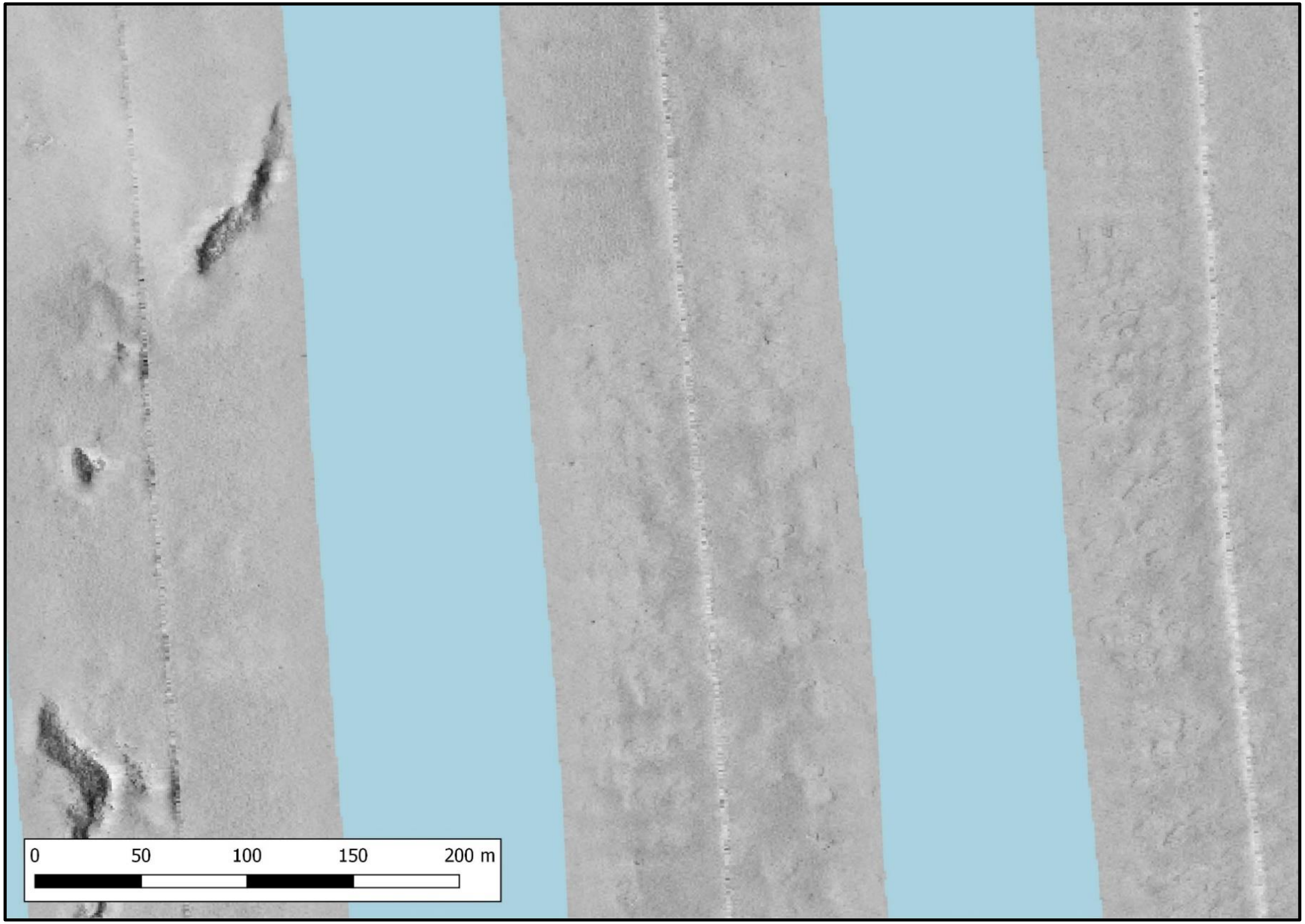

Figure 4. SSS Data Example

6.8 Magnetometer

6.8.1 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.

6.8.2 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.

6.8.3 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.

6.8.4 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.

6.8.5 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.

6.9 Sub Bottom Profiler

6.9.1 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.

6.9.2 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.

6.9.3 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-Sound Velocity Sensor (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.

6.9.4 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.

6.9.5 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; and
6. 2D Spatial Filtering.

6.9.6 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.

6.9.7 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.

6.9.8 The static vertical shifts were carried using RadExPro processing software.

6.9.9 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.

6.9.10 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.

6.9.11 The static vertical shifts were carried using RadExPro processing software.

Horizon Interpretation

6.9.12 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.

6.9.13 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.

Buried Anomaly Interpretation

6.9.14 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.

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

6.9.16 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.

6.9.17 Confidence intervals were assigned to the buried anomalies 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, anomalies 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.).

6.10 Deliverables to MSDS Marine

6.10.1 Following processing of the data and anomaly picking of anomalies the following deliverables in Table 5 were provided to MSDS Marine for further archaeological assessment;

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

Table 5. Survey Deliverables to MSDS Marine

6.11 Archaeological Review

6.11.1 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.

6.11.2 Following delivery of the data from Hornsea 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 anomalies.

6.11.3 The interpretation report considers the full data extents. Whilst some of the data extends beyond the Order Limits, the purpose of the assessment is to characterise the historic environment and therefore all available data has been considered, with the focus of the mitigation measures being on anomalies within the Order Limits.

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

6.11.5 Magnetometer data indicates the presence of ferrous and thus usually anthropogenic material both on, and under the seabed. Where line spacing allows, magnetometer data can provide accurate positions of buried ferrous anomalies (campaigns for the detection of Unexploded Ordnance (UXO) for example typically have sufficient line spacing to allow for accurate positioning of buried ferrous anomalies). The survey line spacing for Hornsea 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 anomalies visible on the seabed.

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

6.11.7 All anomalies 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 anomalies. The archaeological potential is based on the criteria in Table 6 below;

Potential	Criteria
Low	An anomaly 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 anomalies with no wider context or small boulder-like features with associated magnetometer readings.
Medium	An anomaly 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	An anomaly almost certainly of anthropogenic origin and with a high potential of being of archaeological significance – high potential anomalies tend to be the remains of wrecks, the suspected remains of wrecks or known structures of archaeological significance.

Table 6. Criteria for the Assessment of Potential

6.11.8 Where uncertainty existed as to the identification or archaeological potential of an anomaly 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.

6.11.9 Anomalies 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 anomalies are not unnecessarily identified as having archaeological potential when the origination can be identified.

6.11.10 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 an anomaly a reasonable degree of certainty as to the origin of an anomaly can be achieved.

6.11.11 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 an anomaly, or its origin, a precautionary approach is always taken to ensure the most appropriate mitigation for the historic environment.

6.11.12 It should be noted that there may be instances where an anomaly 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 anomalies from multiples angles, including from above.

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

6.12 Mitigation

6.12.1 Embedded mitigation measures are captured by our formal commitments, as outlined in F2.4: Outline Marine Written Scheme of Investigation. This section details the criteria for defining Archaeological Exclusion Zones, which are one form of mitigation which will be applied.

6.12.2 To ensure the most appropriate and robust mitigation for the historic environment without unnecessarily impacting the development, mitigation recommendations including Archaeological Exclusion Zones will be determined on an anomaly-by-anomaly 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 7 below, and are further detailed in F2.4: Outline Marine Written Scheme of Investigation;

Potential	Criteria
Low	No archaeological significance interpreted. Maintain an operational awareness of the anomaly's location, and reporting through the agreed protocol should material of potential archaeological significance be encountered.
Medium	Avoidance of the anomaly's position and where appropriate an archaeological exclusion zone may be recommended. Ground truthing of the anomaly 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 anomaly, any outlying debris and the seabed dynamics as interpreted from the SSS and MBES data.

Table 7. Mitigation Criteria

6.12.3 Where an anomaly 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.

6.12.4 A phased approach to mitigation has been used for Hornsea 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.

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

6.12.6 The mitigation strategies detailed in Table 8 have been used;

Strategy	Criteria
Archaeological Exclusion Zones (AEZs)	For anomalies 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 an anomaly is not visible in the survey data but likely to exist on the seabed at a known position or where the extents of an anomaly 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 an anomaly of archaeological significance around the given position. The anomaly 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.

Table 8. Mitigation Strategies

6.12.7 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 anomaly recommend.

7.0 Results

7.0.1 A total of 256 anomalies of potential anthropogenic origin were identified within the survey extents, 146 of which fall within the Order Limits, these are categorised by potential in Table 9.

Potential	Order Limits	Data Extents	Total
Low	139	101	240
Medium	5	2	7
High	2	7	9
Total	**146**	**110**	**256**

Table 9. Distribution of Anomalies

7.0.2 2363 magnetic anomalies, without strongly correlating visible anomalies, or magnetic anomalies with corresponding features that are likely boulders, were identified within the survey data, 1595 of which fall within the Order Limits. 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 anomalies have been included for completeness. Magnetic anomalies have been discussed further in Section 8.0.

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

7.0.4 The distribution of anomalies 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 anomalies are discussed below according to their assessed potential.

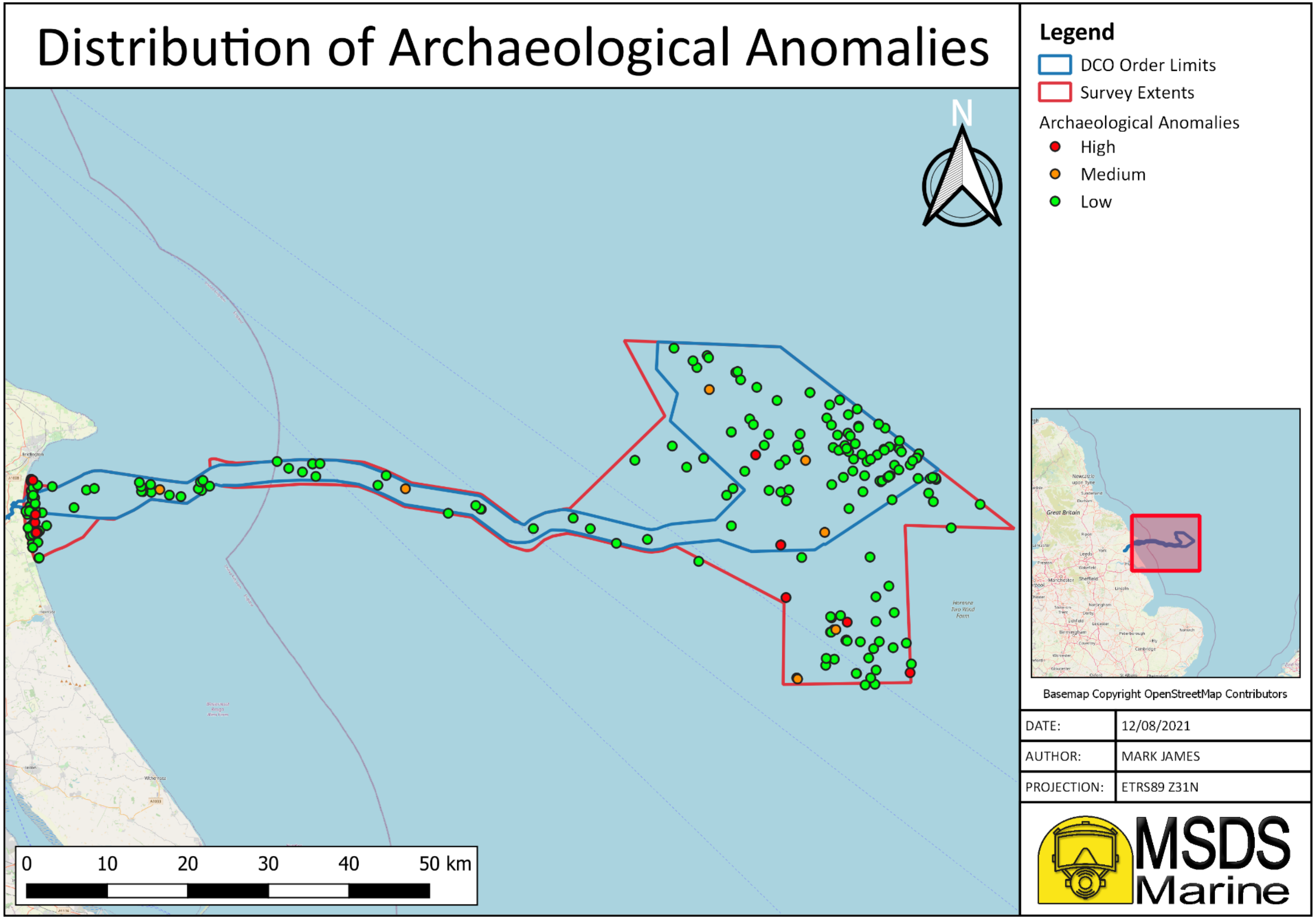

Figure 5. Distribution of Archaeological Anomalies

7.1 Low Potential Anomalies

7.1.1 240 anomalies were identified as of low archaeological potential within the Hornsea Four survey extents, 139 of which fall within the Order Limits, the anomalies can be broken down into broad categories as follows;

Type of Anomaly	Number
Potential anthropogenic debris	125
Potential anthropogenic debris or geology	1
Potential anthropogenic debris with associated magnetic anomaly	112
Potential mound	1
Potential wreck debris	1
Total	240

Table 10. Low Potential Anomaly Types

7.1.2 The anomalies 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 anomalies with associated magnetic anomalies. Where certain of identification, anomalies such as fishing gear were removed from the dataset. Each anomaly was reviewed and established to be of low archaeological potential. A further review was undertaken following assessment of the whole area.

7.1.3 Low potential anomalies 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 anomalies is displayed in Figure 6, further information regarding mitigation can be found in Section 10.0, more information regarding positions and dimensions can be found in Appendix C1 - *Gazetteer of Potential Archaeological Anomalies*.

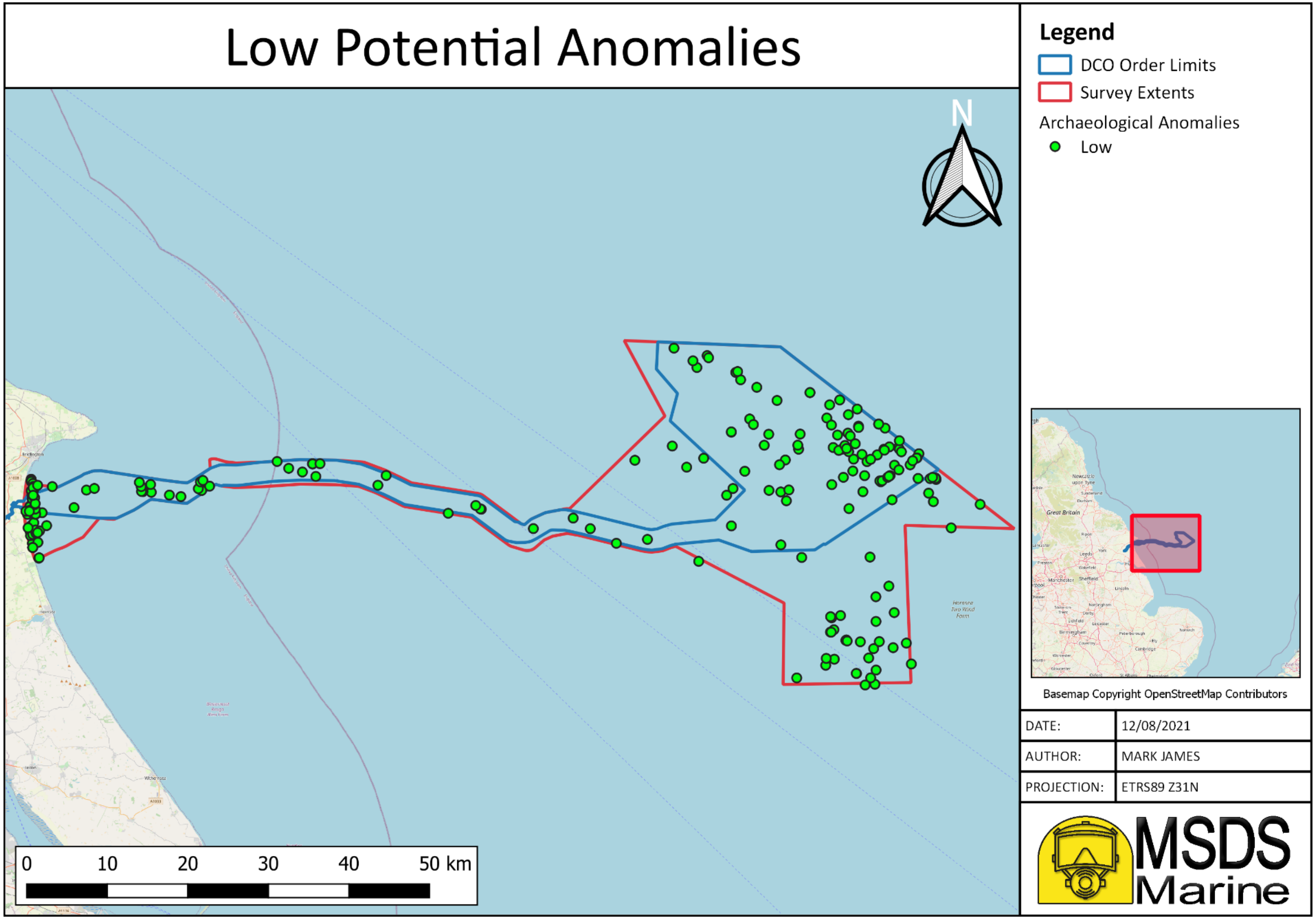

Figure 6. Low Potential Archaeological Anomalies

7.2 Medium Potential Anomalies

7.2.1 Seven anomalies were identified as of medium archaeological potential within the Hornsea Four data, five of which fall within the Order Limits, the anomalies can be broken down into broad categories as follows in Table 11 and the distribution is shown in Figure 7.

Type of Anomaly	Order Limits	Data Extents	Total
Potential wreck	0	1	1
Potential anthropogenic debris	2	0	2
Mound	0	1	1
Potential anthropogenic debris with large magnetic anomaly	2	0	2
Potential ballast mound	1	0	1
Total	5	2	7

Table 11. Medium Potential Anomaly Types

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

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

7.2.4 All medium potential anomalies identified during the assessment are discussed within Section 7.2 of this report and presented in Figure 8 to Figure 14. Further information can be found in Appendix C1 – *Gazetteer of Potential Archaeological Anomalies*.

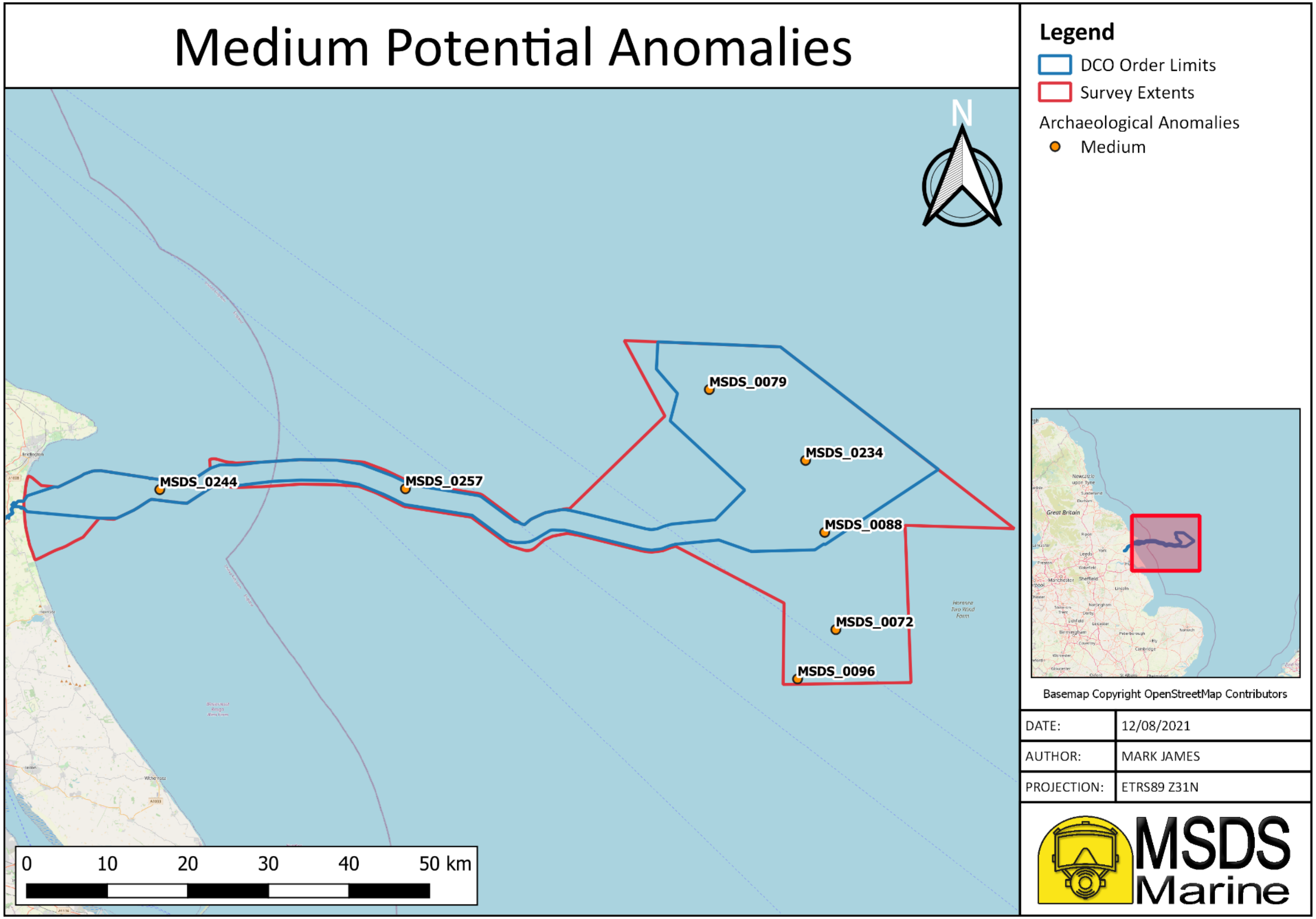

Figure 7. Medium Potential Archaeological Anomalies

Anomaly MSDS_HOW04_2019_ARCH_0072

7.2.5 Anomaly MSDS_HOW04_2019_ARCH_0072 (MSDS_0072 in Figure 8) lies within the data extents but outside the Order Limits and is a prominent mound, bisecting a sand wave and unusual in the surrounding area. The anomaly 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.

7.2.6 The anomaly 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.

Anomaly MSDS_HOW04_2019_ARCH_0079

7.2.7 Anomaly MSDS_HOW04_2019_ARCH_0079 (MSDS_0079 in Figure 9) lies to the north-east of the array area within the Order Limits and is an approximately square feature 4.1m x 4.7m and with a measurable height of 0.3m. The anomaly 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.

7.2.8 The anomaly 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.

Anomaly MSDS_HOW04_2019_ARCH_0088

7.2.9 Anomaly MSDS_HOW04_2019_ARCH_0088 (MSDS_0088 in Figure 10) lies to the south of the array area within the Order Limits 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 anomaly is associated with a magnetic anomaly of 135.9nT indicating the presence of ferrous material.

7.2.10 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.

Anomaly MSDS_HOW04_2019_ARCH_0096

7.2.11 Anomaly MSDS_HOW04_2019_ARCH_0096 (MSDS_0096 in Figure 11) lies at the southern edge of the data extents but outside the Order Limits 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 is noted.

7.2.12 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 anomaly is associated with a magnetic anomaly of 7nT, which given the size of the potential debris field seems low. The form of the anomaly could indicate a wrecked vessel, albeit largely broken up, this would have been accentuated by the wire sweep in 1985.

7.2.13 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.

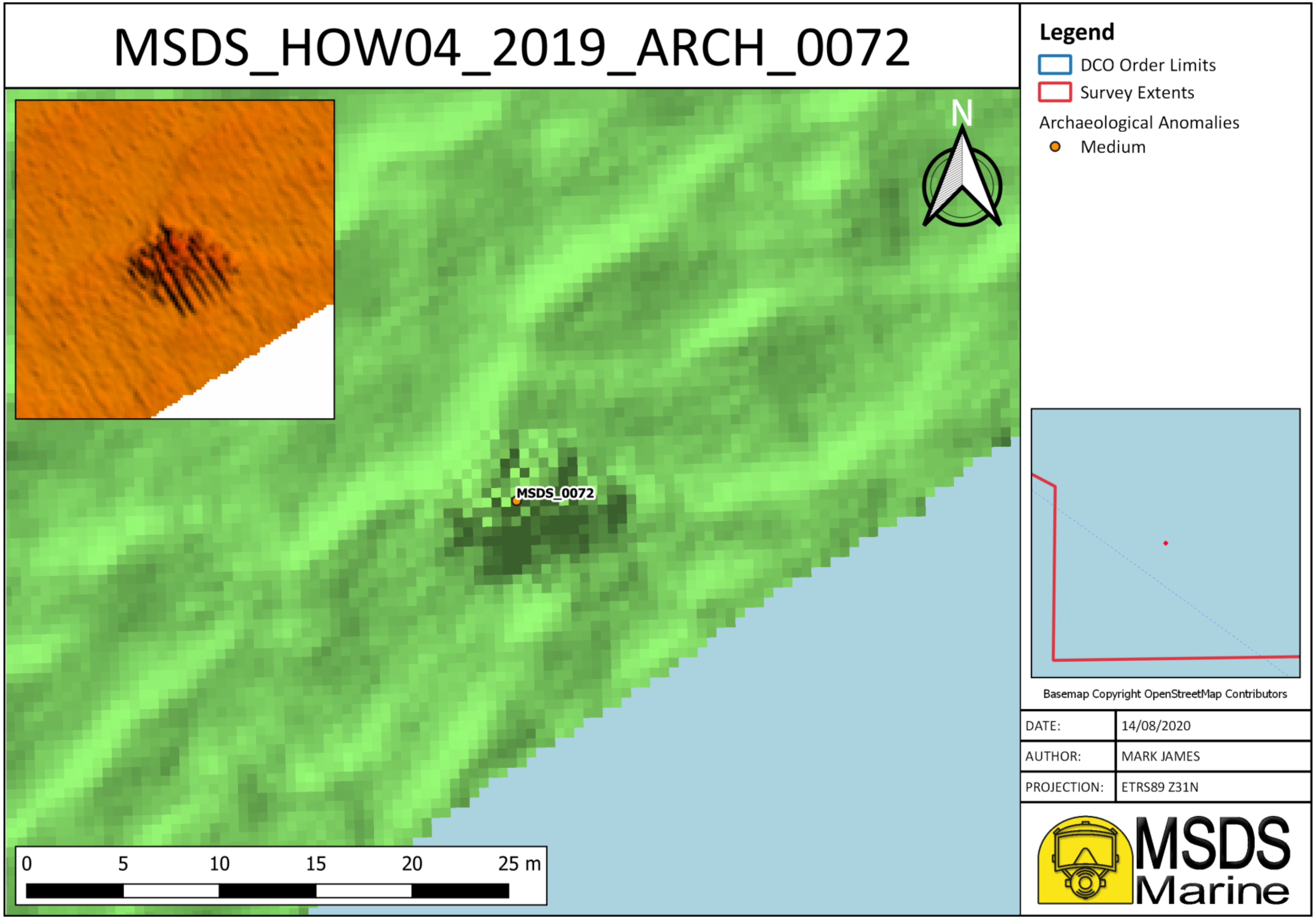

Figure 8. Anomaly MSDS_HOW04_2019_ARCH_0072

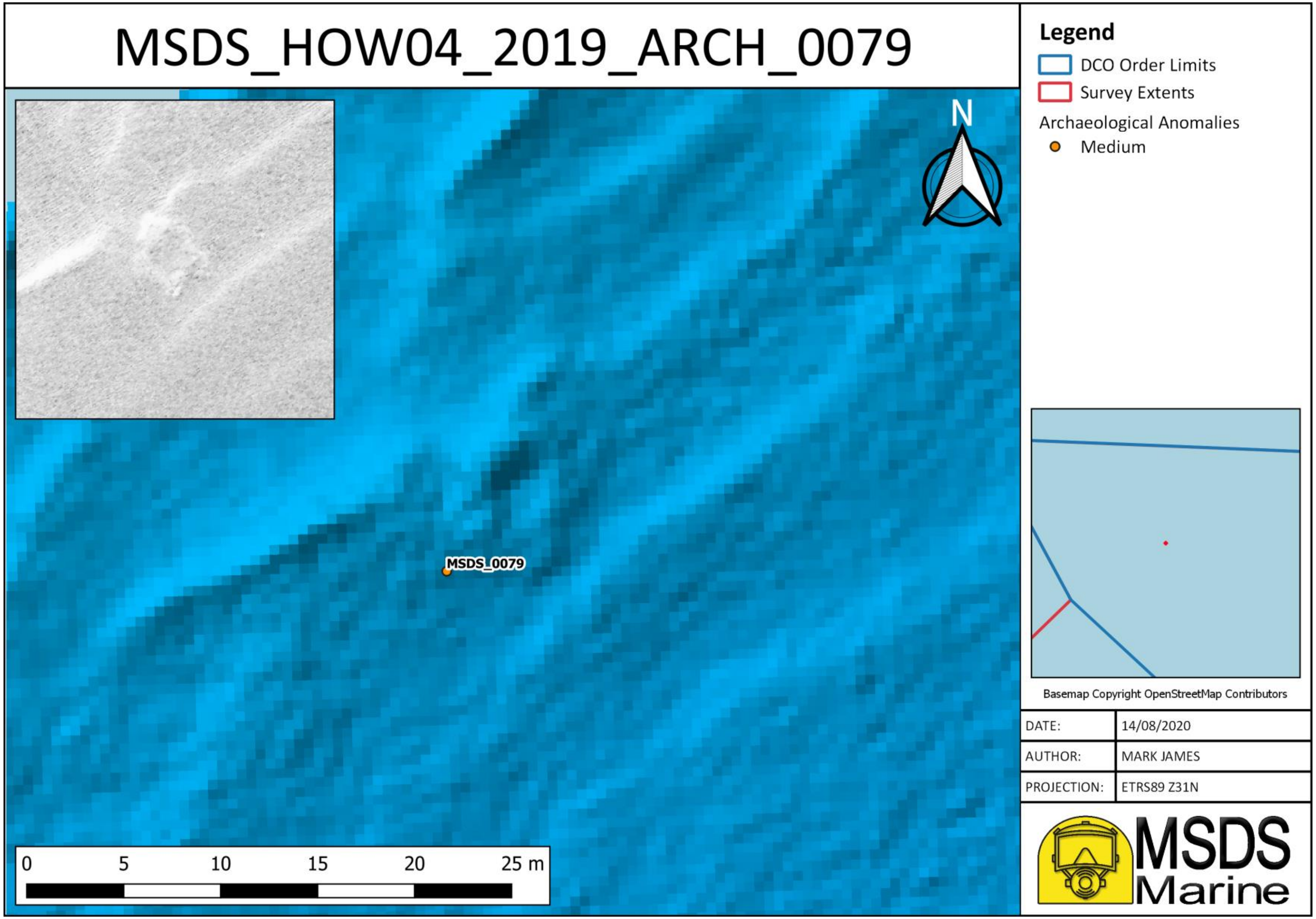

Figure 9. Anomaly MSDS_HOW04_2019_ARCH_0079

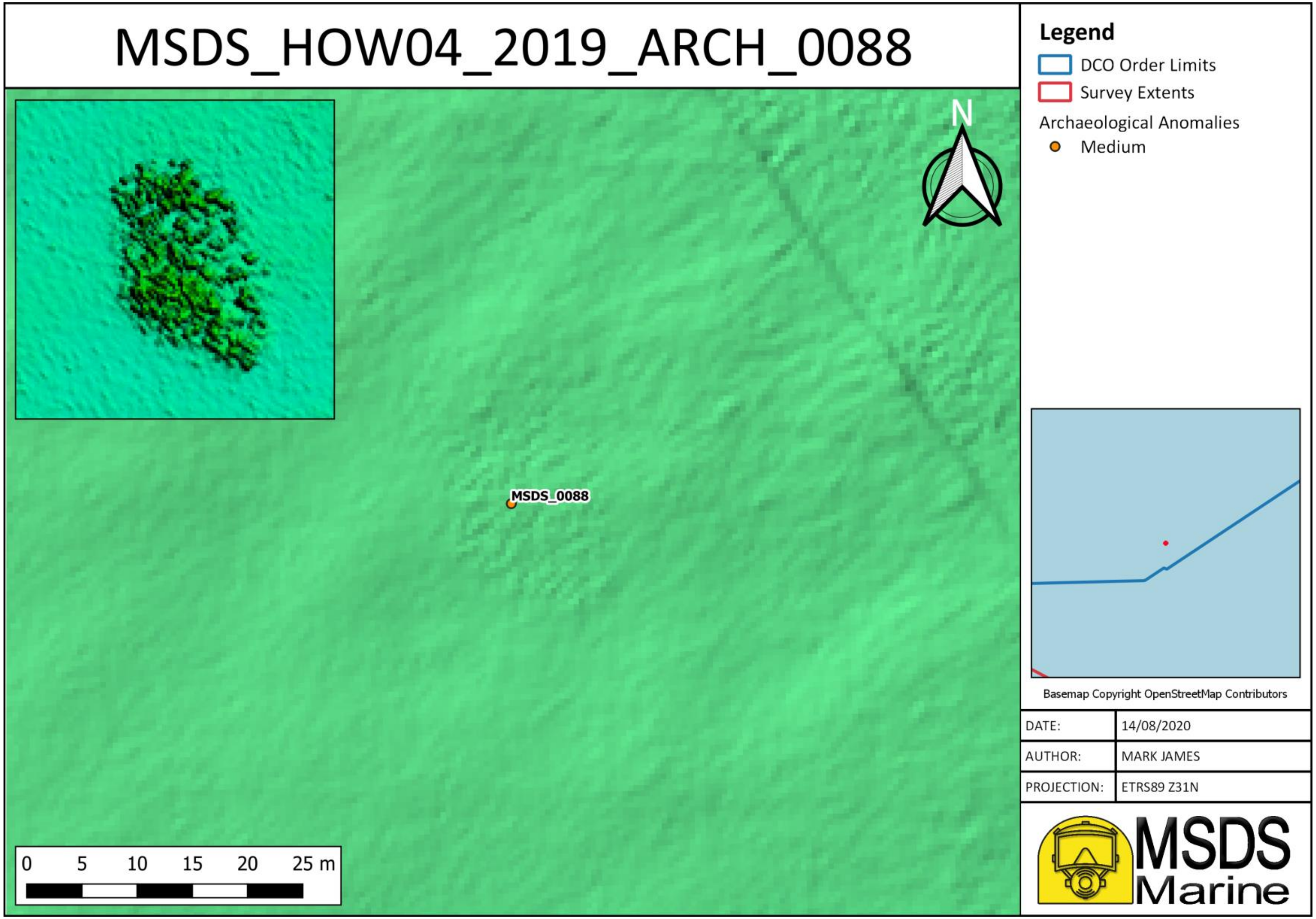

Figure 10. Anomaly MSDS_HOW04_2019_ARCH_0088

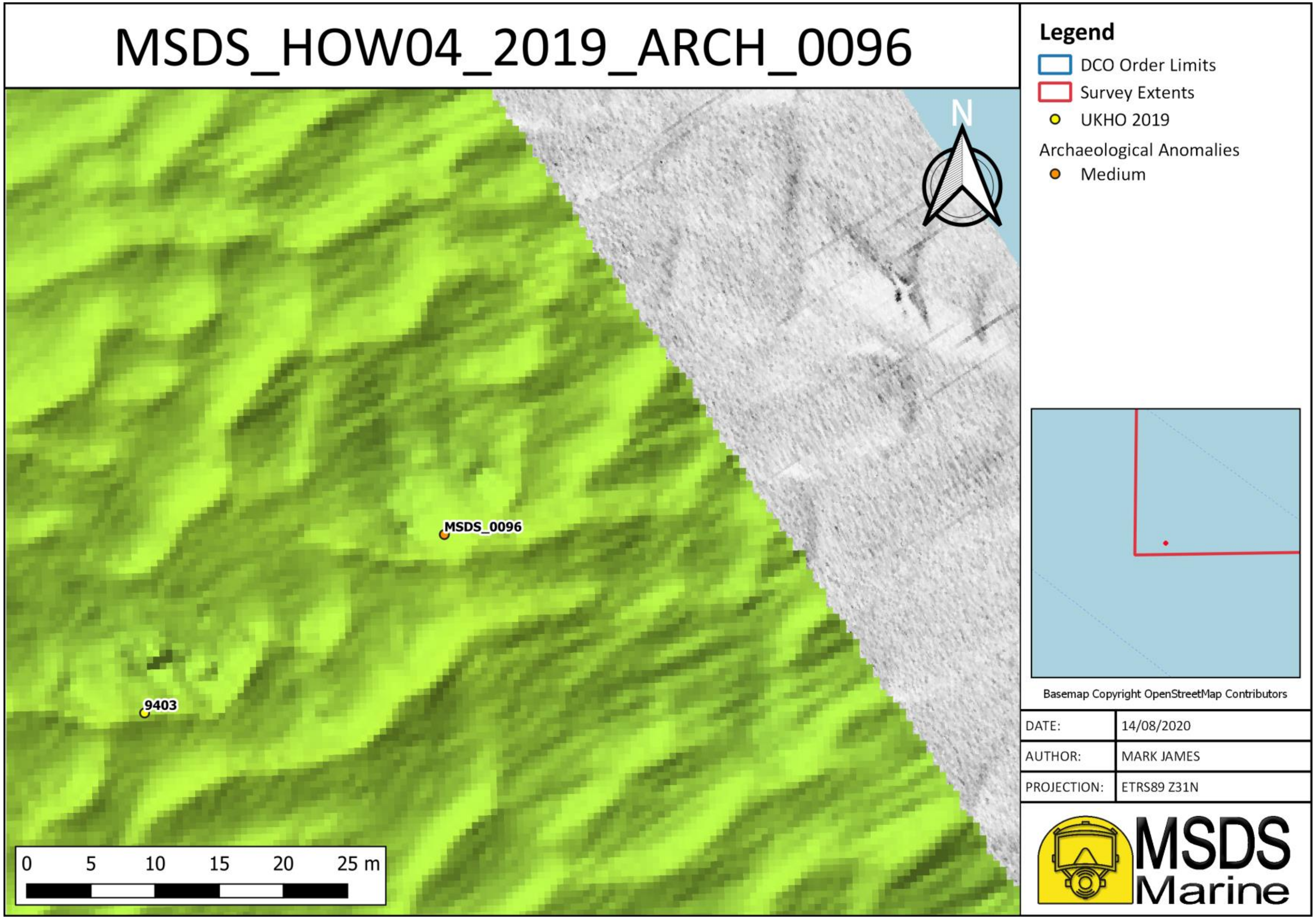

Figure 11. Anomaly MSDS_HOW04_2019_ARCH_0096

Anomaly MSDS_HOW04_2019_ARCH_0234

7.2.14 Anomaly MSDS_HOW04_2019_ARCH_0234 (MSDS_0234 in Figure 12) lies towards the centre of the array area and within the Order Limits 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.

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

Anomaly MSDS_HOW04_2019IF_ARCH_0244

7.2.16 Anomaly MSDS_HOW04_2019IF_ARCH_0244 (MSDS_0244 in Figure 13) lies towards the centre of the ECC approximately 1.7km from the shore and within the Order Limits. The anomaly is a prominent 'L' shaped feature with prominent shadow, a further feature extends toward the further extent of the shadow, potentially indicating further obscured features. The anomaly is associated with a large magnetic anomaly of 291.4nT which indicates anthropogenic origin. The form and the size of the magnetic anomaly may indicate maritime debris such as a lost anchor.

7.2.17 The anomaly is highly likely to be anthropogenic in origin, although not identifiable the strength of the magnetic anomaly means a medium potential rating is appropriate.

Anomaly MSDS_HOW04_2019IF_ARCH_0257

7.2.18 Anomaly MSDS_HOW04_2019IF_ARCH_0257 (MSDS_0257 in Figure 14) lies towards the centre of the ECC approximately 47km from the shore and within the Order Limits. The anomaly is incoherent in form and is largely buried by converging sand waves, the visible element measures 6.7m x 3.7m and is largely rectangular although the shorter edges are not defined. The longer edges are more defined with further material evident between them towards the south-east of the anomaly.

7.2.19 The form of the anomaly likely represents partially buried anthropogenic material and potentially a structure of some sort. The anomaly is not associated with a magnetic anomaly; however, the anomaly lies c.50m from the magnetometer track. The size, the potential anthropogenic origin, and the unknown identity if the anomaly means a medium potential rating is appropriate.

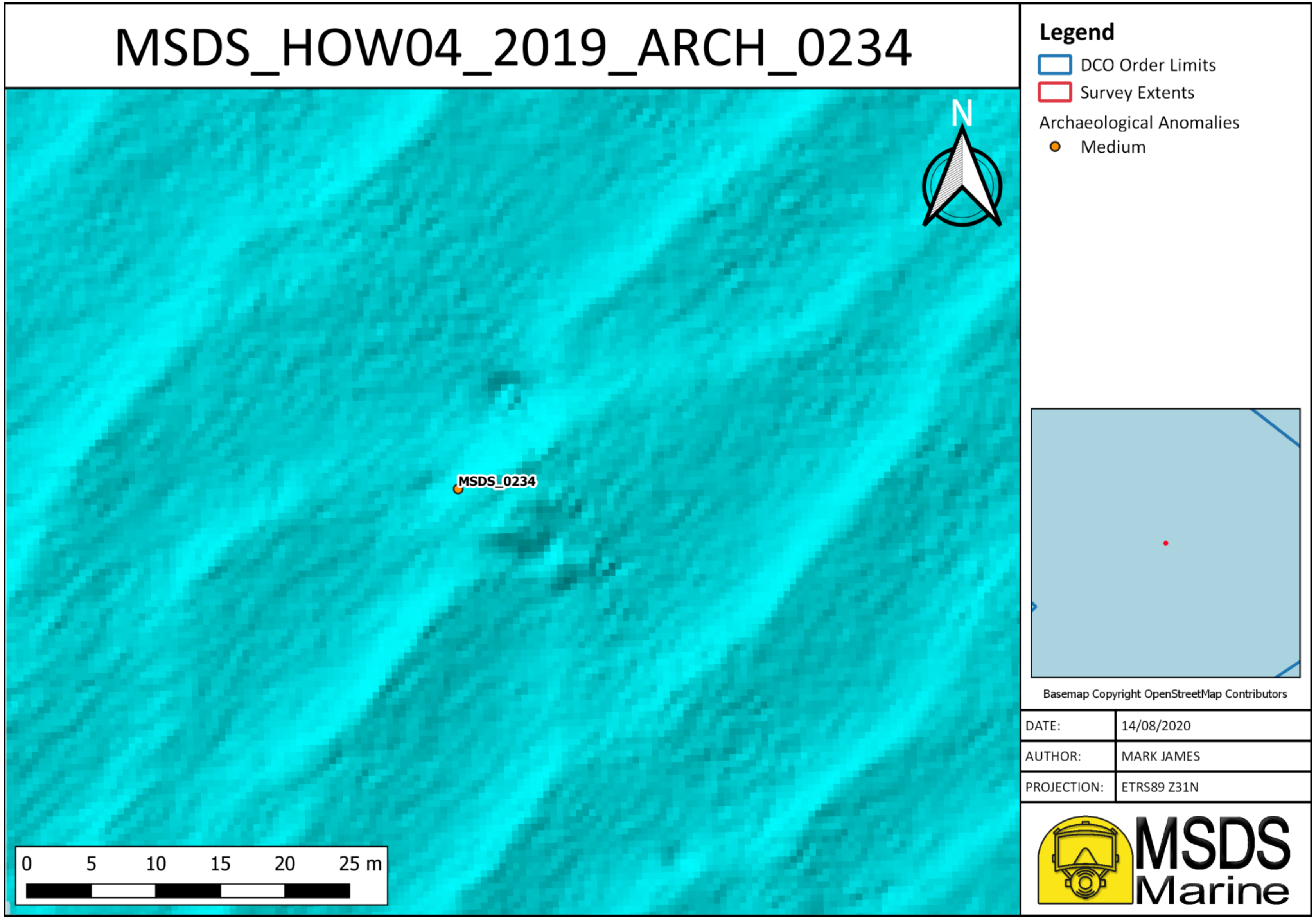

Figure 12. Anomaly MSDS_HOW04_2019_ARCH_0234

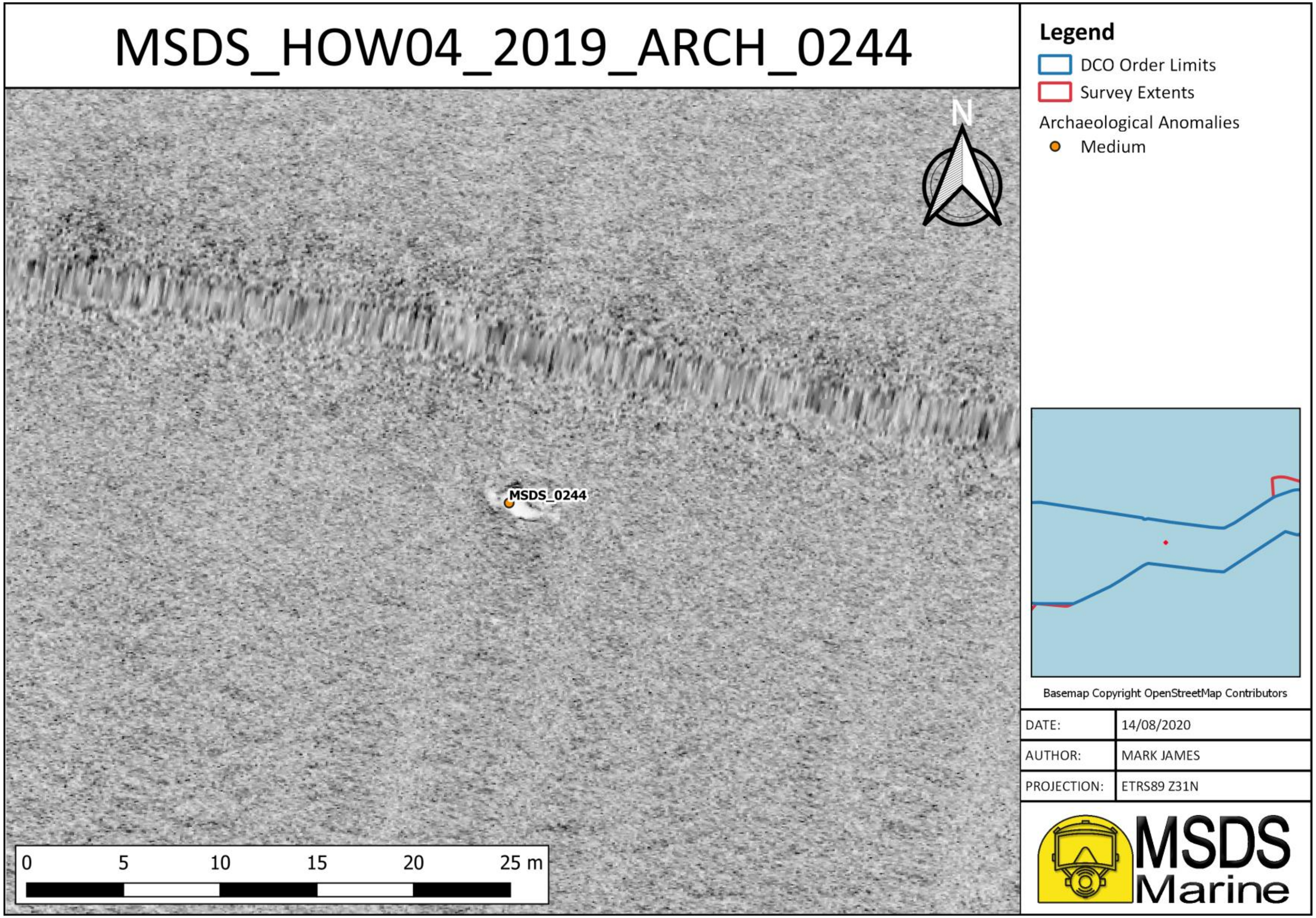

Figure 13. Anomaly MSDS_HOW04_2019IF_ARCH_0244

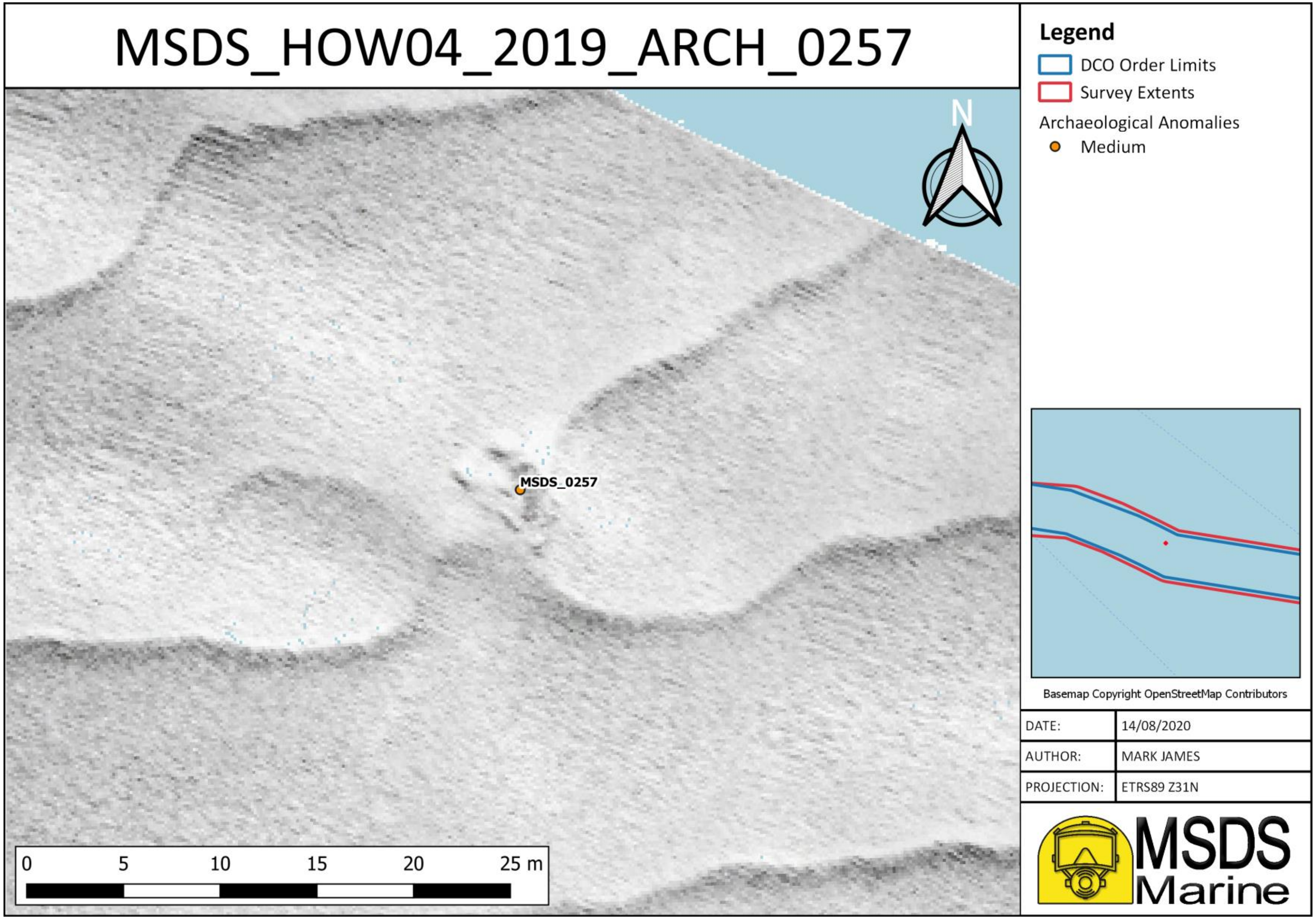

Figure 14. Anomaly MSDS_HOW04_2019IF_ARCH_0257

7.3 High Potential Anomalies

7.3.1 Nine anomalies were identified as of high archaeological potential within the Hornsea Four data, of which two fall within the Order Limits. The anomalies can be broken down as follows in Table 12 and the distribution is shown in Figure 15.

Type of Anomaly	Order Limits	Data Extents	Total
Wreck	1	6	7
Potential wreck	1	1	2
Total	2	7	9

Table 12. High Potential Anomaly Types

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

7.3.3 All high potential anomalies identified during the assessment are discussed within Section 7.3 of this report and presented in Figure 16 to Figure 24. Further information can be found in Appendix C1 – *Gazetteer of Potential Archaeological Anomalies*.

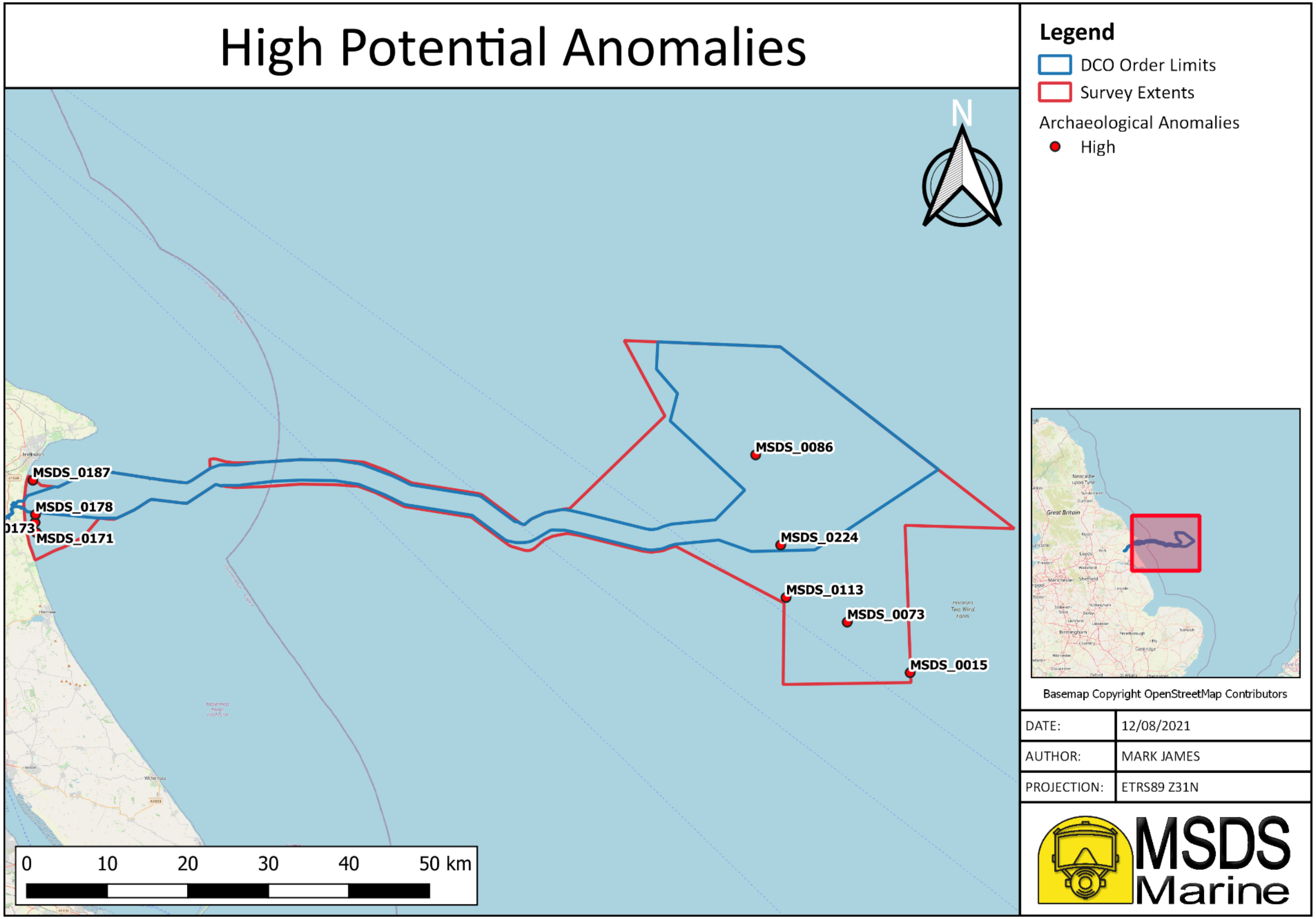

Figure 15. High Potential Archaeological Anomalies

Anomaly MSDS_HOW04_2019_ARCH_0015

7.3.4 Anomaly MSDS_HOW04_2019_ARCH_0015 (MSDS_0015 in Figure 16) lies to the south-east of the data extents outside the Order Limits 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.

7.3.5 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.

7.3.6 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.

Anomaly MSDS_HOW04_2019_ARCH_0073

7.3.7 Anomaly MSDS_HOW04_2019_ARCH_0073 (MSDS_0073 in Figure 17) lies to the south of the data coverage outside the Order Limits 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.

7.3.8 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.

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

Anomaly MSDS_HOW04_2019_ARCH_0086

7.3.10 Anomaly MSDS_HOW04_2019_ARCH_0086 (MSDS_0086 in Figure 18) lies to the east of the array area within the Order Limits and is an unusual anomaly 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.

7.3.11 The anomaly is not associated with a UKHO record.

7.3.12 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 appropriate.

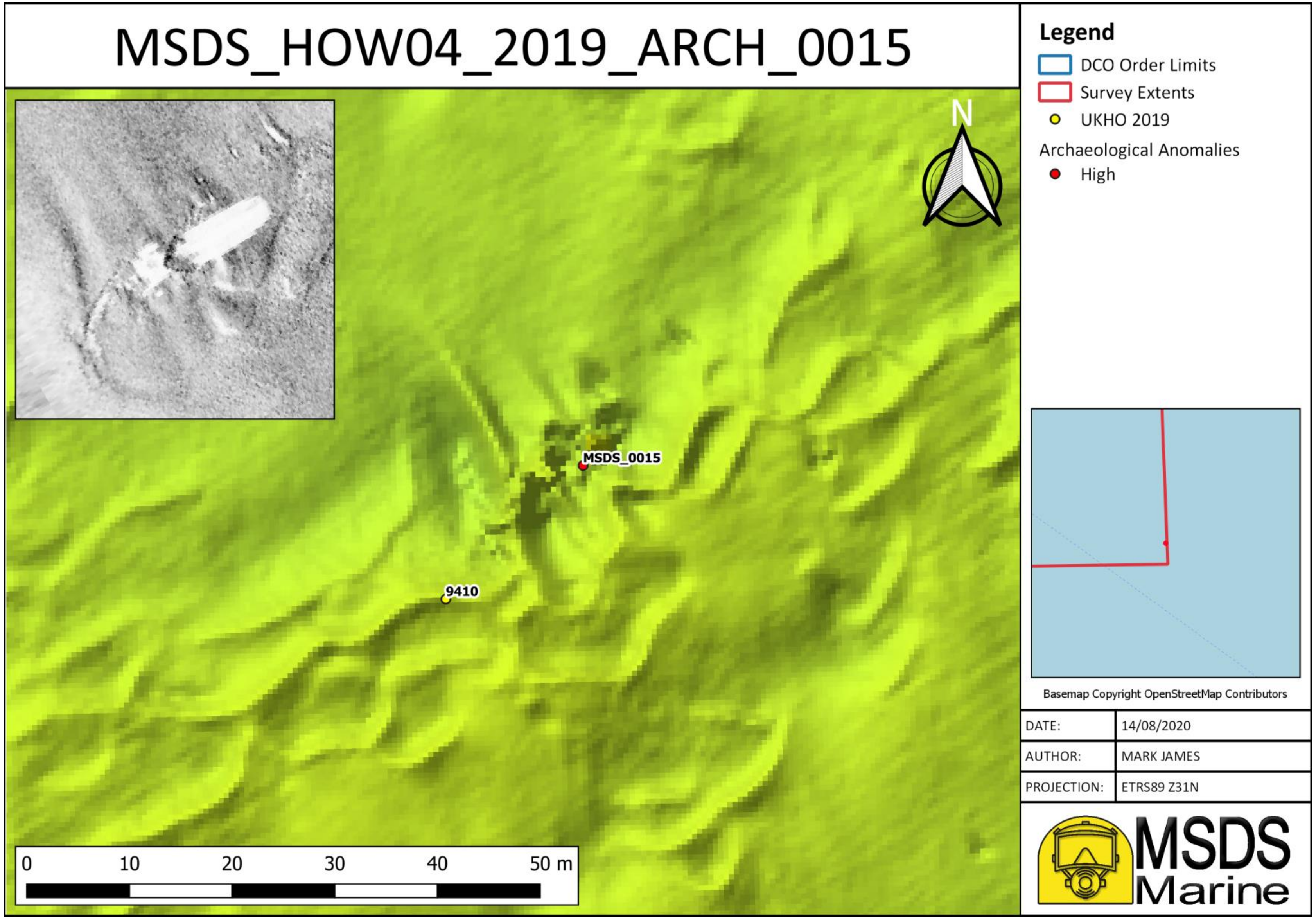

Figure 16. Anomaly MSDS_HOW04_2019_ARCH_0015

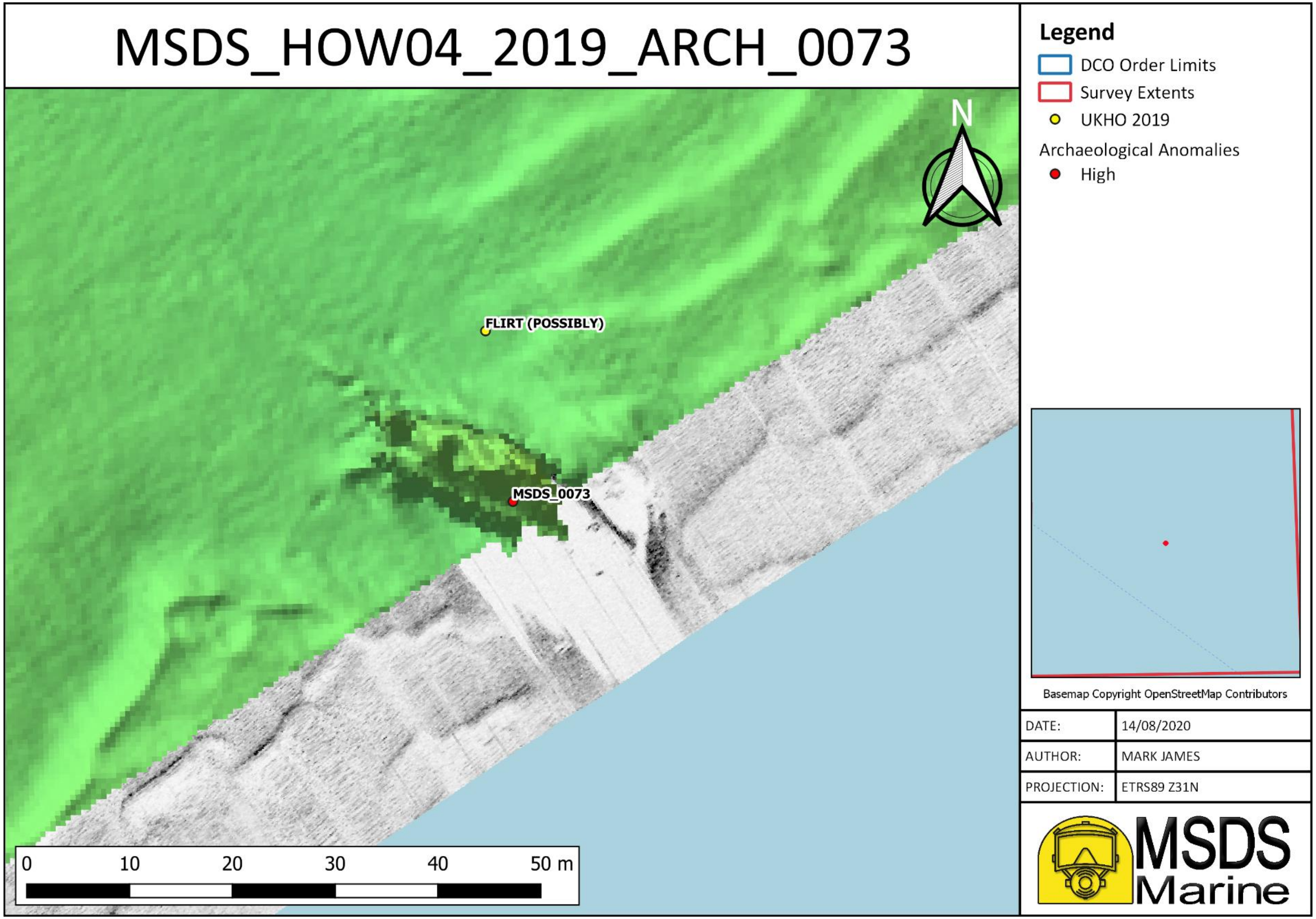

Figure 17. Anomaly MSDS_HOW04_2019_ARCH_0073

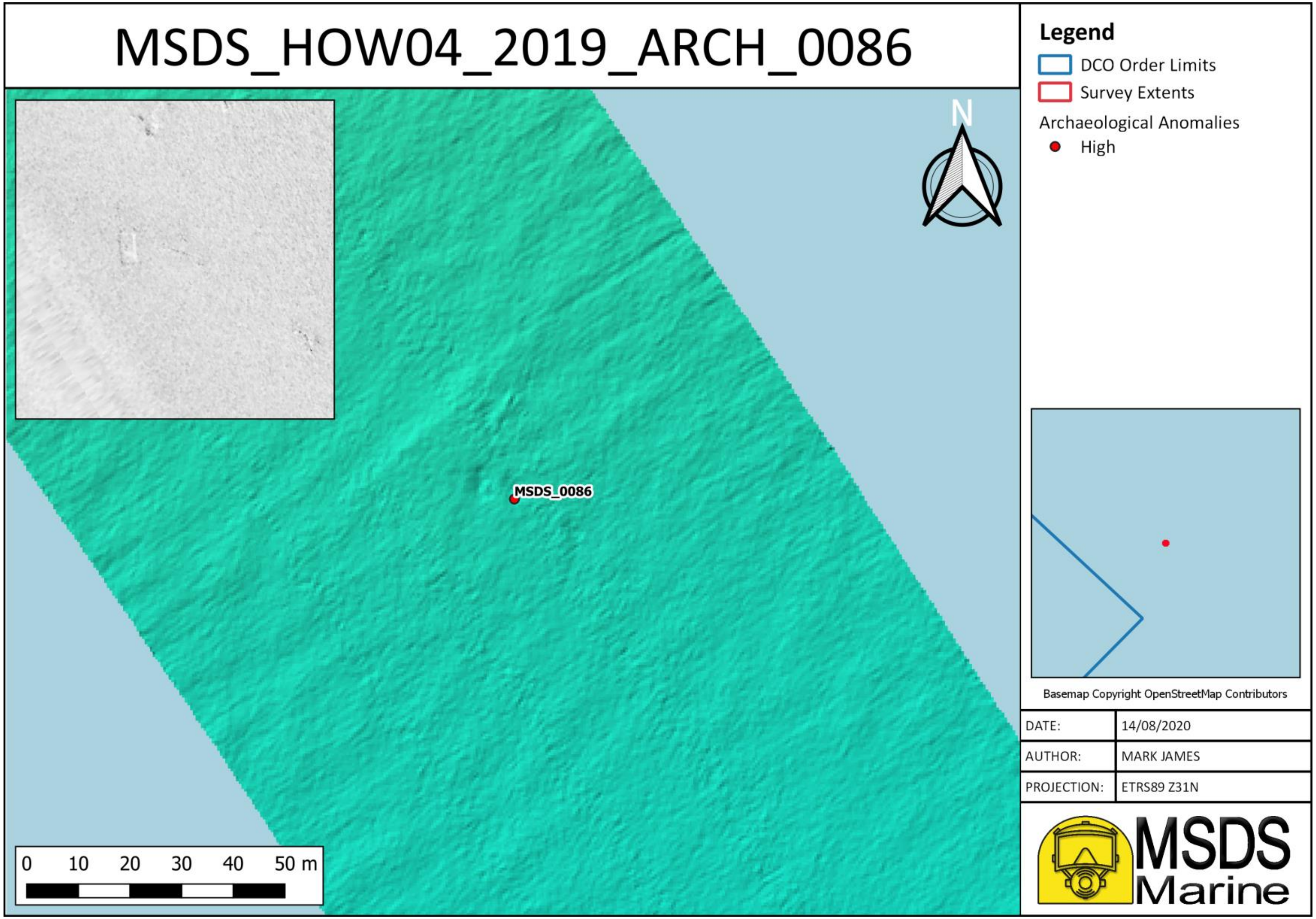

Figure 18. Anomaly MSDS_HOW04_2019_ARCH_0086

Anomaly MSDS_HOW04_2019_ARCH_0113

7.3.13 Anomaly MSDS_HOW04_2019_ARCH_0113 (MSDS_0113 in Figure 19) lies within the data extents but outside the Order Limits 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 anomalies extend to the north-west up to c.113m, whilst likely geological in origin, given the size of the wreck, the form of the anomalies 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

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

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

Anomaly MSDS_HOW04_2019_ARCH_0171

7.3.16 Anomaly MSDS_HOW04_2019_ARCH_0171 (MSDS_0171 in Figure 20) lies to the western extents of the data close to shore but outside the Order Limits 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.

7.3.17 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.

7.3.18 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.

Anomaly MSDS_HOW04_2019_ARCH_0173

7.3.19 Anomaly MSDS_HOW04_2019_ARCH_0173 (MSDS_0173 in Figure 21) lies to the western extents of the data close to shore but outside the Order Limits 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.

7.3.20 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.

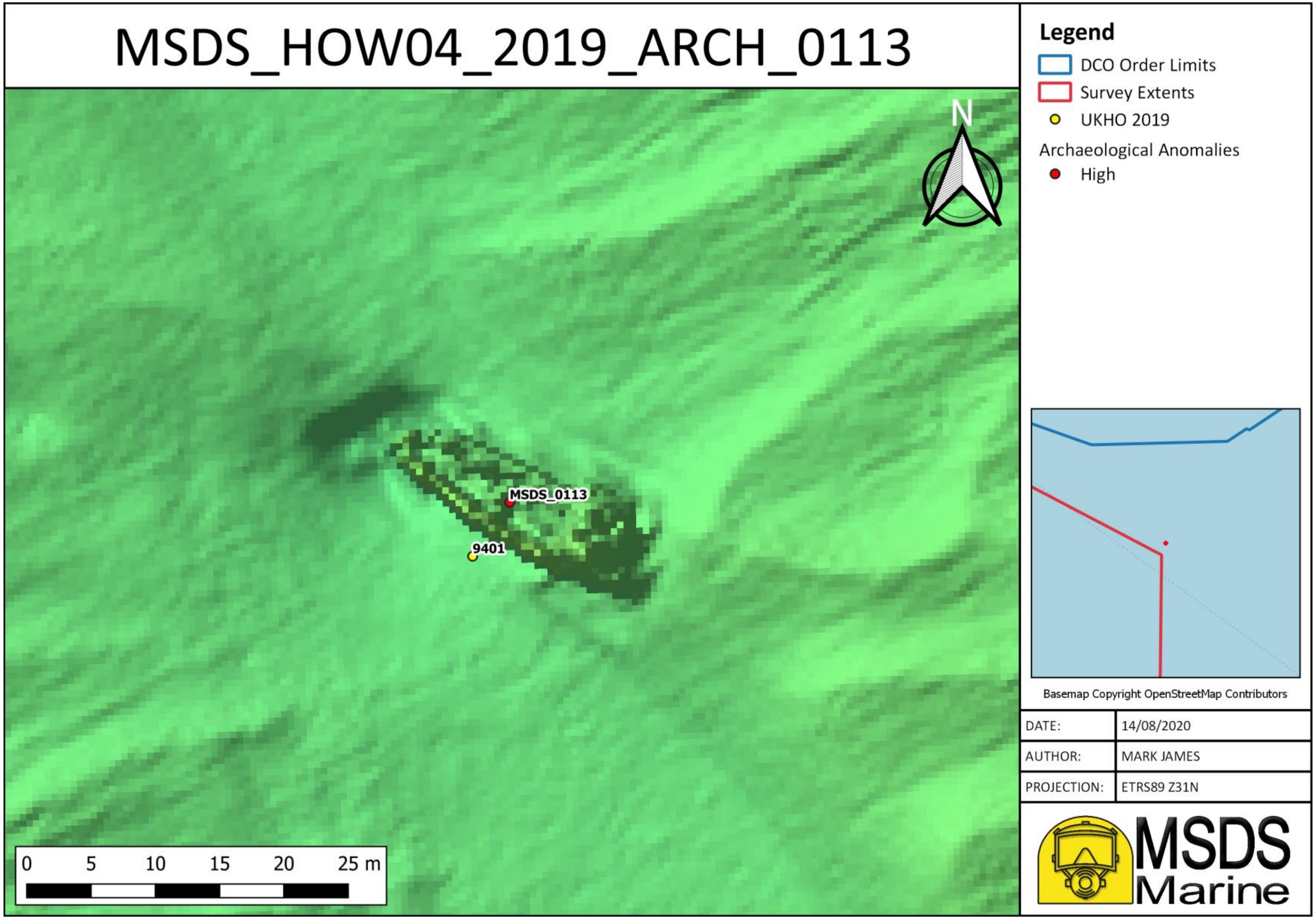

Figure 19. Anomaly MSDS_HOW04_2019_ARCH_0113

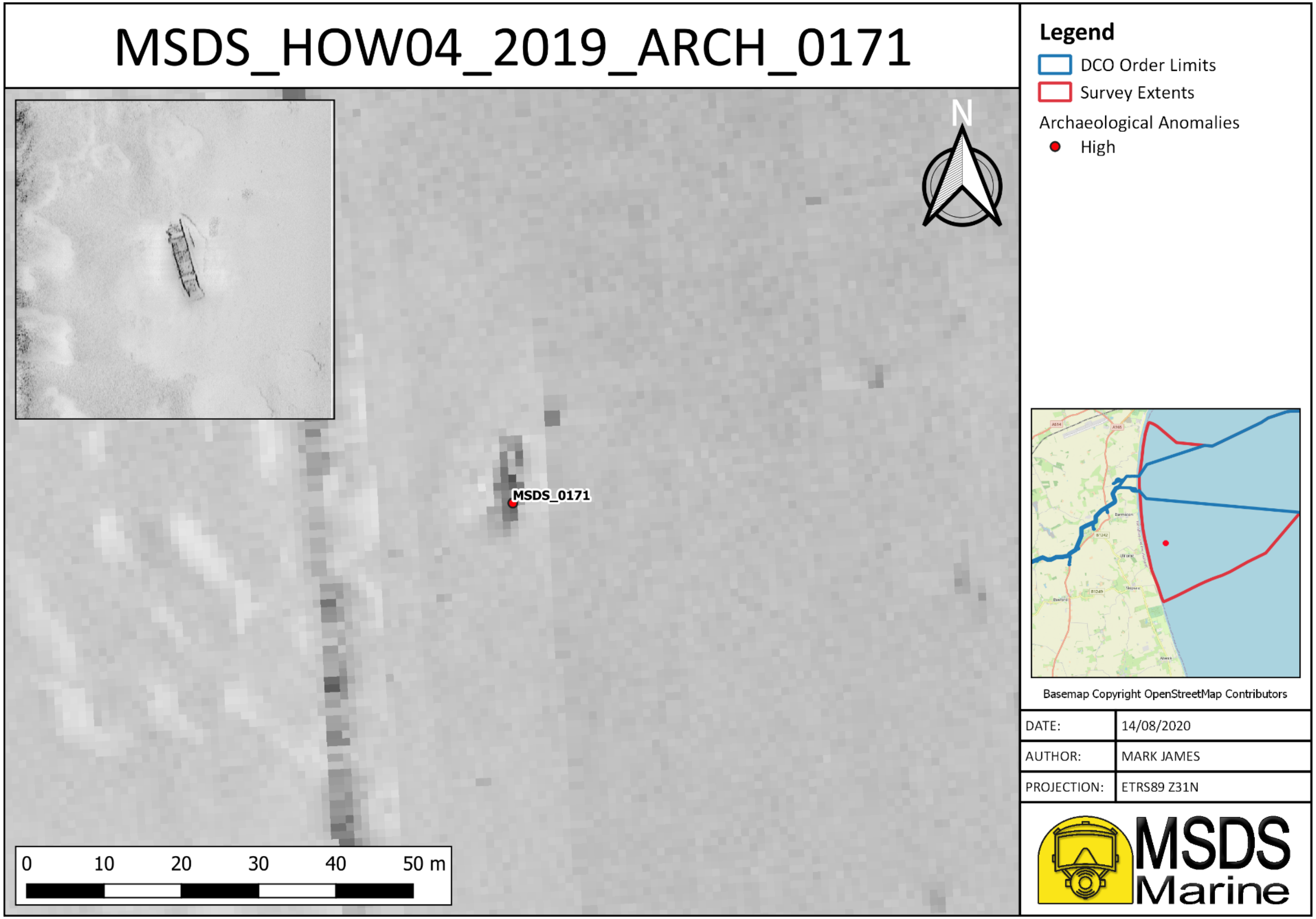

Figure 20. Anomaly MSDS_HOW04_2019_ARCH_0171

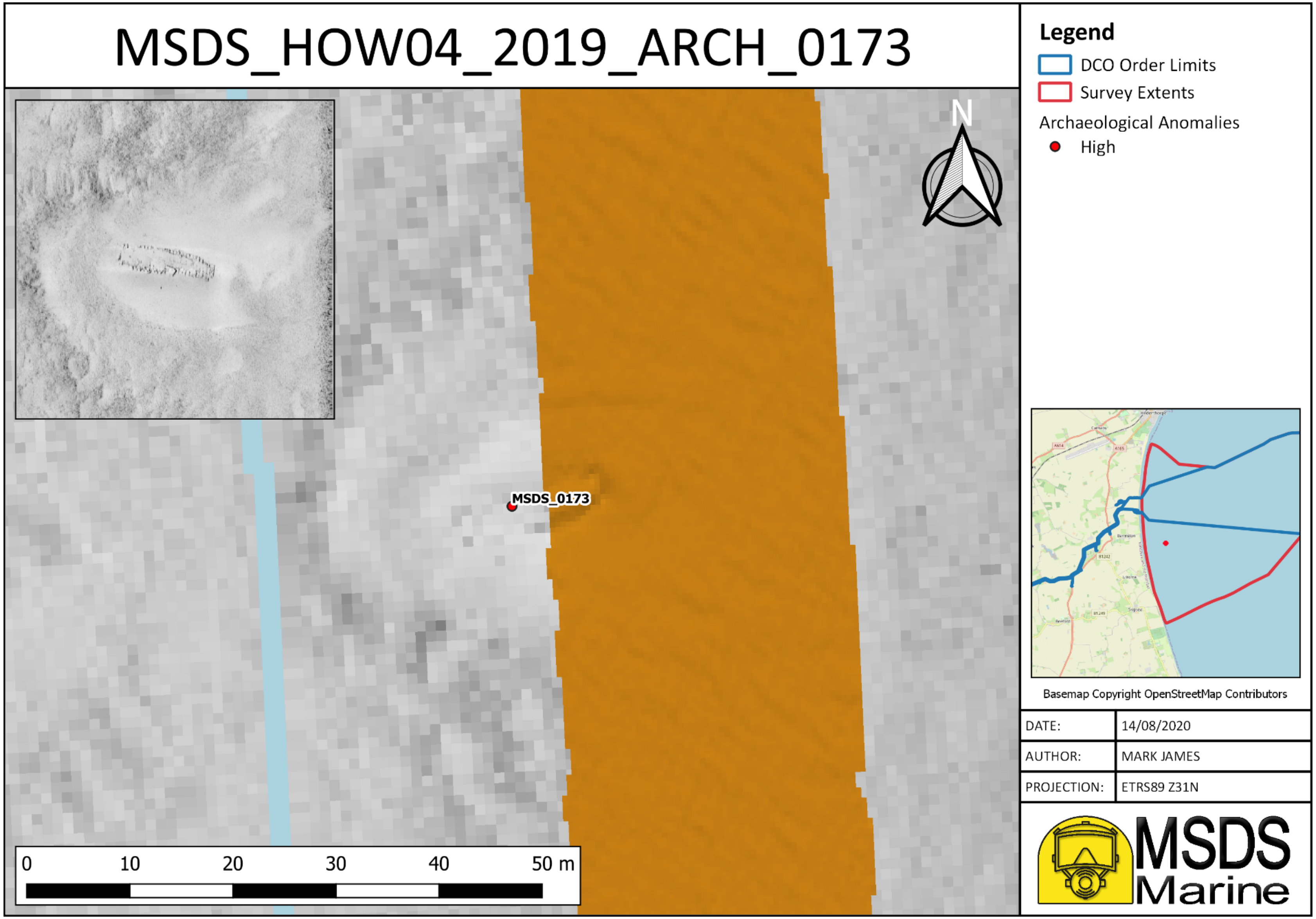

Figure 21. Anomaly MSDS_HOW04_2019_ARCH_0173

Anomaly MSDS_HOW04_2019_ARCH_0178

7.3.21 Anomaly MSDS_HOW04_2019_ARCH_0178 (MSDS_0178 in Figure 22) lies to the western extents of the data close to shore but outside the Order Limits 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.

7.3.22 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 under two when the aft section broke off and was dispersed by explosives.

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

Anomaly MSDS_HOW04_2019_ARCH_0187

7.3.24 Anomaly MSDS_HOW04_2019_ARCH_0187 (MSDS_0187 in Figure 23) lies to the western extents of the data close to shore but outside the Order Limits 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.

7.3.25 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.

Anomaly MSDS_HOW04_2019_ARCH_0224

7.3.26 Anomaly MSDS_HOW04_2019_ARCH_0224 (MSDS_0224 in Figure 24) lies towards the southern edge of the array area inside the Order Limits 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.

7.3.27 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 and each time returned to the owners. The vessel was in the possession of its owners at the time of sinking.

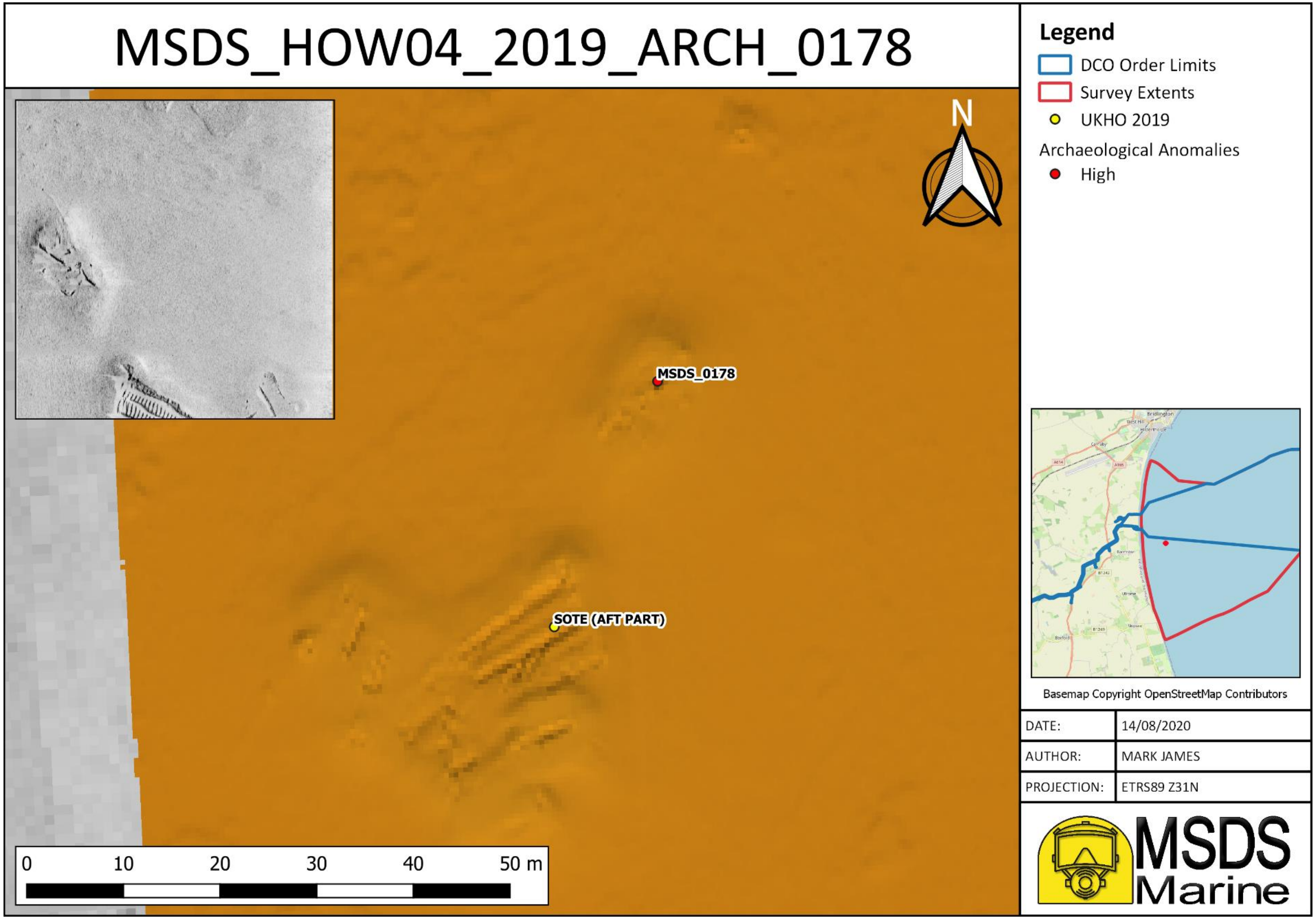

Figure 22. Anomaly MSDS_HOW04_2019_ARCH_0178

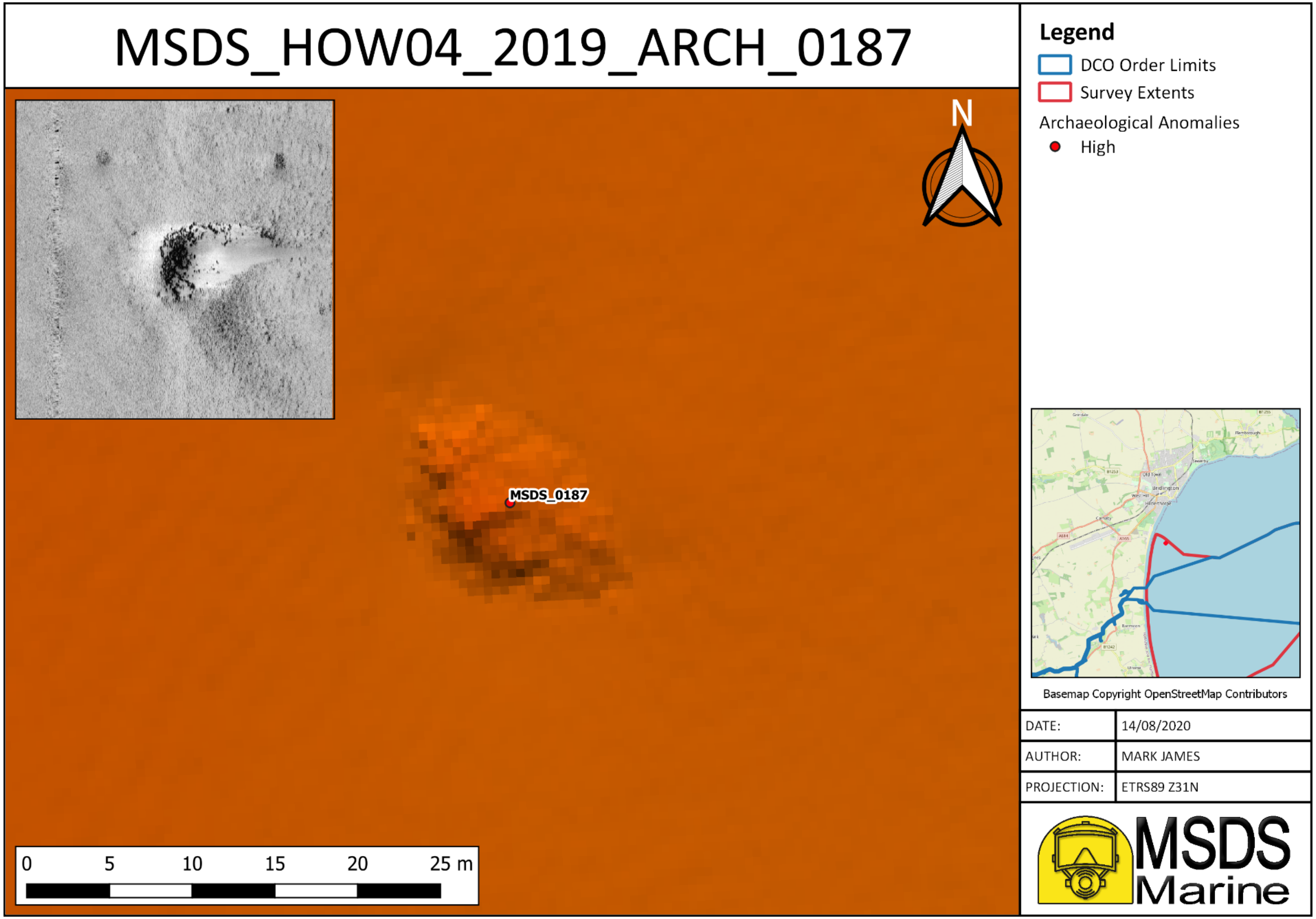

Figure 23. Anomaly MSDS_HOW04_2019_ARCH_0187

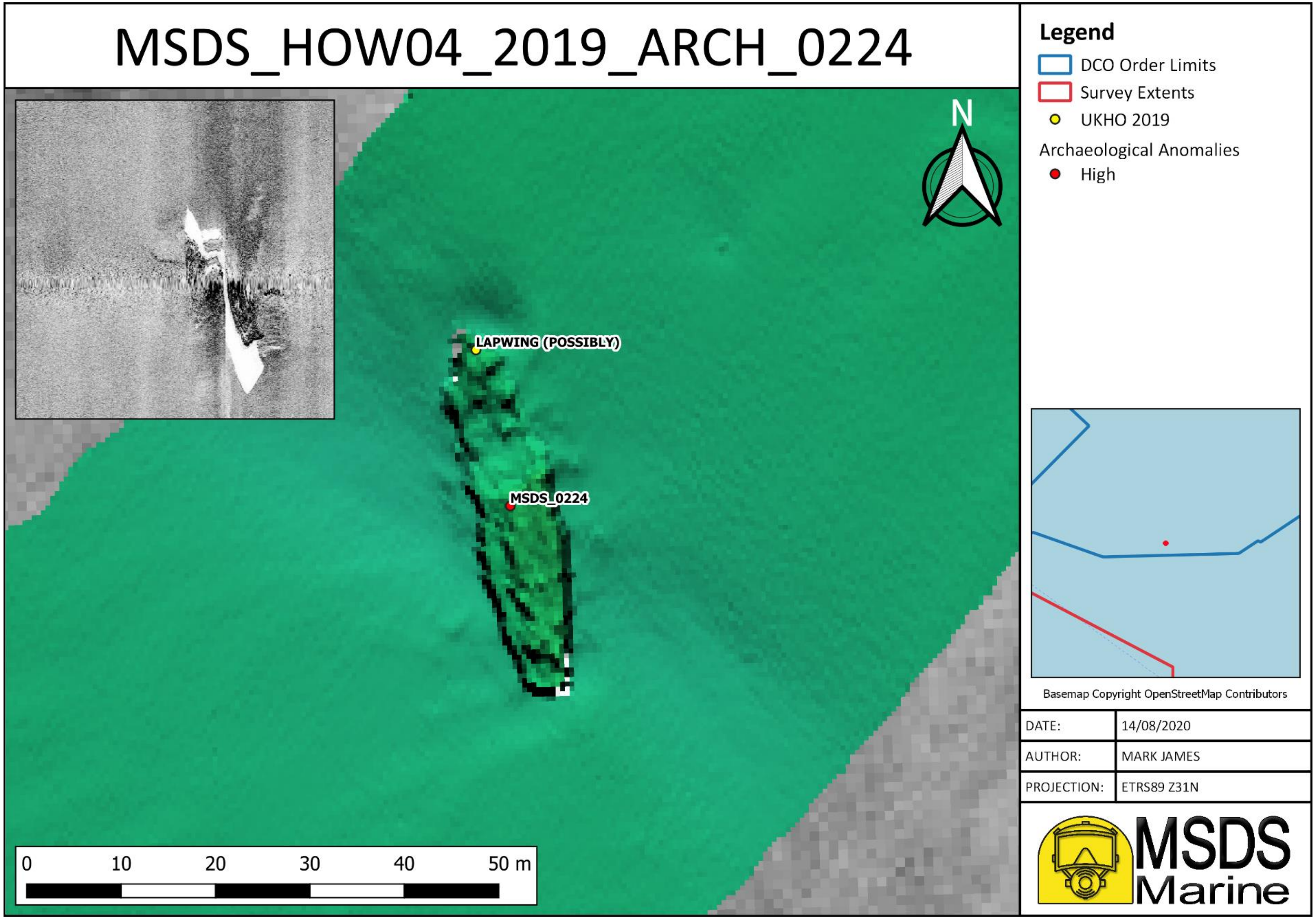

Figure 24. Anomaly MSDS_HOW04_2019_ARCH_0224

8.0 Magnetic Anomalies

8.0.1 2363 magnetic anomalies, not correlating with known features or associated with anomalies of archaeological potential, were identified within the survey extents, 1582 of which lie within the Order Limits, the distribution of intensities is shown below in Table 13 and the distribution presented in Figure 25.

Intensity (nT)	Order Limits	Data Extents	Total
5 - 50	1477	682	2159
50 - 100	64	54	118
100 - 200	29	31	60
200+	12	14	26
Total	**1582**	**781**	**2363**

Table 13. Magnetic Anomalies

8.0.2 Anomalies 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.

8.0.3 The data collection methodology across the Hornsea 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.

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

8.1 Large Magnetic Anomalies

8.1.1 Eighty-six magnetic anomalies considered large (>100nT) have been identified within the data extents, of which 41 lie within the Order Limits, 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 14 and presented in Figure 26.

8.1.2 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 anomalies.

MSDS ID	Easting (m)	Northing (m)	Intensity (nT)	Order Limits
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_2019IF_MAG_2433	300470.7	5992501.9	102.9	Yes
MSDS_HOW04_2019IF_MAG_3089	335807.5	5992732.7	107.0	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_2019IF_MAG_2333	298913.6	5992789.3	117.7	Yes
MSDS_HOW04_2019IF_MAG_2868	326378.4	5995255.9	120.7	Yes
MSDS_HOW04_2019_MAG_1479	387631.0	6000164.0	121.5	Yes
MSDS_HOW04_2019IF_MAG_2796	323498.5	5995444.9	123.2	Yes
MSDS_HOW04_2019IF_MAG_2386	299635	5992662.4	127.8	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_2019IF_MAG_2412	300195.1	5992554.5	132.4	Yes
MSDS_HOW04_2019IF_MAG_3262	379416.3	5984248.1	132.7	Yes
MSDS_HOW04_2019IF_MAG_2514	301937.4	5993243.1	132.8	Yes
MSDS_HOW04_2019_MAG_2294	290723.0	5991072.0	135.5	Yes
MSDS_HOW04_2019IF_MAG_2360	299333.5	5992719.3	135.7	Yes
MSDS_HOW04_2019IF_MAG_3258	377849.8	5988987.0	139.3	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_2019IF_MAG_2679	305755.3	5993549.8	160.9	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_2019IF_MAG_2577	302793.4	5992062.4	186.5	Yes
MSDS_HOW04_2019_MAG_1495	379489.0	5994783.0	189.1	Yes
MSDS_HOW04_2019_MAG_1496	380061.0	5993875.0	229.2	Yes
MSDS_HOW04_2019IF_MAG_3143	343055.9	5990408.6	233.1	Yes
MSDS_HOW04_2019_MAG_1499	378695.0	5989836.0	294.7	Yes
MSDS_HOW04_2019IF_MAG_3159	346561.5	5988984.5	542.8	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_2019IF_MAG_3186	350823.4	5985537.7	772.4	Yes
MSDS_HOW04_2019IF_MAG_2880	327118	5994713.6	880.7	Yes
MSDS_HOW04_2019IF_MAG_2882	327440.8	5994693.6	1212.2	Yes
MSDS_HOW04_2019IF_MAG_2505	301793.3	5992763.8	1403.9	Yes
MSDS_HOW04_2019IF_MAG_2413	300202.3	5992066	2689.2	Yes
MSDS_HOW04_2019IF_MAG_2503	301731.5	5992775.6	5469.1	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_1484	403109.0	5985587.0	131.0	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_2304	331606.8	5995242.2	192.7	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_1498	398466.0	5987861.0	255.5	No
MSDS_HOW04_2019_MAG_2306	290180.8	5993114.9	275.7	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

Table 14. Large Magnetic Anomalies

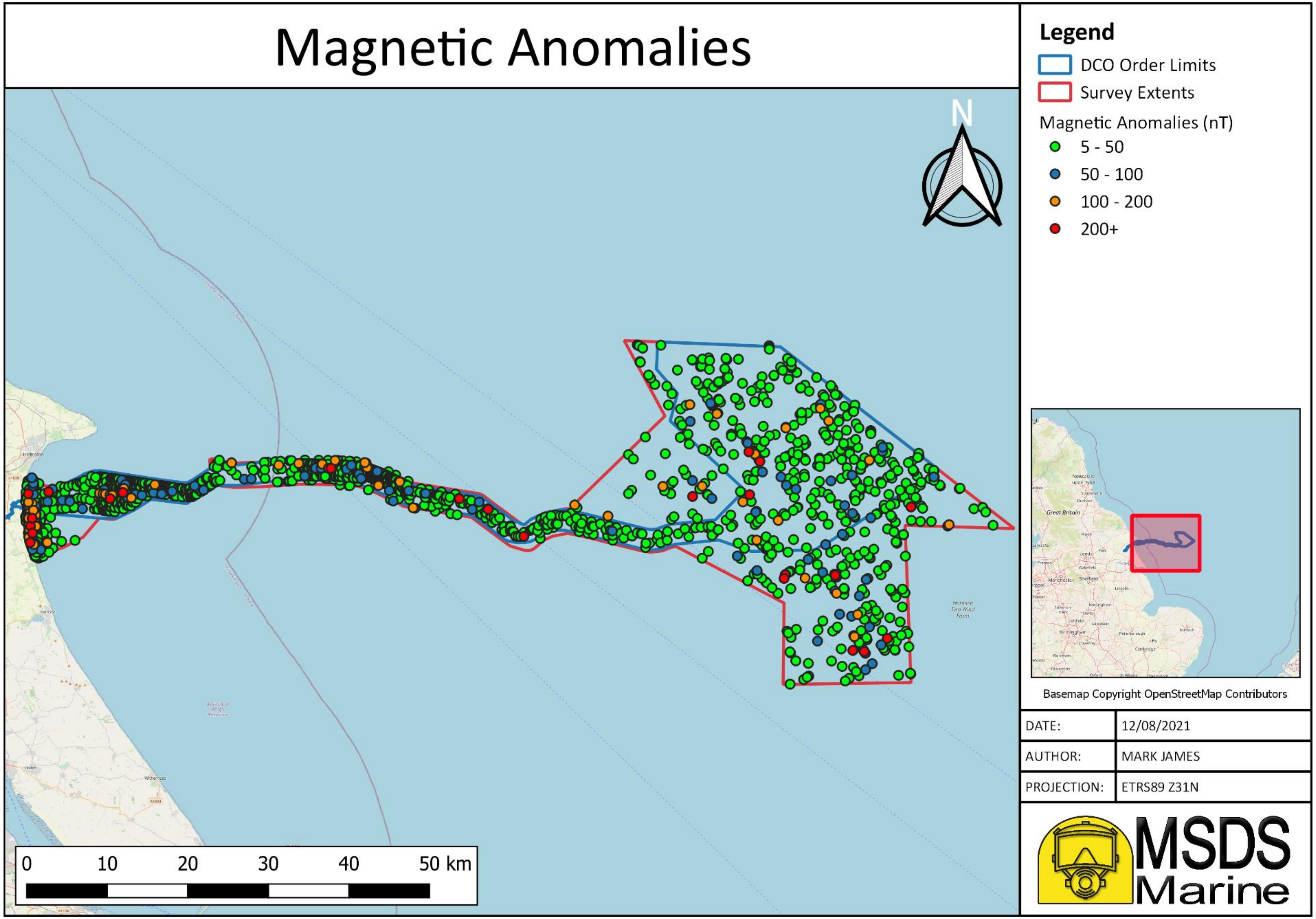

Figure 25. Magnetic Anomalies

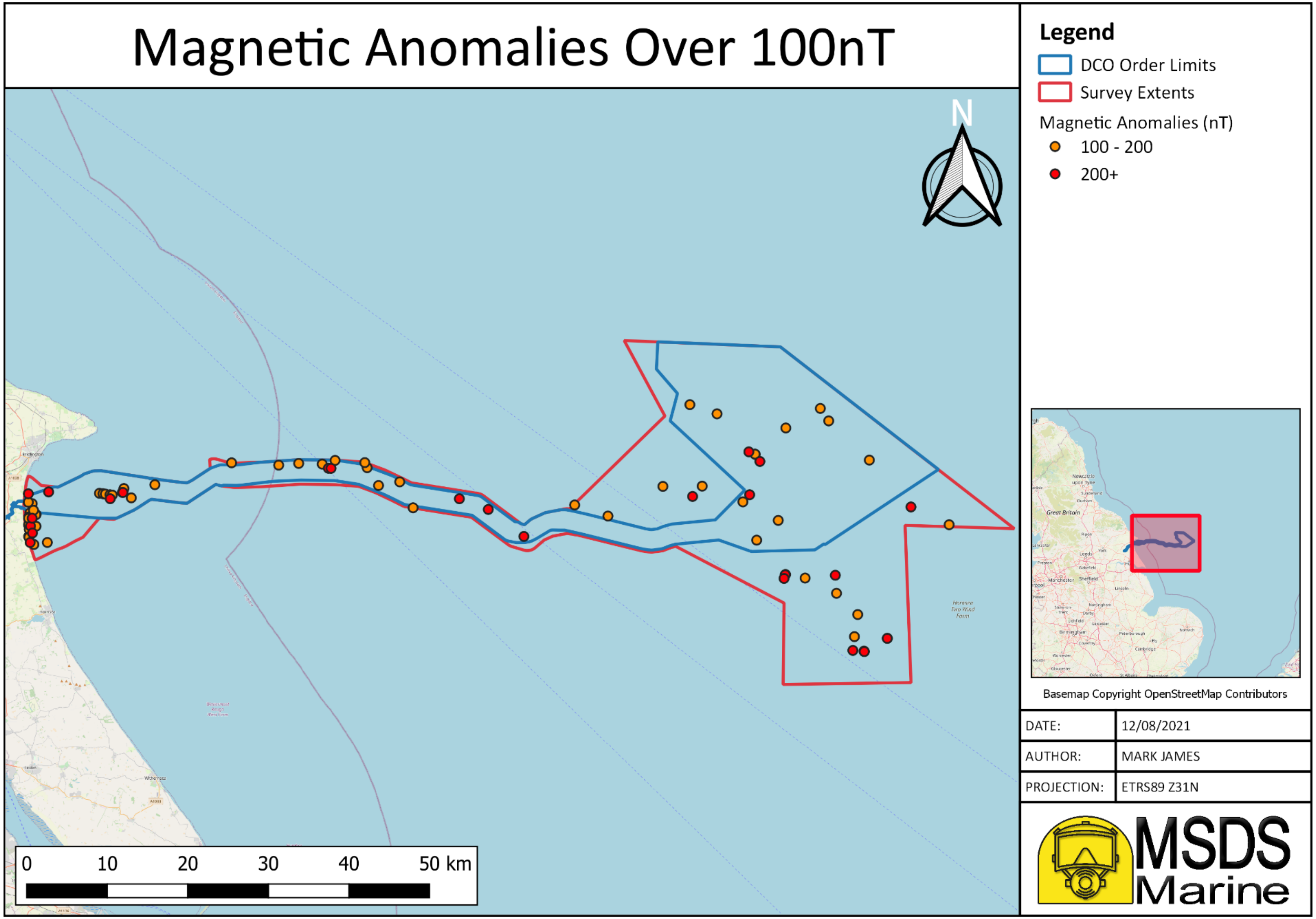

Figure 26. Large Magnetic Anomalies

9.0 United Kingdom Hydrographic Office Data

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

9.0.2 Fifteen UKHO records, or potential features relating to records, were identified within the data extents, the distribution is shown in Figure 27.

9.0.3 Six records were identified as corresponding with anomalies of archaeological potential on the seabed (Table 15) and have been discussed within this report.

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

Table 15. Archaeological Anomalies with Corresponding UKHO Records

9.0.4 A further nine records fall within the extents of the data, but no features of potential archaeological potential were identified at the positions. Five of the records, including four of the five records of wreck, are recorded as dead meaning that they have not been identified in a number of previous surveys. Three live records relate to lost geotechnical equipment, foul ground, and a possible cable. A further record of wreck (6165) has not been categorised as dead in the records; however, no evidence was found of a wreck in any of the geophysical datasets. The wreck was originally detected in 1980 and positioned using a Decca Navigator System (Decca) with no records of subsequent surveys recorded, therefore it is likely that the position is inaccurate and if live falls outside the limits of the data. The records are summarised in Table 16 below.

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
6165		Live	Non-dangerous wreck

Table 16. UKHO Records Not Identified in the Dataset

9.0.5 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 survey extents is presented in Figure 28 to demonstrate the concentration outside of the data extents.

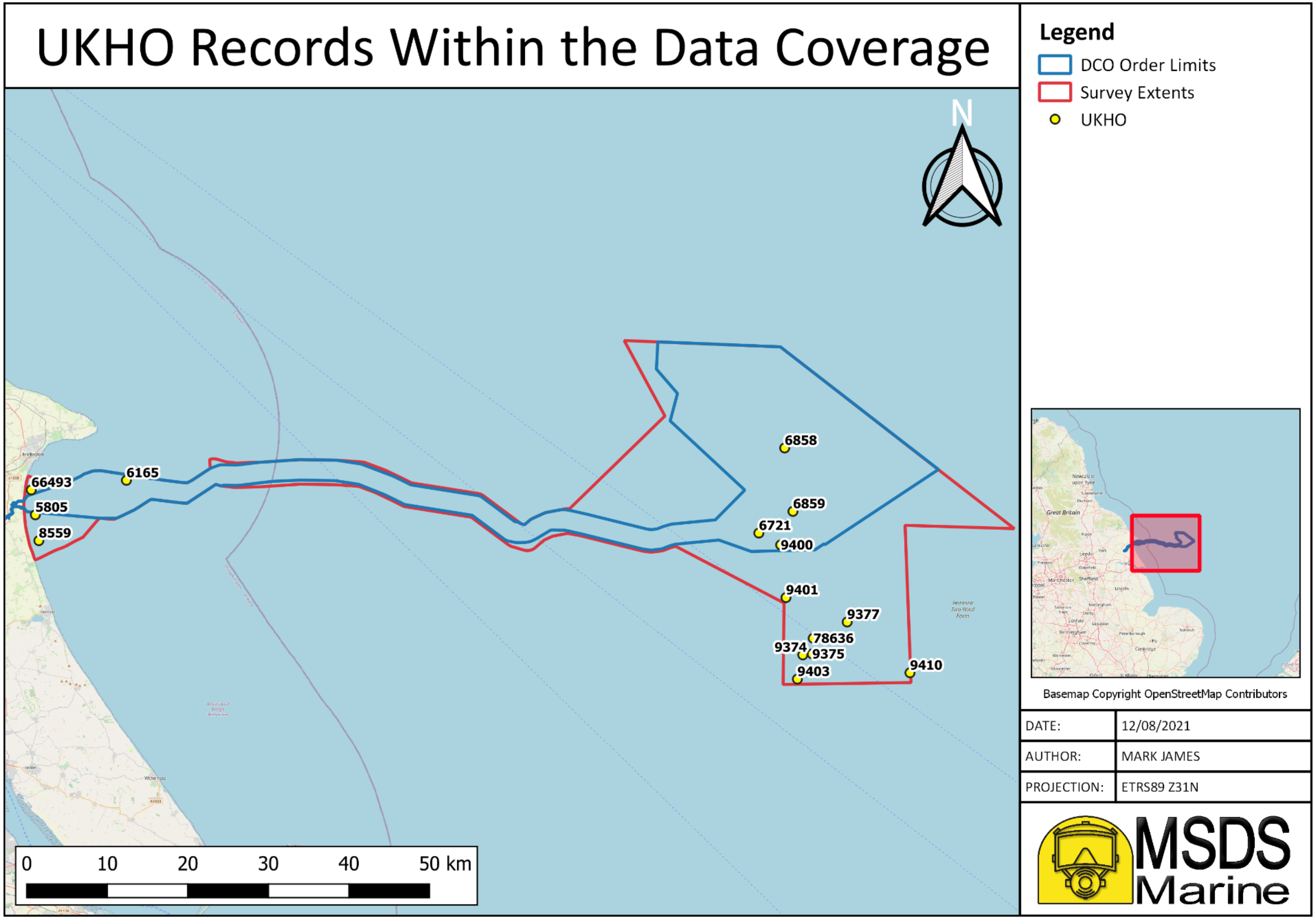

Figure 27. Distribution of UKHO Records Within the Dataset

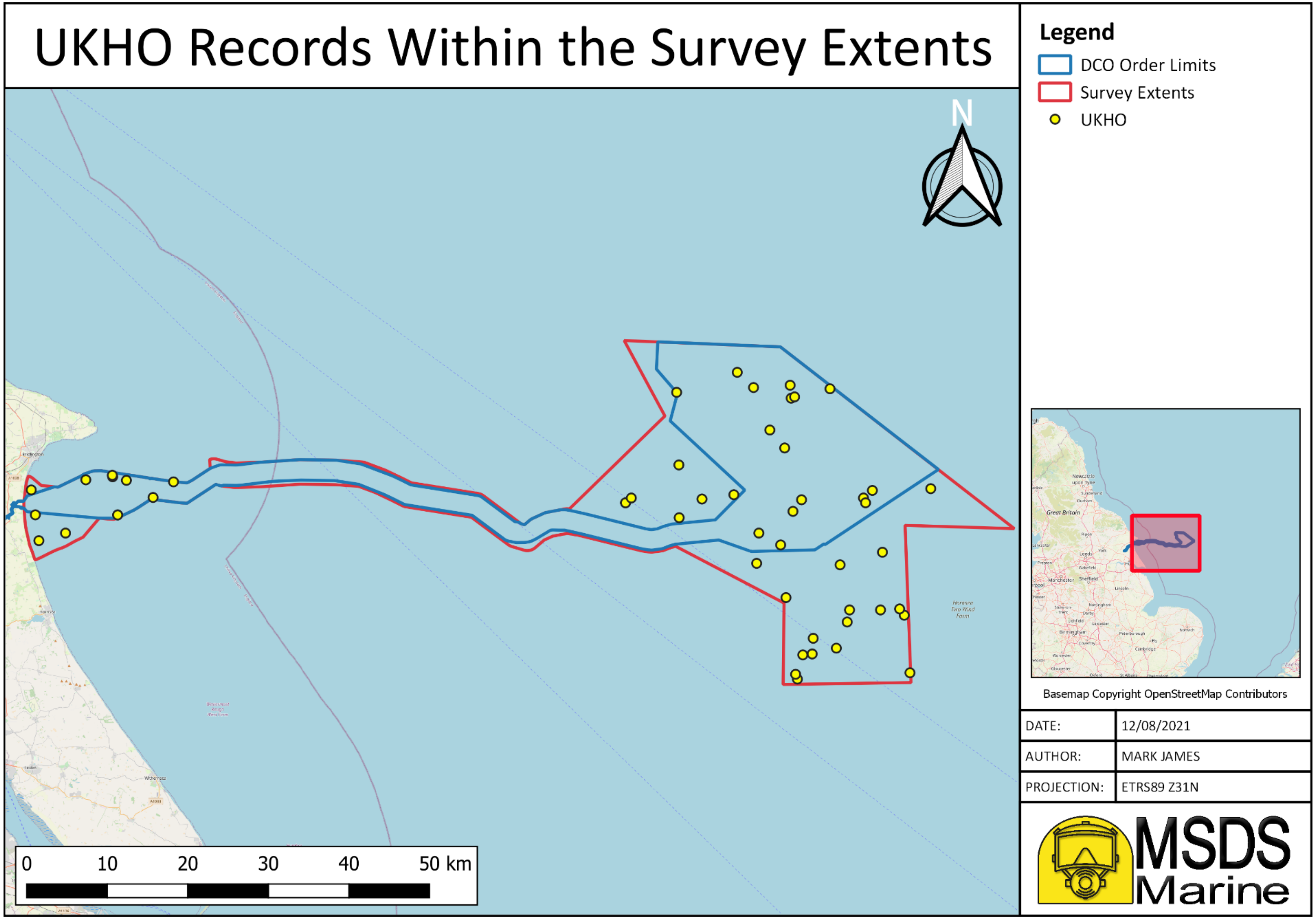

Figure 28. Distribution of UKHO Records

10.0 Mitigation

10.0.1 Hornsea Four has adopted commitments (primary design principles inherent as part of Hornsea Four, installation techniques and engineering designs/modifications) as part of their pre-application phase, to eliminate and/or reduce the likely significant effect arising from of a number of impacts. These are outlined in Volume A4, Annex 5.2 Commitments Register.

10.0.2 Further commitments (adoption of best practice guidance), referred to as tertiary commitments, are embedded as an inherent aspect of the EIA process. Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are reduced to environmentally acceptable levels.

10.0.3 Embedded mitigation measures are captured by our formal commitments, as outlined in F2.4: Outline Marine Written Scheme of Investigation. This section provides recommendations for how to treat anomalies of low, medium, and high archaeological potential through the implementation of AEZs, TAEZs and AAP

10.0.4 The mitigation strategies recommended for seabed anomalies 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 F2.4: Outline Marine Written Scheme of Investigation and Section 11.0: Recommendations for Future Work.

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

10.1 Low Archaeological Potential Anomalies

10.1.1 Low potential anomalies have been identified as potentially anthropogenic in origin but unlikely to be of archaeological significance and no exclusion zones are recommended for these anomalies. 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

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

10.2.2 Exclusion zone radius' have been determined from the centre point of the anomaly or cluster of anomalies. Anomalies and their recommended exclusion zones are detailed in Table 17 and Table 18 and the distribution shown Figure 29. Each exclusion zone is presented in Figure 31 to Figure 37. Note, where discrepancies exist between the position within different datasets, the position deemed to be most accurate has been used.

10.2.3 In total seven recommended archaeological exclusion zones have been assigned within the Order Limits, two high potential and five medium potential.

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

Table 17. High Potential Recommended Archaeological Exclusion Zones. Note: AEZ radii are from the given position which relates to the centre point of the anomaly

MSDS ID	Potential	Basic Description	Easting	Northing	AEZ Radius
MSDS_HOW04_2019_ARCH_0079	Medium	Potential anthropogenic debris	374099.1	6002824.4	15m
MSDS_HOW04_2019_ARCH_0088	Medium	Potential ballast mound	387801.1	5984995.7	30m
MSDS_HOW04_2019_ARCH_0234	Medium	Potential anthropogenic debris with large magnetic anomaly	385666.0	5993861.0	25m
MSDS_HOW04_2019IF_ARCH_0244	Medium	Potential anthropogenic debris with large magnetic anomaly	306336.1	5992925.3	15m
MSDS_HOW04_2019IF_ARCH_0257	Medium	Potential anthropogenic debris	336477.5	5991865.6	15m

Table 18. Medium Potential Recommended Archaeological Exclusion Zones. Note: AEZ radii are from the given position which relates to the centre point of the anomaly

10.3 Temporary Archaeological Exclusion Zones

10.3.1 Temporary archaeological exclusion zones are recommended during the archaeological assessment of early phases of survey data. Their use is primarily to provide mitigation for anomalies 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 anomaly.

10.3.2 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

10.4.1 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.

10.4.2 Magnetic anomalies >100nT within the Order Limits have been identified to characterise the Hornsea 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 anomalies and that the areas will be monitored during future assessments. The positions and amplitudes are detailed in Table 19 and the distribution shown in Figure 31 to Figure 37.

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_2019IF_MAG_2433	300470.7	5992501.9	102.9
MSDS_HOW04_2019IF_MAG_3089	335807.5	5992732.7	107.0
MSDS_HOW04_2019_MAG_2285	331877.0	5994607.8	115.4
MSDS_HOW04_2019_MAG_1477	383345.0	5997883.0	115.8
MSDS_HOW04_2019IF_MAG_2333	298913.6	5992789.3	117.7
MSDS_HOW04_2019IF_MAG_2868	326378.4	5995255.9	120.7
MSDS_HOW04_2019_MAG_1479	387631.0	6000164.0	121.5
MSDS_HOW04_2019IF_MAG_2796	323498.5	5995444.9	123.2
MSDS_HOW04_2019IF_MAG_2386	299635	5992662.4	127.8
MSDS_HOW04_2019_MAG_1482	374960.0	5999833.0	128.8

MSDS_HOW04_2019_MAG_1483	382128.0	5986602.0	130.2
MSDS_HOW04_2019IF_MAG_2412	300195.1	5992554.5	132.4
MSDS_HOW04_2019IF_MAG_3262	379416.3	5984248.1	132.7
MSDS_HOW04_2019IF_MAG_2514	301937.4	5993243.1	132.8
MSDS_HOW04_2019_MAG_2294	290723.0	5991072.0	135.5
MSDS_HOW04_2019IF_MAG_2360	299333.5	5992719.3	135.7
MSDS_HOW04_2019IF_MAG_3258	377849.8	5988987.0	139.3
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_2019IF_MAG_2679	305755.3	5993549.8	160.9
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_2019IF_MAG_2577	302793.4	5992062.4	186.5
MSDS_HOW04_2019_MAG_1495	379489.0	5994783.0	189.1
MSDS_HOW04_2019_MAG_1496	380061.0	5993875.0	229.2
MSDS_HOW04_2019IF_MAG_3143	343055.9	5990408.6	233.1
MSDS_HOW04_2019_MAG_1499	378695.0	5989836.0	294.7
MSDS_HOW04_2019IF_MAG_3159	346561.5	5988984.5	542.8
MSDS_HOW04_2019_MAG_2310	292680.5	5993228.4	578.6
MSDS_HOW04_2019_MAG_1504	378737.0	5995085.0	593.8
MSDS_HOW04_2019IF_MAG_3186	350823.4	5985537.7	772.4
MSDS_HOW04_2019IF_MAG_2880	327118	5994713.6	880.7
MSDS_HOW04_2019IF_MAG_2882	327440.8	5994693.6	1212.2
MSDS_HOW04_2019IF_MAG_2505	301793.3	5992763.8	1403.9
MSDS_HOW04_2019IF_MAG_2413	300202.3	5992066	2689.2
MSDS_HOW04_2019IF_MAG_2503	301731.5	5992775.6	5469.1

Table 19. Areas of Archaeological Potential

10.5 Notes on Exclusion Zones

10.5.1 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 Four, and the curator, Historic England, and the Marine Management Organisation (MMO).

Exclusion zones are implemented to protect, *in-situ,* potentially archaeologically significant material.

10.5.2 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 an anomaly 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, in consultation with Historic England and the MMO, to ensure mitigation is appropriate to the archaeological significance of the anomaly.

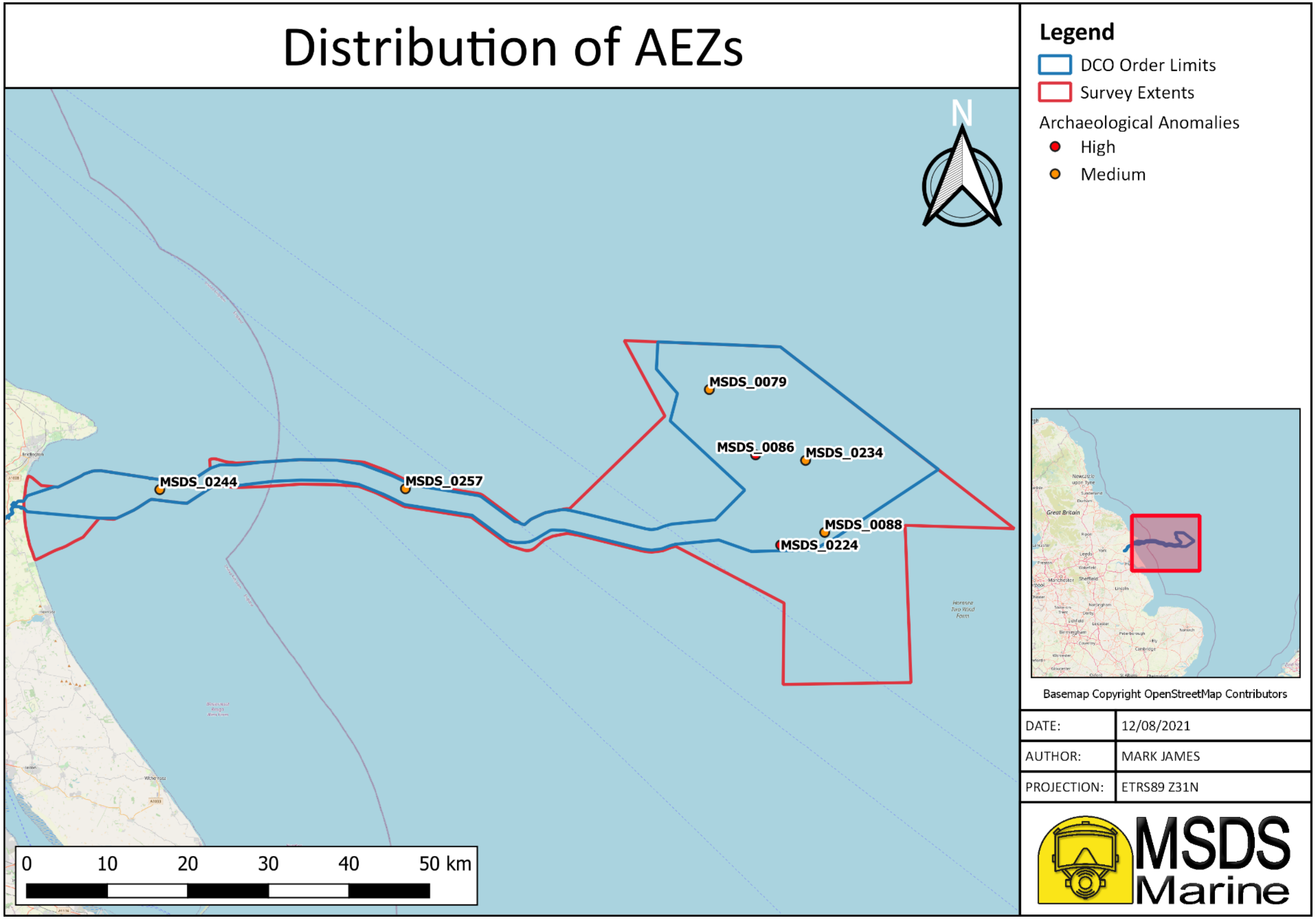

Figure 29. Distribution of Archaeological Exclusion Zones

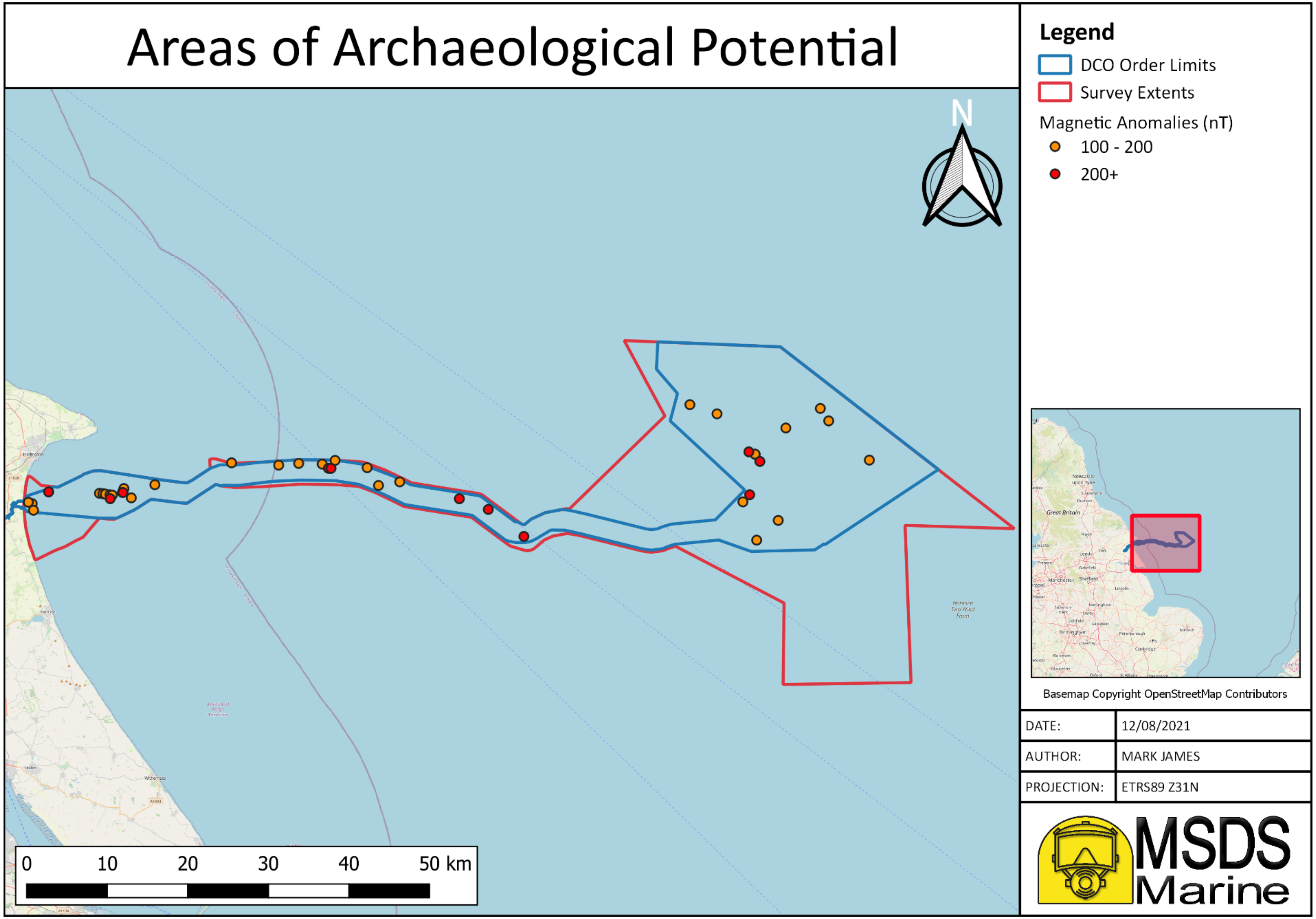

Figure 30. Areas of Archaeological Potential

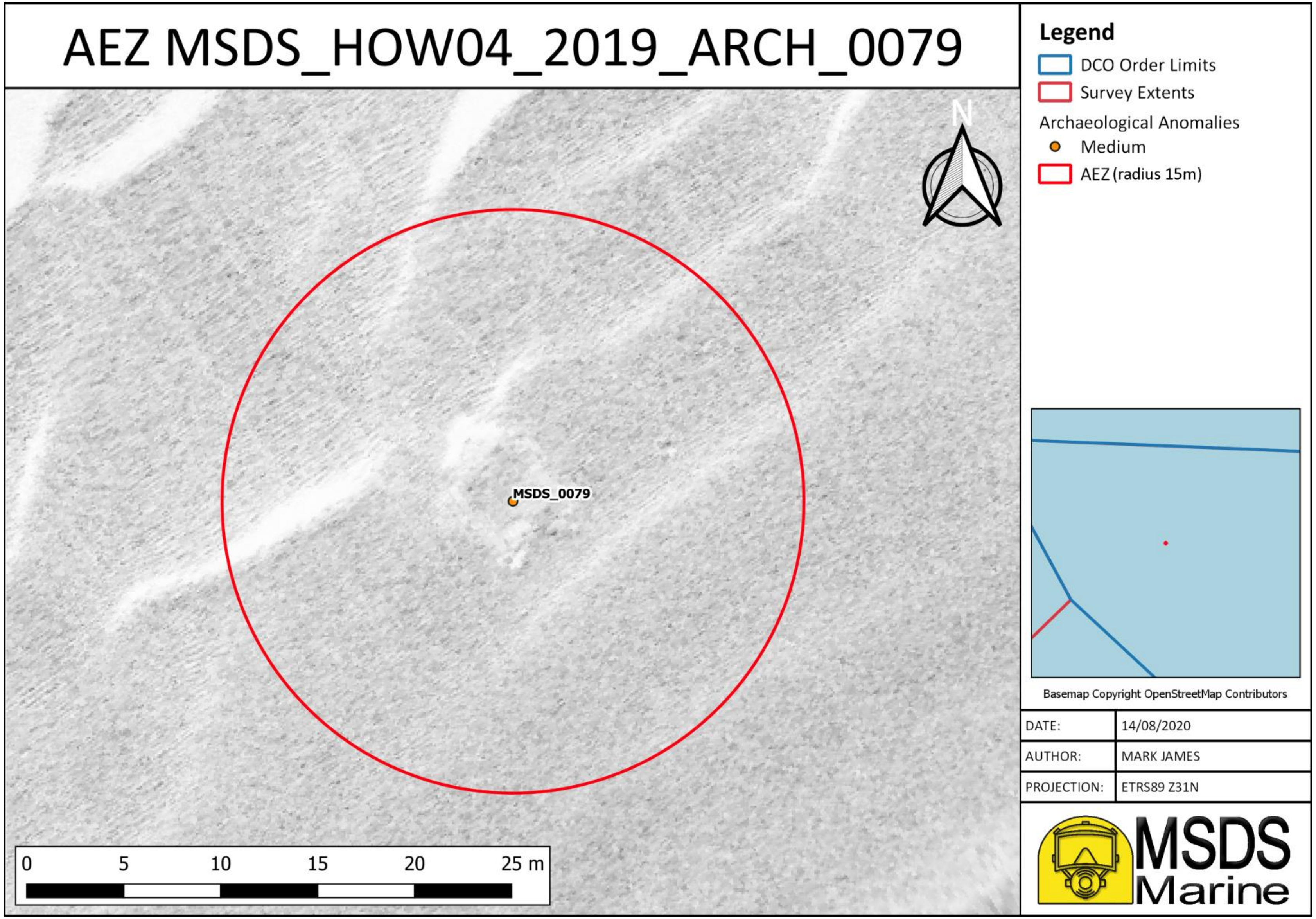

Figure 31. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0079

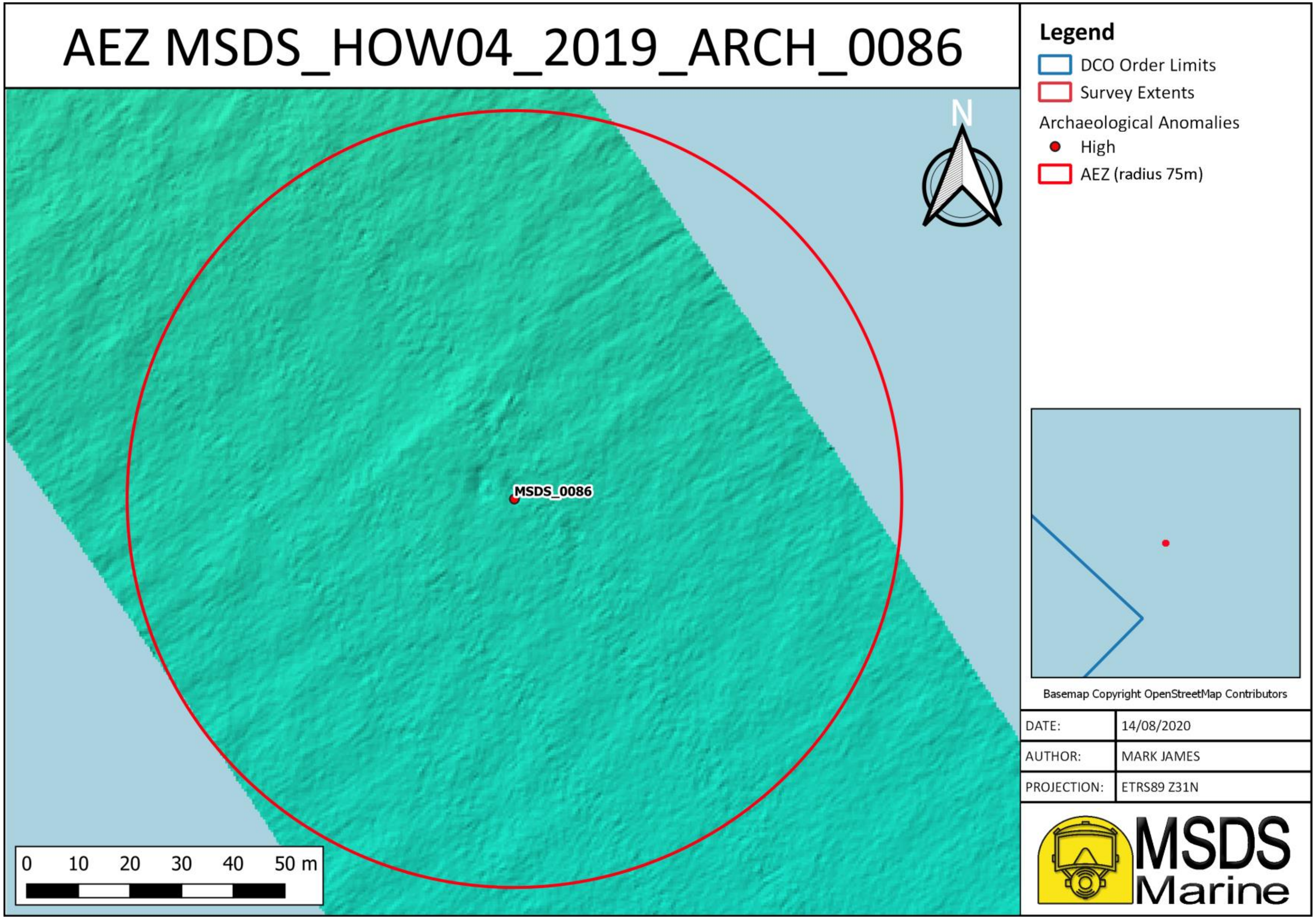

Figure 32. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0086

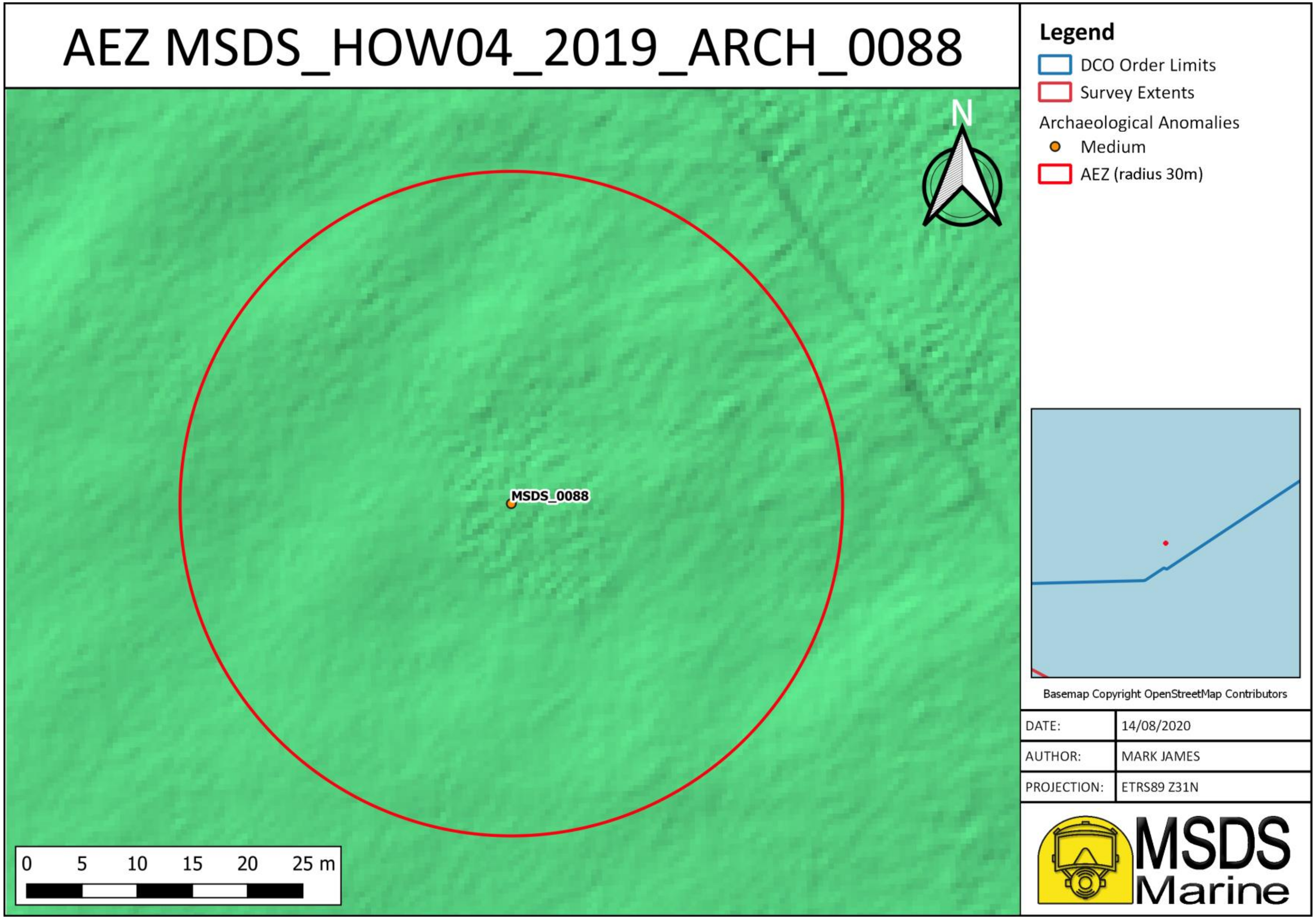

Figure 33. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0088

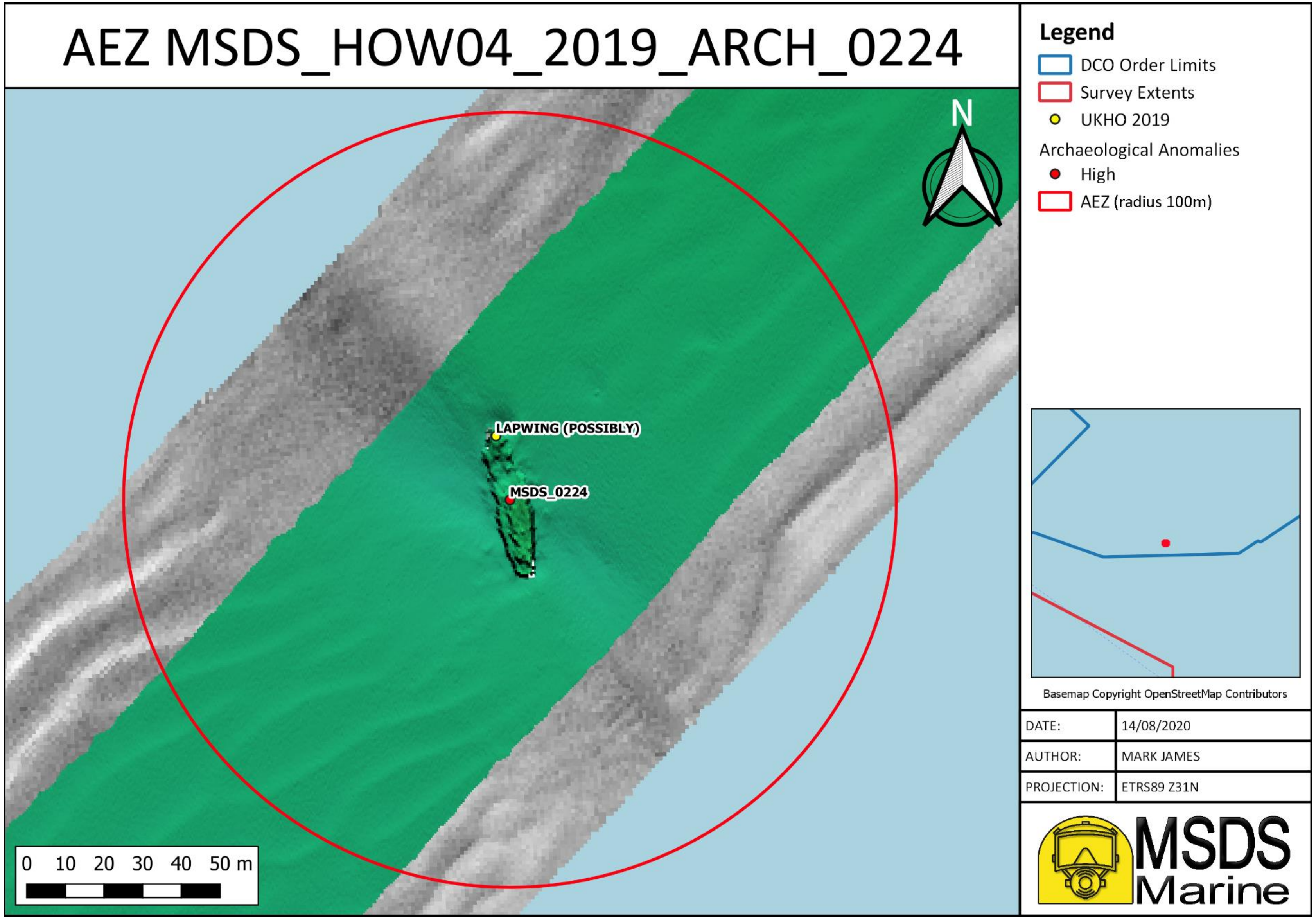

Figure 34. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0224

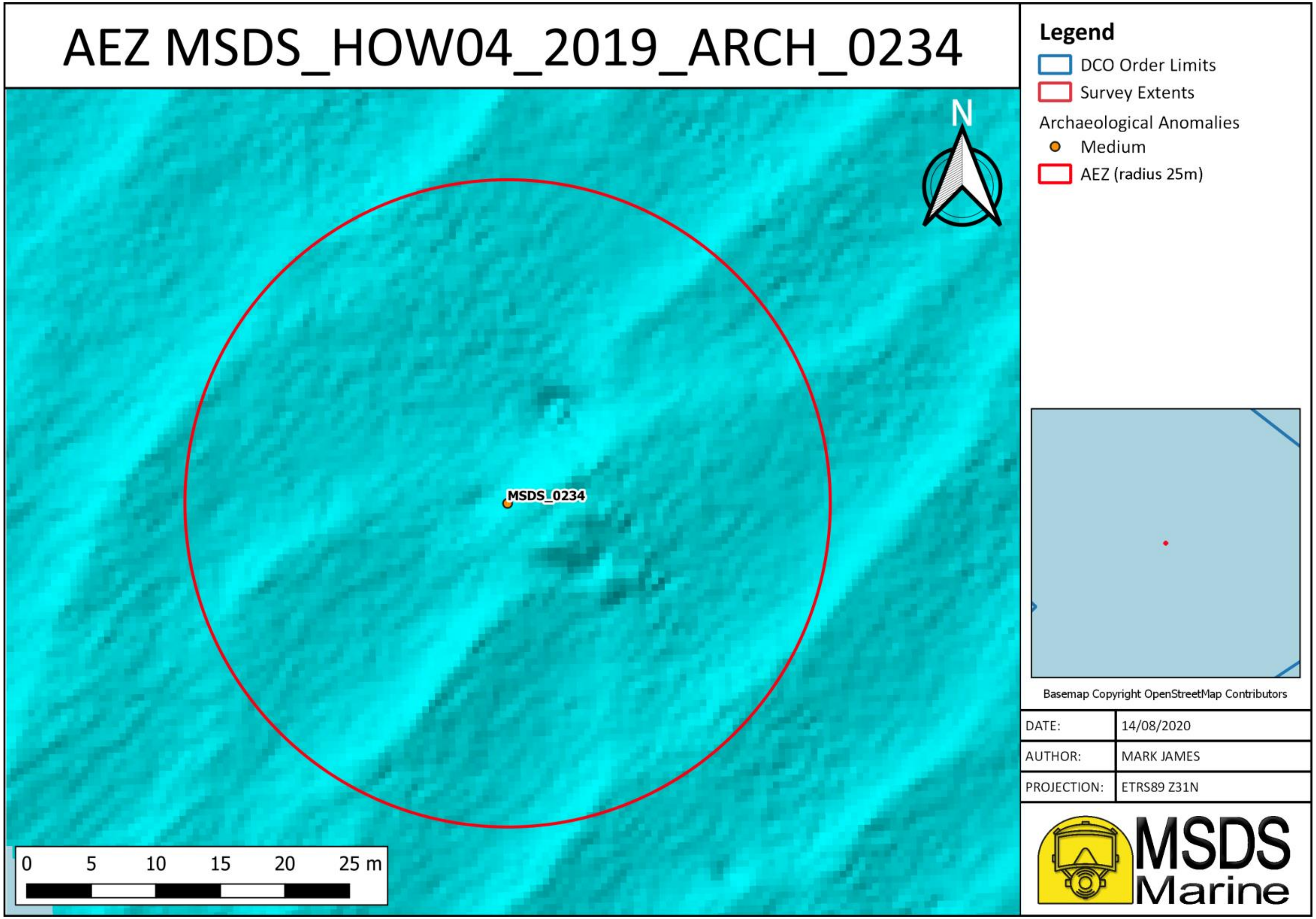

Figure 35. Archaeological Exclusion Zone MSDS_HOW04_2019_ARCH_0234

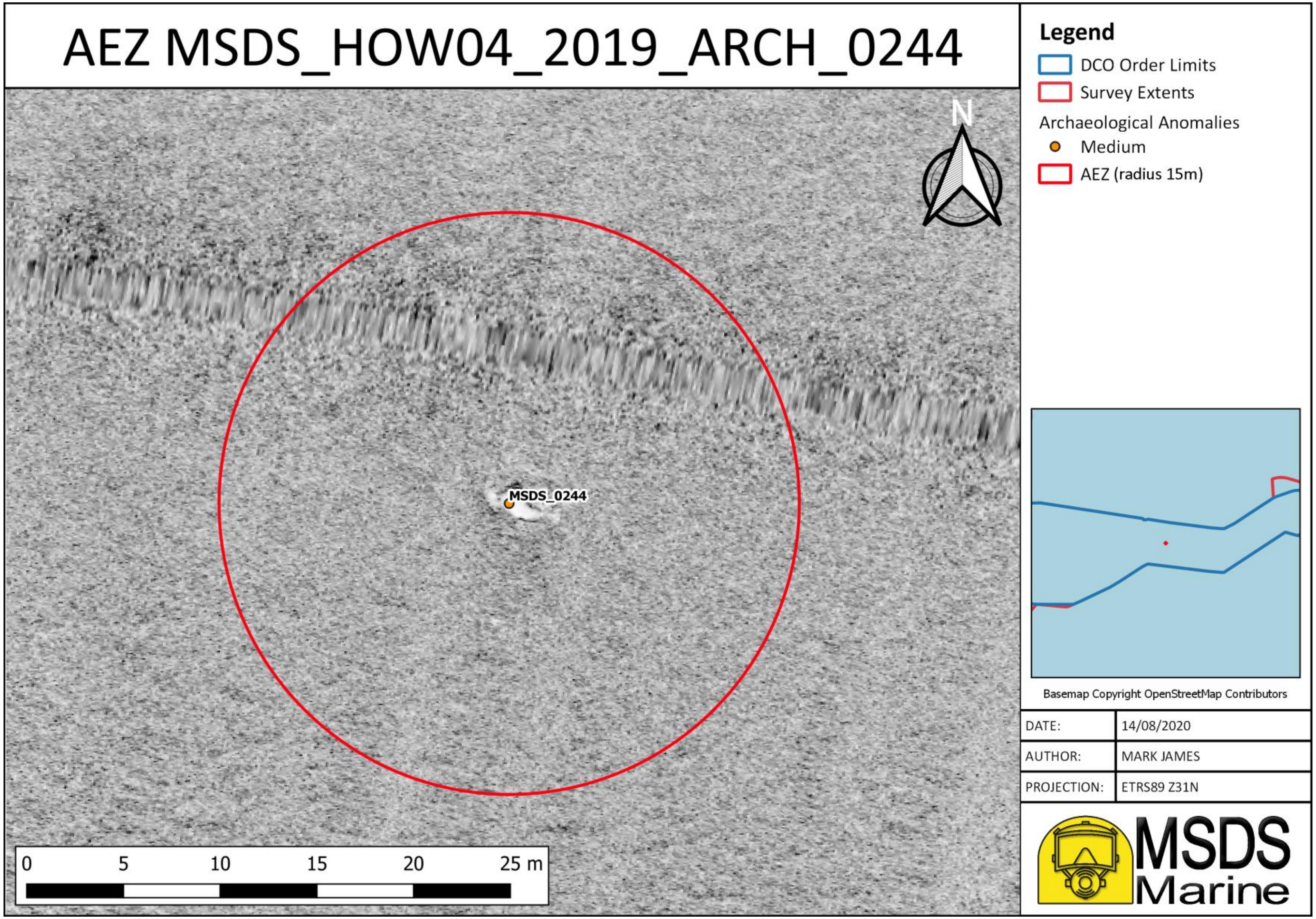

Figure 36. Archaeological Exclusion Zone MSDS_HOW04_2019IF_ARCH_0244

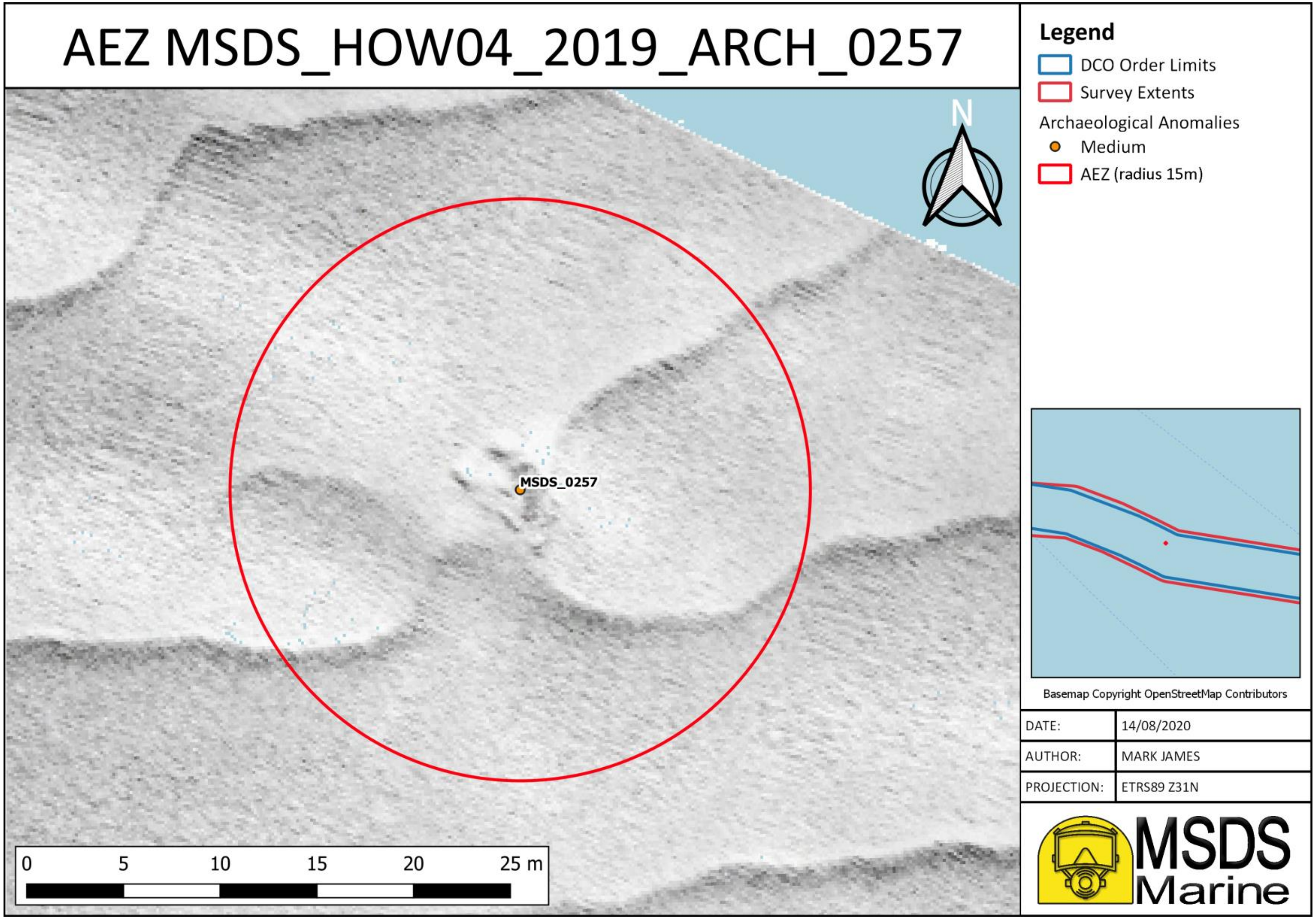

Figure 37. Archaeological Exclusion Zone MSDS_HOW04_2019IF_ARCH_0257

11.0 Recommendations for Future Work

11.0.1 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 Four. Whilst the dates are subject to change, the anticipated timeframes for planned survey works are outlined in Table 20 below.

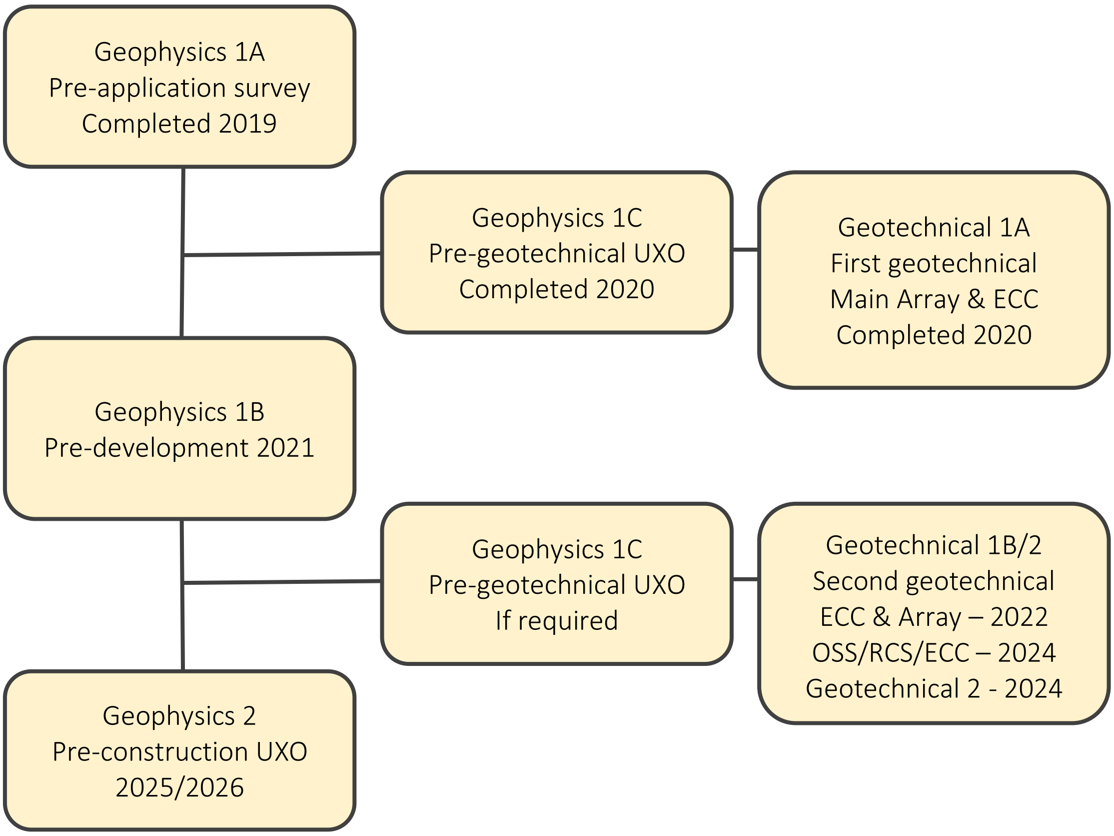

Figure 38. Planned and Completed Survey Works for Hornsea Four

11.0.2 The survey strategy and framework are established by Hornsea Four and has been used on previous Orsted 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.

Survey Phase	Description
Geophysics 1A Pre-application survey Completed 2019	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 anomalies >1.0m. Sensors: MBES, SSS, MAG, SBP
Geophysics 1B Pre-development In stages 2021 & 2024	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 anomalies >0.5m. Sensors: MBES, SSS, MAG, SBP
Geophysics 1C Pre-geotechnical As required	Geophysics 1C is a targeted program of pre-geotechnical 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 anomalies >0.3m. Sensors: MBES, SSS, MAG, SBP
Geophysics 2 Pre-construction UXO 2025/2026	Geophysics 2 is the final planned pre-construction 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 anomalies >0.3m. The survey informs the final route planning, UXO clearance works and final archaeological mitigation.

Table 20. Hornsea Four Planned and Completed Survey Works

11.0.3 The broad minimum specification for each tranche of surveys can be found in Table 21 below.

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

Table 21. Survey Specifications for Each Phase of Survey

11.0.4 The following sections set out recommendations for future survey works, also included within F2.4: Outline Marine Written Scheme of Investigation.

Archaeological Assessment of Data

11.0.5 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.

11.0.6 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.

11.0.7 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.

11.0.8 The methodology for the archaeological interpretation of data will follow those previously agreed with Historic England on both current and previous Orsted 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.

Survey Specification

11.0.9 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 anomaly to be ensonified and positional accuracy.

11.0.10 Of particular relevance is the specification for Geophysics 1c and Geophysics 2, these phases of survey are undertaken prior to seabed disturbance (i.e. 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 anomalies >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 anomalies 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.

Reporting

11.0.11 Reporting will follow the procedures set out within F2.4: Outline Marine Written Scheme of Investigation.

11.1 Additional Recommendations

11.1.1 Additional recommendations are set out within F2.4: Outline Marine Written Scheme of Investigation include continued use of a Protocol for Archaeological Discoveries.

12.0 References

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Appendix C1 - Gazetteer of Potential Archaeological Anomalies

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_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_2019IF_ARCH_0244	306336.1	5992925.3	2.2	1.2	1	291.4	Medium	15	Potential anthropogenic debris with large magnetic anomaly	Null	Null
MSDS_HOW04_2019IF_ARCH_0257	336477.5	5991865.6	6.7	3.7	0.2	Null	Medium	15	Potential anthropogenic debris	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	Null	Null

									with associated magnetic anomaly		
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	Null	Null

									with associated magnetic anomaly		
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	Null	Null

									with associated magnetic anomaly		
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
MSDS_HOW04_2019_ARCH_0147	290166.7	5991066.0	0.8	0.5	0.1	9.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null

MSDS_HOW04_2019_ARCH_0148	290239.0	5988746.4	1.1	0.3	0.1	28.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0149	290181.4	5988529.1	0.5	0.3	0.1	41.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0150	290591.4	5988909.4	0.6	0.3	0.2	12.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0151	290400.2	5988747.2	1.5	0.3	0.3	11.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0152	290220.5	5987981.4	1.3	0.4	0.3	96.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0153	290496.8	5988120.7	1.3	0.7	0.3	81.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0154	290496.4	5988119.2	1.1	0.7	0.2	81.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0155	290577.9	5993482.0	6.8	0.3	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0156	290573.0	5993486.9	0.5	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0157	290600.5	5991129.1	4.3	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0158	290692.5	5989531.3	11.7	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0159	290729.1	5990629.9	0.8	0.4	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0160	290613.8	5994881.3	8.7	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019_ARCH_0161	290570.8	5994707.4	8.1	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0162	290639.9	5994678.0	5.4	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0163	290595.0	5994631.3	5.7	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0164	290625.5	5994611.2	15.8	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0165	290617.6	5993271.3	5.8	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0166	290652.6	5992456.8	4.1	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0167	290649.8	5992452.5	5.7	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0168	290725.6	5990630.4	6.7	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0169	290648.8	5992456.5	17.1	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0170	290900.4	5988245.9	1.2	0.7	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0172	290870.5	5988647.0	8.3	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0174	290806.6	5994350.4	30.2	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0175	290820.0	5993880.7	5.8	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0176	290829.4	5993485.4	1.6	0.8	0.2	12.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0177	290892.9	5990928.0	1.4	0.7	0.5	20	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0179	290949.6	5990562.5	24.2	0.1	0.1	21.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0180	290954.2	5990575.7	1	0.7	0.2	21.9	Low	0	Potential anthropogenic debris	Null	Null

									with associated magnetic anomaly		
MSDS_HOW04_2019_ARCH_0181	290959.1	5990601.3	1.7	0.9	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0182	290956.4	5990587.5	27	0.1	0.1	21.9	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0183	290938.2	5991204.6	2	1	0.1	27.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0184	290920.7	5991766.2	0.5	0.4	0.1	11.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0185	290840.4	5993969.9	1	0.6	0.2	23.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0186	290849.7	5993984.5	1	0.5	0.1	20.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0188	290806.2	5993825.6	3.3	0.3	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0189	291109.6	5985174.0	1.2	0.5	0.4	29.4	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0190	291089.5	5987115.8	0.8	0.6	0.2	10.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0191	290930.7	5992606.1	1.7	0.6	0.2	134.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0192	290970.4	5991876.4	22.9	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019_ARCH_0193	290613.9	5993000.0	1.9	1.1	1	11.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0194	290576.5	5993482.3	0.5	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0195	291159.1	5985217.1	0.6	0.4	0.3	8.4	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0196	290801.3	5993828.4	0.8	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0197	290764.0	5992898.2	1.3	0.7	0.6	79.7	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0198	289961.6	5988952.8	6.6	0.3	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0199	289783.8	5990993.3	19.7	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0200	290207.6	5990961.8	1.1	0.4	0.2	15.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0201	290422.2	5986511.1	0.9	0.2	0.4	22.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0202	290426.4	5986506.8	0.5	0.4	0.3	22.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0203	290422.3	5986516.2	0.9	0.2	0.2	22.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0204	290421.7	5986514.9	0.6	0.4	0.3	22.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null

MSDS_HOW04_2019_ARCH_0205	291355.2	5988514.8	2.8	0.7	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0206	291371.0	5994106.0	2.4	0.6	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0207	292252.2	5989121.6	53.3	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0208	297329.8	5993249.2	13.6	0.1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0209	291112.2	5988314.1	11.4	0.7	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0210	341625.2	5988684.3	1.5	0.6	0.7	9.8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0211	333112.5	5992416.9	0.9	0.7	0.4	107	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0212	320862.0	5995782.2	0.7	0.3	0.5	8	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0213	322250.7	5994892.4	0.5	0.4	0.6	7.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019_ARCH_0214	323914.3	5994379.3	12.4	0.7	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0215	356949.7	5987591.8	6.8	3.5	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0216	359014.1	5986232.0	10.8	90	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0223	373176.5	5994450.4	8.5	3.6	0.6	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0225	364737.0	5994438.9	4	1.2	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0226	369366.9	5996047.5	0.8	0.7	0.5	19.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null

MSDS_HOW04_2019_ARCH_0227	371059.6	5993413.1	1.2	0.3	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0228	362161.6	5984348.8	3.7	1	0.7	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0229	375869.9	5989846.4	3	1.9	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0230	376671.0	5990650.6	2.1	1.7	0.5	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0231	372219.8	5981842.3	8.8	5.8	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0232	376358.0	5986078.4	3.3	1.7	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019_ARCH_0233	377622.9	6004925.2	25.4	10.4	Null	Null	Low	0	Potential anthropogenic debris or geology	Null	Null
MSDS_HOW04_2019IF_ARCH_0235	312460.7	5993096.2	1	0.7	0.4	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0236	311465.1	5992604	0.8	0.7	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0237	311068.2	5992843	1.7	0.7	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0238	311354.3	5993659.1	1.9	1.1	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0239	311672.8	5993826.7	1	0.6	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0240	305277.1	5992645.5	0.5	0.3	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0241	304262.2	5992774.5	0.8	0.5	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0242	304254.9	5992772.1	0.5	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0243	304079.4	5992798.7	0.8	0.4	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0245	304069.1	5993384	1.5	0.9	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0246	305230.9	5993600.6	0.5	0.4	0.5	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0247	298312.9	5993408.4	0.6	0.3	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019IF_ARCH_0248	308892.3	5991961.8	1.5	1.1	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0249	307488	5992205.2	1.8	1.6	1.6	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0250	303863.8	5993915.3	2.1	2.1	0.3	113.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019IF_ARCH_0251	325196.5	5995333.2	1.8	1.5	1.1	60.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019IF_ARCH_0252	325200.4	5995331.6	2.1	1.6	0.9	60.1	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019IF_ARCH_0253	334173.4	5993574.5	15.6	0.2	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0254	325197.2	5995329.2	0.5	0.5	0.4	27.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019IF_ARCH_0255	325197.3	5995327.1	0.5	0.3	0.2	27.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019IF_ARCH_0256	325198.1	5995324	0.8	0.6	0.2	27.6	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2019IF_ARCH_0258	326106.8	5995313.5	3.3	1	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0259	345704.5	5989039	1.9	0.3	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0260	345587.5	5989090.8	1	0.4	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0261	345036.7	5989525	1.2	0.4	0.1	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0262	325539.7	5993776.6	0.7	0.5	0.2	Null	Low	0	Potential anthropogenic debris	Null	Null

MSDS_HOW04_2019IF_ARCH_0263	365995.3	5984710.9	4.7	0.6	0.3	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2019IF_ARCH_0264	352019.1	5986460.9	1.2	1.2	0.7	28.2	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2020GT_ARCH_0265	384757.7	5995744	1.2	1	Null	7.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2020GT_ARCH_0266	380646.2	5995840	4.7	3.9	Null	Null	Low	0	Potential anthropogenic debris	Null	Null
MSDS_HOW04_2020GT_ARCH_0267	376652.5	5997547	1.6	0.67	Null	48.3	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null
MSDS_HOW04_2020GT_ARCH_0268	376654	5997582	1.9	0.77	Null	33.5	Low	0	Potential anthropogenic debris with associated magnetic anomaly	Null	Null

Hornsea Project Four: Environmental Statement (ES)

Appendix D of ES Annex 9.1: Palaeogeographic Review of Geophysical Survey Data

Prepared	MSDS Marine. April 2020
Checked	MSDS Marine. August 2021
Accepted	David King, Orsted. August 2021
Approved	Julian Carolan, Orsted. September 2021

A5.9.1
Version B

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:	Ørsted Hornsea Project Four Ltd. (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	31/08/2021
Quality Assurance	Mark James
Company Number	9782276
Version number:	2.0
Summary of changes	Changes to reflect updates to ground model and geotechnical locations; Changes to reflect comments from the Applicant; Changes to reflect amendments to Order Limits.

Table of Contents

List of Figures

List of Tables

Term	Acronyms and Abbreviations
Agreement for Lease	AfL
Borehole	BH
Coastal and Offshore Archaeological Research Services	COARS
Cone Penetration Test	CPT
Development Consent Order	DCO
Environmental Impact Assessment	EIA
Export Cable Corridor	ECC
Export Cable Route	ECR (the term ECC is preferred, though ECR has been used for core positions and so is included here).
High Voltage Alternating Current	HVAC
High Voltage Direct Current	HVDC
Magnetometer	Mag
Multibeam Echosounder	MBES
North Sea Palaeolandscape Project	NSPP
Offshore Sub Station	OSS
Regional Environmental Characterisation	REC
Side Scan Sonar	SSS
Sub-Bottom Profiler	SBP
Ultra-High Resolution Seismic	UHRS
Unexploded Ordnance	UXO
Vibrocore	VC
Written Scheme of Investigation	WSI

1.0 Introduction

1.1 Palaeogeographic Review of Geophysical Survey Data

1.1.1 The purpose of this report is to inform on the palaeoenvironmental aspects of the ground model created for the Hornsea Project Four Offshore Wind Farm (hereafter Hornsea Four) and led by Orsted Hornsea Project Four Limited (the Applicant).

1.1.2 Ground models integrate interpreted geophysical and geotechnical data to characterise the geological and engineering conditions of an area. There is considerable overlap between investigation for geological and engineering purposes, and investigations undertaken by archaeologists to develop an understanding of the palaeolandscape along with palaeoenvironmental and archaeological potential. Recognising this cross-over, the Applicant commissioned MSDS Marine to provide input into the Hornsea Four ground model to ensure that the resultant model could be used for archaeological, as well as geological and engineering purposes.

1.1.3 Archaeological advice has aimed to maximise the information gained from the ground model. This advice has accompanied the development of the ground model from its early stages, ensuring that the resultant model is suitable for understanding the palaeolandscape within the Hornsea Four Development Consent Order (DCO) Order Limits. The specific archaeological input has included review of key areas of geophysical survey data relating to the submerged prehistoric landscape, accompanied by 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 of the area within the Order Limits, which has been fed into the EIA.

1.1.4 This report includes a series of mapped horizons derived from the current iteration of the ground model showing the distribution of all sub-surface deposits within the Order Limits, along with interpretations relating to the origin, archaeological and palaeoenvironmental potential of the deposits. Understanding of the extent and thickness of these sub-surface deposits will continue to be honed by future geophysical and geotechnical campaigns, outlined in Table 1, the results of which will be used to refine the ground model. These results will be fed into geoarchaeological assessments which will accompany future geotechnical campaigns, as set out by the Outline Marine WSI document (F2.4: Outline Marine Written Scheme of Investigation).

1.1.5 In addition, this report details the following:

- Geophysical and geotechnical surveys undertaken for Hornsea Four which form the basis for the ground model (including dates surveys were undertaken, and specifications);
- Geophysical survey acquisition and interpretation methods and their suitability for assessing archaeological potential based on the resultant ground model;
- Archaeological input into geotechnical locations; and

- 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.

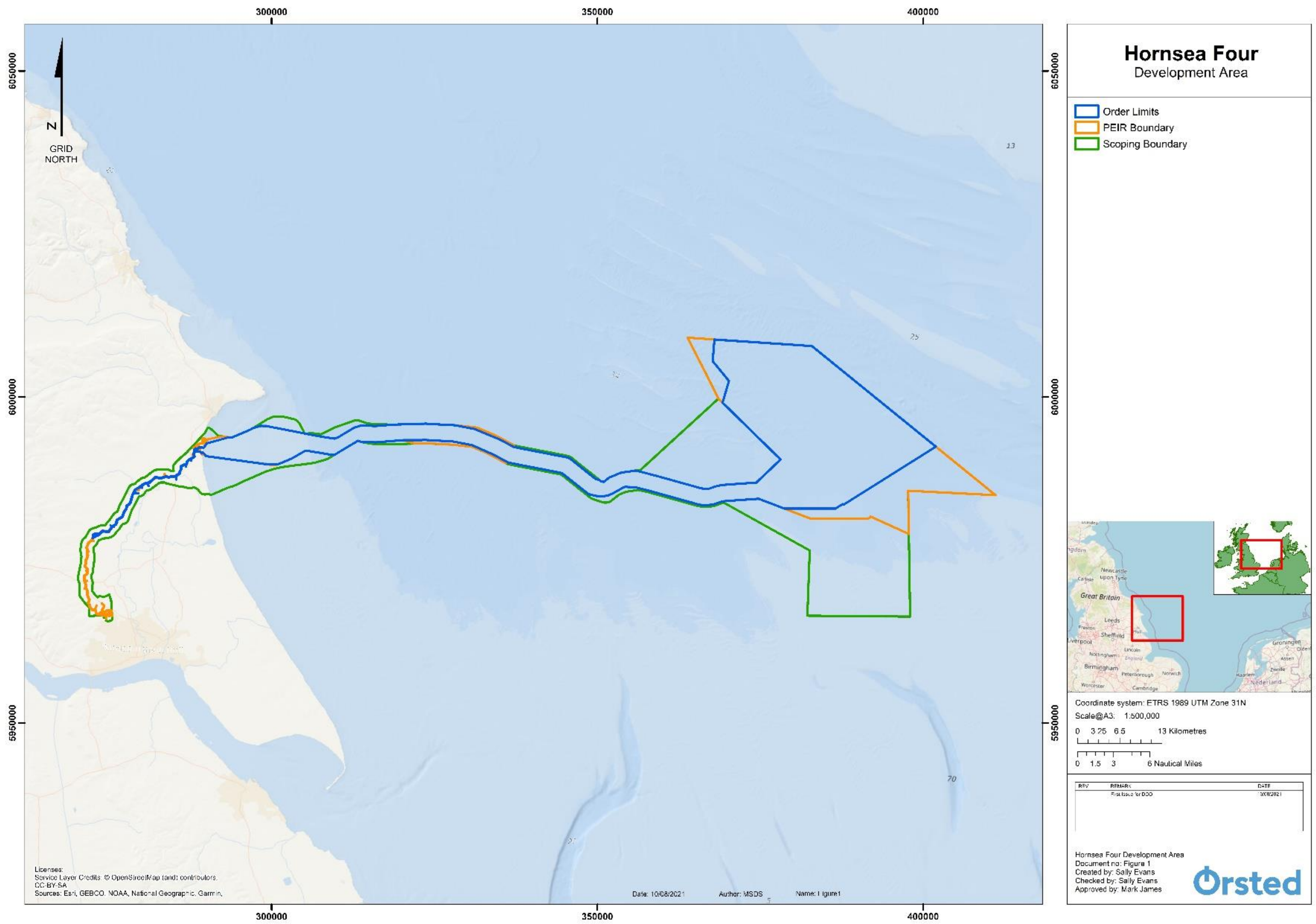

Figure 1: Hornsea Four Development Area

2.0 Previous Geoarchaeological and Palaeolandscape Work in the Area

2.1 Relevant Projects

2.1.1 There are a number of projects which provide information which is of relevance to the Hornsea Four palaeolandscape and its interpretation. These include projects which have analysed seismic data and cores to improve understanding of the palaeolandscape within the area. Those of particular importance, which cover the area, or part of the area, included within the Hornsea Four Order Limits (Figure 1) include:

- The North Sea Palaeolandscape Project (NSPP) (Fitch et al. 2005, Gaffney et al. 2007). This project assessed the potential of submerged landscapes in the southern North Sea using seismic data from offshore industry. The majority of the offshore cable route, the south-western part of the array area, and a small part of the north-eastern array area are covered by this project;
- Earlier studies within the Hornsea Zone, including the initial Hornsea Zone assessments which included the Hornsea Four area, and later work by specific Hornsea Projects. Hornsea Project Two is particularly relevant due to its proximity to Hornsea Four, though work from Hornsea One and Hornsea Three also provides important information about the wider palaeolandscape. Work has included the collection of seismic data, cores and the creation of ground models (e.g. Smith 2019) in addition to marine archaeology technical reports and reports on geoarchaeological assessment;
- Other development projects include the Viking Link Interconnector, which has included assessment of a linear area passing within *c.* 2km of the southern part of the Hornsea Four array area, and has included assessment of seismic data and collection of cores from within close proximity to the Hornsea Four Order Limits (Wessex Archaeology 2017);
- Other recent studies have focused on the Late Glacial history of the area including parts of the Hornsea Four array area (e.g. Dove et al. 2017);
- Wider studies which have covered the area including the technical report for the Strategic Environmental Assessment (SEA) of Area 3 (Flemming 2002); and
- Other studies in the wider area include the Humber Regional Environmental Characterisation (REC) which covered an area to the south of Hornsea Four (Tappin et al. 2011), and the ongoing Lost Frontiers project led by Vince Gaffney (e.g. Gaffney et al. 2017), which includes the collection of cores to the north, south and east of the Hornsea Four Order Limits, from either side of the Outer Silver Pit.

2.2 Findings

2.2.1 The Hornsea Project Two ground model has identified the formations and stratigraphy of the wider area including modern marine sediments, with underlying Botney Cut, Bolders Bank, Eem, Egmond Ground, Sand Hole, Swarte Bank and Yarmouth Roads Formations (Smith 2019). Earlier studies (outlined in Section 2.1) have focused on the particular potential of some of these deposits.

2.2.2 The NSPP characterised areas of archaeological potential within its study area. The potential assigned by the NSPP related to the palaeolandscape features (such as channels, coastlines and topography) mapped by the project, and the likelihood that human activity took place within each area of the landscape during the Upper Palaeolithic and Mesolithic, following the retreat of the Devensian ice sheet and prior to the Holocene marine transgression. The majority of the Hornsea Four Export Cable Corridor (ECC) covered by the study was characterised by the NSPP as of low to moderate potential, as was the south-eastern part of the array area while the north-western part of the array area was characterised largely as low to very low potential. Smaller pockets of moderate potential were identified midway along the ECC.

2.2.3 While the NSPP found archaeological potential to be generally low it did map palaeolandscape features within the Hornsea Four Order Limits, such as channels equivalent to the Botney Cut formation, which are likely to have palaeoenvironmental potential. Hornsea Two (c. 3.5km to the south-east of Hornsea Four at its closest point), has mapped the Botney cut channels and other palaeolandscape features in much greater detail (Smith 2019) than the NSPP, and the current ground model for Hornsea Two indicates that Botney Cut channels may run toward the Hornsea Four area from the southeast, incised into the Bolders Bank Formation. Other studies, such as the Marine Archaeology Technical Report for Viking Link EIA (Wessex Archaeology 2017) identified further evidence of channels close to the southern part of the Hornsea Four array area. These channels (numbered 7549-7553 in the EIA) were largely found to be incised into the Bolders Bank Formation and covered by modern marine sediments. Fills were indicative of fluvial origins, of early Holocene date. Geoarchaeological analysis and radiocarbon dating of samples from a core taken from one of these channels (core B13-03-ARCH) provided dates from the Mesolithic (sample from depths of 2.05-2.20m below seabed level, with a calibrated date of *c.* 9000BC), and lower fills dated to the Late Upper Palaeolithic (samples from depths of 3.00-3.03m below seabed level, with calibrated dates spanning 11,500-10,500 BC) with some evidence of reworking in the lower fills (Wessex Archaeology 2017).

2.2.4 However, the extent of the Botney cut channels across the Hornsea Four Order Limits generally may be more limited (see Figure 4) than other parts of the Hornsea Zone, particularly when compared with those identified within Hornsea Three (further eastward and including an area of salt marsh channel systems mapped by the NSPP).

2.2.5 The Late Devensian glacial history of the area has also been investigated by other studies (Dove et al. 2017), and moraines (likely equivalent to Bolders Bank) have been identified from locations within the Hornsea Four array area, as well as overlying active sediment waves.

3.0 Geophysical Surveys and Ground Model Development

3.1.1 This section gives an overview of completed and planned geophysical surveys, their interpretation methods, suitability for assessing archaeological potential and incorporation within the Hornsea Four ground model.

3.1.2 Geophysical surveys for Hornsea Four are due to take place in a series of phases. Each phase providing more detailed surveys than the previous, so that the final datasets present a high-resolution understanding of the sub-surface deposits within the Order Limits. Geophysical surveys for the Hornsea Zone were first undertaken in 2011. A sequence of surveys is planned to take place in the coming years. These are set out in Table 1 below, along with planned geotechnical surveys. Table 2 sets out the phases of ground model development in relation to geophysical survey campaigns and geotechnical campaigns. The latter are discussed within Section 4.0. The current ground model is Version 1a (Table 2).

Table 1: Summary of site- specific survey data

Scope	Indicative timescale	Survey detail	Archaeological assessment
Geophysics 1A Pre-application survey Data acquired during summer 2018 and 2019	Completed	Multibeam Echosounder (MBES), Side Scan Sonar (SSS), Magnetometer (MAG), Sub-bottom Profiler (SBP), in the array area also Ultra-high Resolution Seismic (UHRS) to inform the application process and characterise the Order Limits.	Volume A5, Annex 9.1: Marine Archaeology Technical Report, Appendices C and D.
GT1A: Geotechnical campaign at Main Array and ECC. Data acquired in summer 2020.	Survey completed – reporting ongoing.	Intrusive ground investigations comprising seabed and down-hole testing (Cone Penetration Tests (CPT's), Vibrocores and Boreholes) to ground truth the geophysical ground model to inform the site design and characterise the Order Limits.	A staged geoarchaeological assessment will be submitted to Historic England after completion of the archaeological assessment of geotechnical data.
Geophysical seismic survey of Main Array and ECC	April/June 2021	Infill surveys of Array ad ECC	Archaeological assessment of infill data
Geophysical MBES survey of Main Array ahead of sand wave clearance	April/June 2021	Full coverage MBES ECC and Array.	Archaeological assessments of survey data where relevant.
Geophysical surveys and geotechnical campaigns at the landfall site	April/June 2021	Geophysical and geotechnical survey	Archaeological assessments of survey data and a staged geoarchaeological assessment.
GT1B: Geotechnical campaign at Main Array	May/June 2021	Geotechnical survey at Array	Archaeological assessments of survey data where relevant.
GT1B: Geotechnical campaign at ECC	May/June 2022	Geotechnical survey at ECC	Archaeological assessments of survey data where relevant.
GT1B: Geotechnical campaign at OSS and HVAC booster/HVDC converter substations	May/June 2024	Geotechnical campaign	Archaeological assessments of survey data where relevant.

GT2: Geotechnical campaign at Array	April/June 2024	Geotechnical survey at Array	Archaeological assessments of survey data where relevant.
GP2A: Geophysical UXO detection survey at ECC and Array	April/July2025	Geophysical UXO detection survey	Archaeological assessments of survey data where relevant.
GP2B: UXO surveys at Array and ECC	April/July 2026	Geophysical UXO detection survey	Archaeological assessments of survey data where relevant.

Table 2: Overview of ground model development in relation to geophysical and geotechnical campaigns

Ground Model Version	Version 0	Version 1a			Version 1b		Version 2			
Geotechnical Campaign	Desk study		Geotechnical 1a Investigation	Geotechnical 1a site assessment	Geotechnical 1b Investigation	Geotechnical 1b site assessment	Geotechnical 2 Investigation	Geotechnical 2 site assessment		
Geophysical Campaign	Desk study	Geophysical 1a Investigation		Geophysical 1a site assessment	Geophysical 1b Investigation	Geophysical 1b site assessment	Geophysical 1c Investigation	Geophysical 1c site assessment	Geophysical 2a Investigation	Geophysical 2a site assessment
Array: Data on which ground model is based	2011 Hornsea Zone surveys: MBES (1m bin grids); SBP data 100 x 500m line spacing; UHRS data 100 x 500m line, 100m penetration; and data from existing published studies	Gardeline UHRS data, restricted coverage along run line, 70m penetration. GeoSurveys interpretation; Gardeline SBP Innomar Seismic data along run line and interpretation; 2011 Hornsea zone well data 2016 Hornsea Two well data	6 boreholes 8 vibrocores 14 CPTs at core locations and an additional 4 CPTs		Full coverage surveys planned, with 100m line spacing. Detailed specifications TBC.		Detailed specifications TBC.		Survey coverage including a 100m buffer around cable routes in addition to areas around turbines and substations, with 15m line spacing.	
ECC: Data on which ground model is based		2018 BibbyHydromap SBP Innomar and interpretation; 2019 BibbyHydromap SBP Innomar	24 vibrocores 24 CPTs							

Current Ground Model Phase
(Q2 2020)

3.1.3 Geophysical surveys are 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.

3.1.4 The geophysical survey data collected in 2011, 2018 and 2019 forms the basis for the Hornsea Four ground model to be used for EIA purposes (see Table 2). Figure 2, Figure 11 and Figure 12 show survey lines for this data within the array area and ECC. The ground model is currently in Version 1a, and as of Q2 2020 the ground model has incorporated data from 2011, 2018 and 2019. This ground model will be developed in the post-consent period by further geophysical surveys and geotechnical campaigns, as set out in Table 1 and Table 2.

3.1.5 The 2011 geophysical surveys on which the initial version of the ground model was based (Version 0) included:

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

3.1.6 The specifications for the 2018 and 2019 geophysical surveys (geophysical 1a, 1c and infill data) included:

- MBES data including infill data (1m average grid, with an estimated 100m swath). The primary aims of this data collection were to collect data showing accurate water depths; slope analysis; and contact ID and positioning;
- SBP data including infill data (along the run line, covering the onshore and offshore areas and the upper 10m below the seabed, with 10-20cm resolution vertically). The primary aims of this data collection were: geological characterisation in cable burial depth of interest (including features of archaeological interest); qualitative buried boulder assessment; existing infrastructure and geo-hazard mapping; and
- UHRS (array and booster station search area only. Along run-line, covering the upper 70m below seabed with 20-50cm vertical resolution).

3.1.7 Later geophysical campaigns (geophysical 1b and 2a) 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.

3.1.8 The sub-bottom profiler and seismic data provide the primary information on the sub surface deposits. All horizons identified in these datasets interpreted and the base of the deposits mapped.

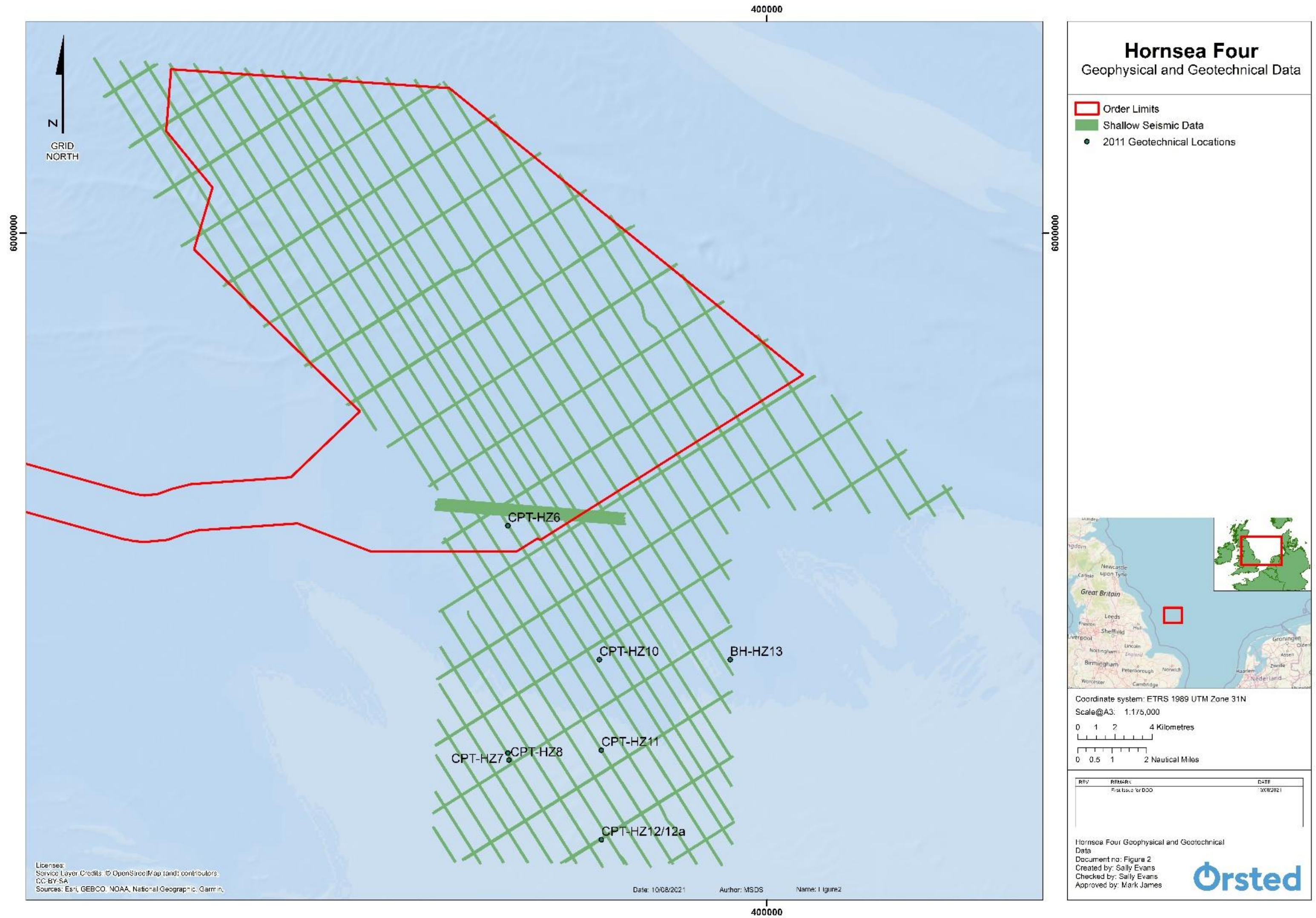

Figure 2: Locations of 2011 geotechnical investigations within Hornsea Four AfL and locations of geophysical survey lines in the array area.

4.0 Geotechnical Investigations and Ground Model Development

4.1.1 With the exception of the work of other studies (see Section 2), the only geotechnical work conducted within the Hornsea Four Agreement for Lease (AfL) area comprises that undertaken in 2011 (see Table 2 and Figure 2). These were collected as part of the Hornsea zone investigations, and included:

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

4.1.2 These investigations were all undertaken in the southern part of the AfL and only one of the locations falls within the current Order Limits (Figure 2). A geotechnical campaign (Geotechnical 1a) within the DCO Order Limits was completed in summer 2020, with reporting ongoing, and future campaigns are also being planned. Further information on the ongoing campaign is included below and information relating to the future campaigns is included within Table 1 and Table 2.

5.0 Sedimentary horizons identified within the Order Limits

5.1.1 The Southern North Sea, within which the Hornsea Four DCO Order Limits are situated, 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 region, which have varying levels of archaeological and palaeoenvironmental potential. The archaeological potential for the Order Limits, based on desk-based sources and existing studies is set out within the scoping report (Orsted, 2018) and, in greater detail, within the Marine Archaeology Technical Report (Volume A5, Annex 9.1) which forms part of the EIA. Key sources are also set out within Section 2.0 of this report. This section provides added detail specific to the Hornsea Four Order Limits which is the result of the assessment of geophysical survey data and ground model development.

Array Area

5.1.2 Table 3 provides an overview of the sedimentary sequence within the Order Limits as identified within the ground model. The current ground model is based on data set out in Sections 3.0 and 4.0.

5.1.3 In addition to an overview of deposits, Table 3 also includes a description of the primary characteristics of each formation along with the likely origins. This is a necessary step to understanding palaeoenvironmental and archaeological potential, as the potential differs between geological deposits, depending on the nature and origin of the sediments which forms the deposits, and the post-depositional factors which have affected them. At this stage interpretations of potential are based primarily on deposits identified through geophysical survey data collected by Hornsea Four and interpreted and mapped within the ground model, in addition to archaeological review of seismic profiles at locations from within the Hornsea Four Order Limits. This is supported by knowledge gained within the other Hornsea project areas, in particular from Hornsea Two which lies close to the Hornsea Four Order Limits, based on their ground models (Smith 2019) and geotechnical work (COARS and MSDS Marine 2020, in review), and with reference to geotechnical work associated with other projects (e.g. Viking Link Interconnector, Wessex Archaeology 2017). The geotechnical 1a campaign specific to Hornsea Four was completed in summer 2020 and reporting is ongoing. As such, the results of this campaign are not yet available but will be used, along with future geotechnical campaigns (detailed in Table 1) to further confirm the interpretation of deposits and their palaeoenvironmental and archaeological potential within the Order Limits. 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.

5.1.4 Those deposits which are thought to have heightened archaeological and palaeoenvironmental potential for *in situ* remains, based on the evidence set out above, have been highlighted in green in Table 3. Of particular interest are potential Holocene deposits which predate the marine inundation of the area, Botney Cut deposits, Eem formation and Yarmouth Roads deposits. Additionally, while the bulk of some deposits such as those which are fully marine or glacially derived, may not be of specific archaeological interest, sampling and dating of certain deposits may help to answer questions which can aid overall understanding of the area and the changing palaeolandscapes. Uneroded surfaces of such deposits which may have been aerially exposed may also hold archaeological potential, and archaeological finds may occur within secondary contexts. Palaeoenvironmental and archaeological potential of the deposits are discussed further in Section 6.0.

Deposit	Description	Distribution mapped
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 moraines and other glacial features along the export cable route may hold organic deposits of Holocene date.	Figure 3
Botney Cut	Related to the Late Devensian and Early Holocene period. Predominantly glacio-fluvial channel features and till. Some of the Botney cut features may be re-interpreted as Bolders bank	Figure 4
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	Figure 5

	deposit in the southern part of the array area, with more erosive properties to the north.	
Eem Formation	Related to the Ipswichian interglacial. Fine to medium grained shelly marine sands, or intertidal/sub-tidal deposits.	Figure 6
Egmond Ground	Fine grained marine sands interbedded with clays	Figure 7
Swarte Bank	Related to the Anglian glaciation. Primarily characterised by sub glacial valleys incised into the Yarmouth Roads formation and underlying deposits (where present).	Figure 8
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.	Figure 9
Chalk	Bedrock	Not illustrated
Pre-Chalk	Bedrock	Not illustrated

Table 3: Summary of sedimentary sequence and deposits of archaeological interest within the Hornsea Four DCO Order Limits.

5.1.5 The ground model includes information on the base and thickness of each deposit identified within the Order Limits, as interpreted from seismic profiles. This information has been gridded and exported from the ground model to create Figure 3 to Figure 9. These figures map the distribution and presence of deposits within the Order Limits, by illustrating the base of each deposit, and are key to the understanding of archaeological and palaeoenvironmental potential when coupled with the interpretation of these deposits as set out by Table 3.

5.1.6 The figures represent the deposits as currently identified along the lines for which survey data has been collected. Line spacing is currently wide (as seen in Figure 3 to Figure 9, and described in Section 3.0), and future geophysical survey campaigns will achieve narrower line spacing. This will serve to improve the resolution with which the formations are mapped, and these results will feed into the ground model (Table 2). They will also be included within the geoarchaeological assessments which will accompany geotechnical campaigns, aiding the overall investigation and understanding of the palaeolandscape within the Order Limits (see Table 7 within the Outline Marine WSI (F2.4: Outline Marine Written Scheme of Investigation)).

5.1.7 Additional data outside of the Order Limits which has been collected by Hornsea Four is presented as it contributes toward the understanding of the palaeoenvironmental and archaeological potential within the Order Limits.

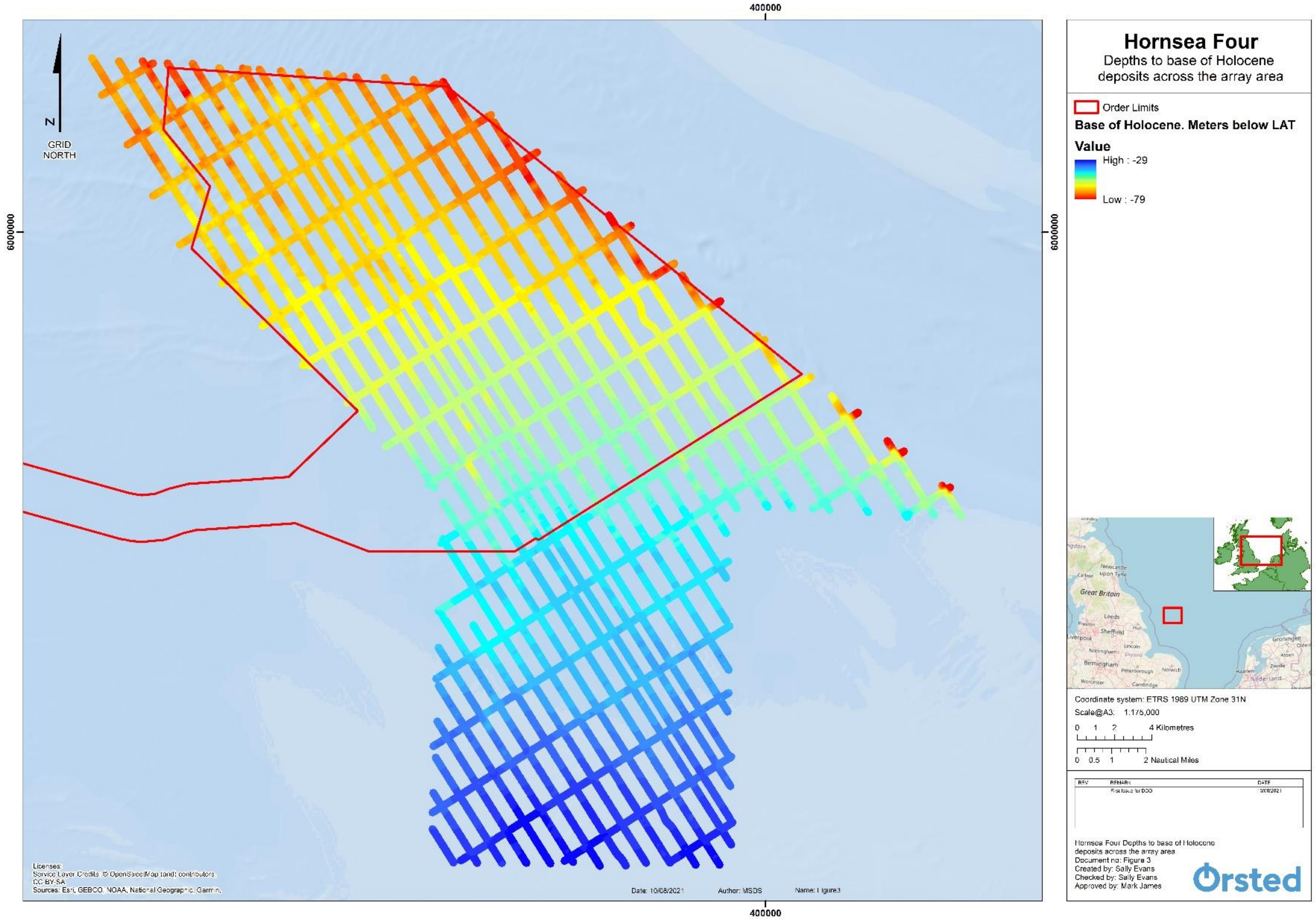

Figure 3: Depths to base of Holocene deposits across the array area.

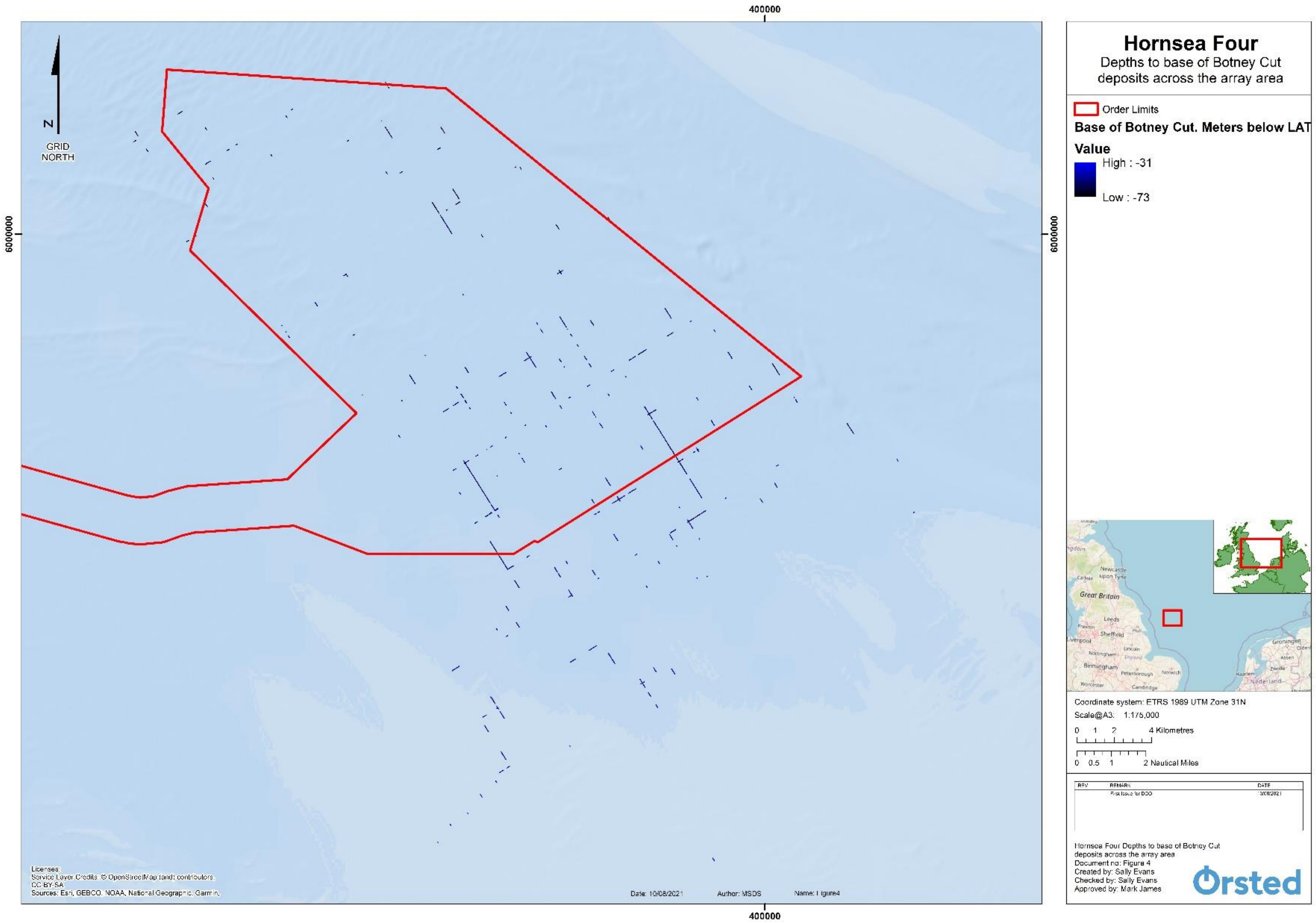

Figure 4: Depths to the base of Botney Cut deposits within the array area.

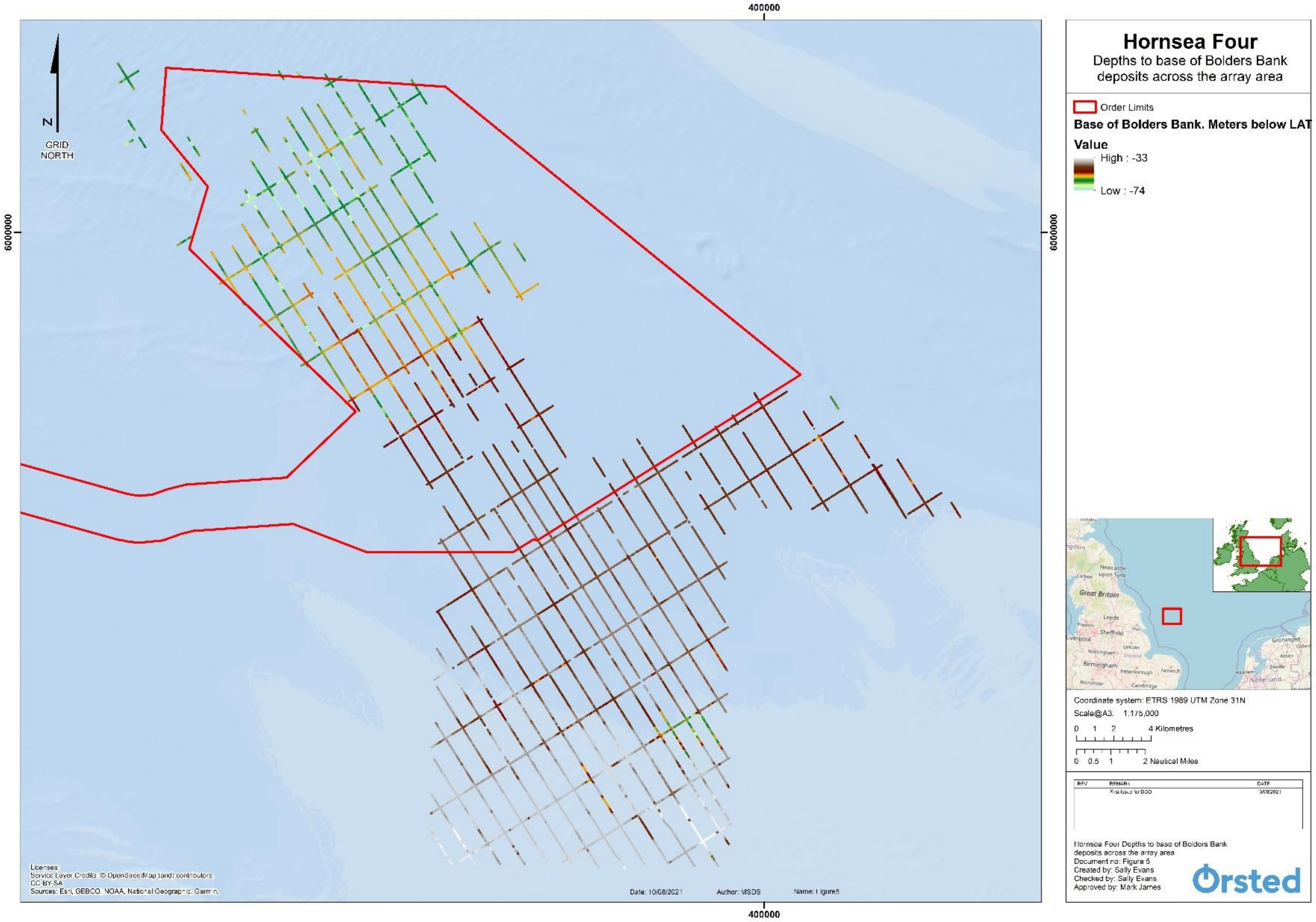

Figure 5: Depths to base of Boulders Bank deposits across the array area.

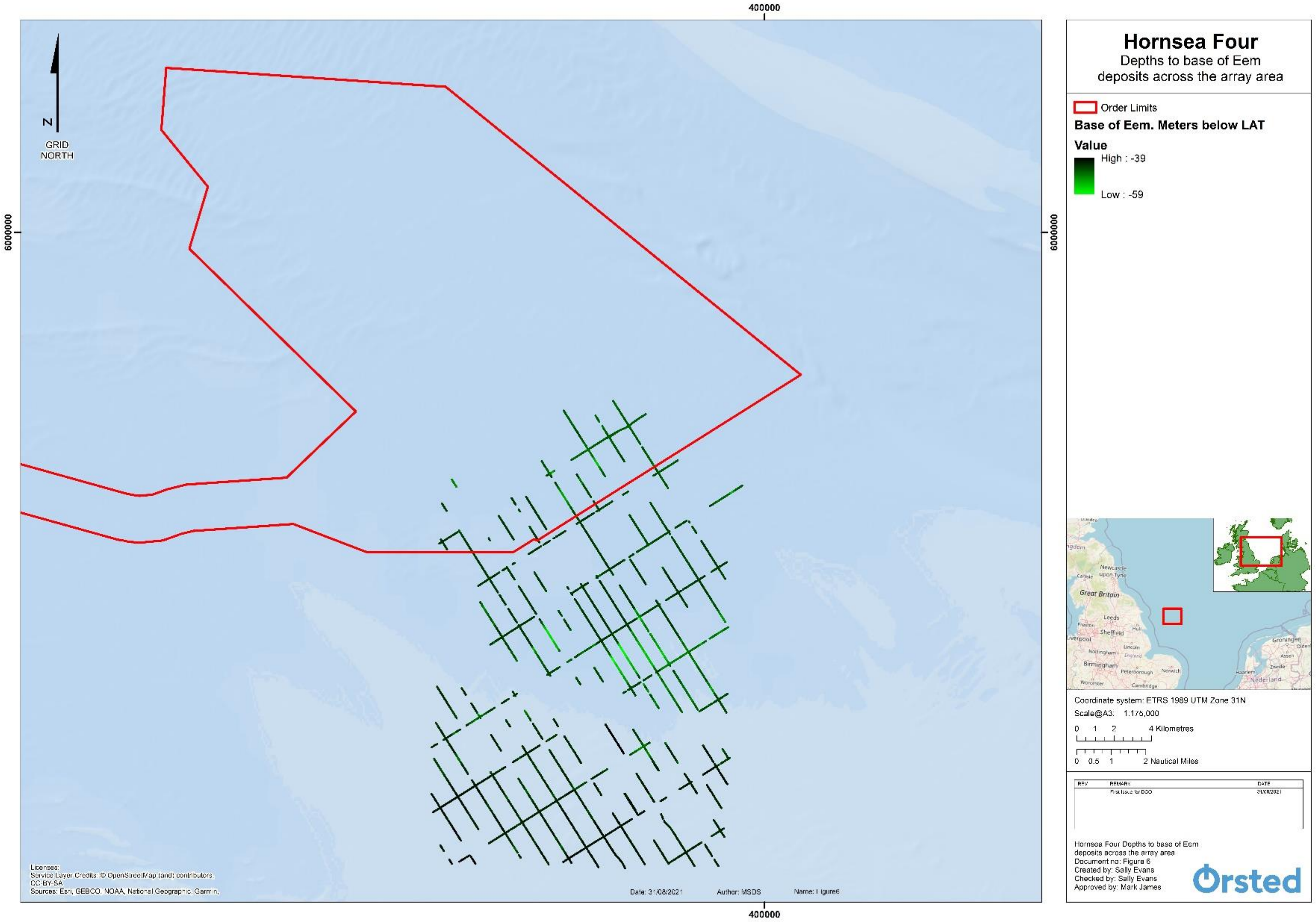

Figure 6: Depths to base of Eem deposits across the array area.

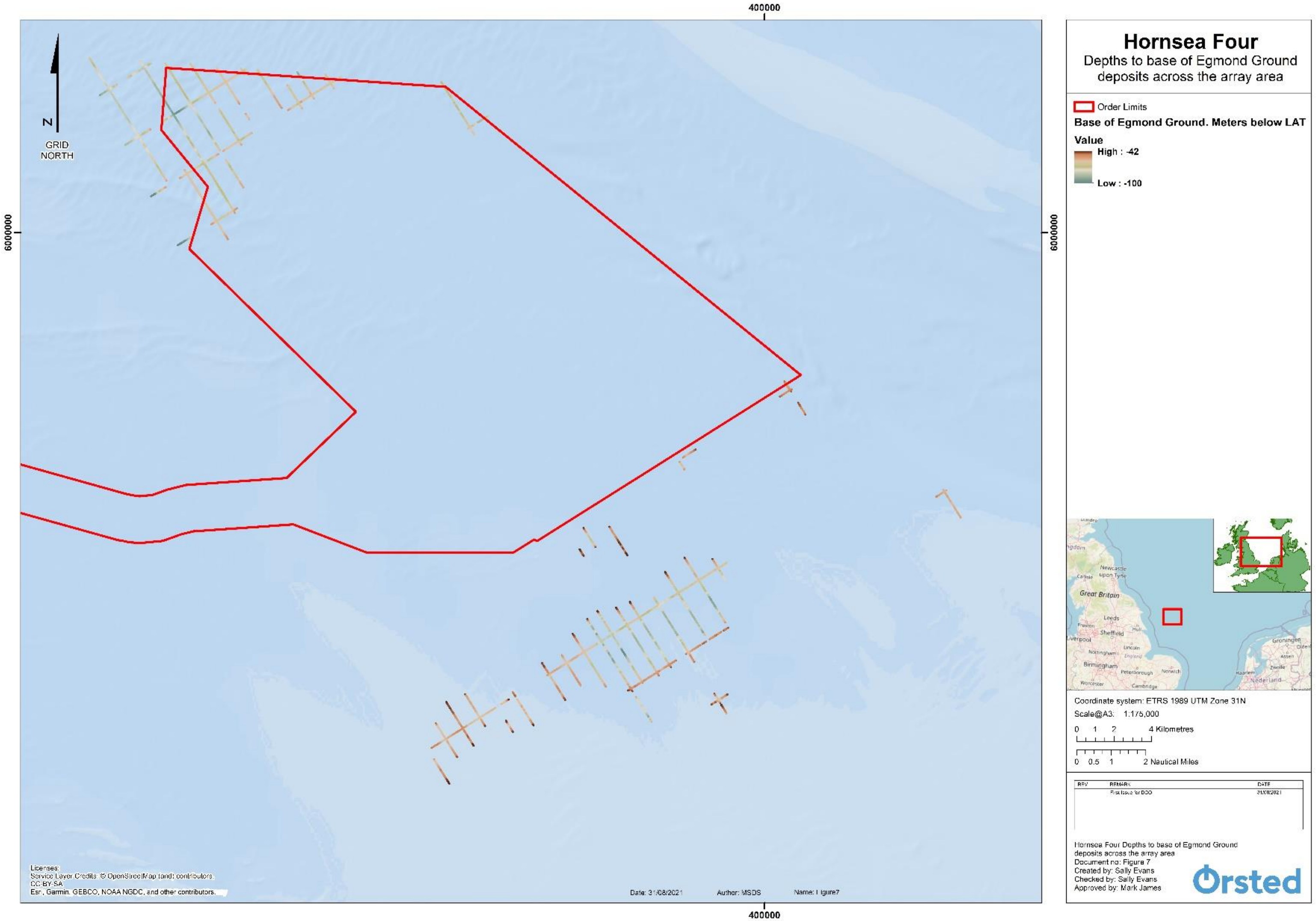

Figure 7: Depths to base of Egmond Ground deposits across the array area.

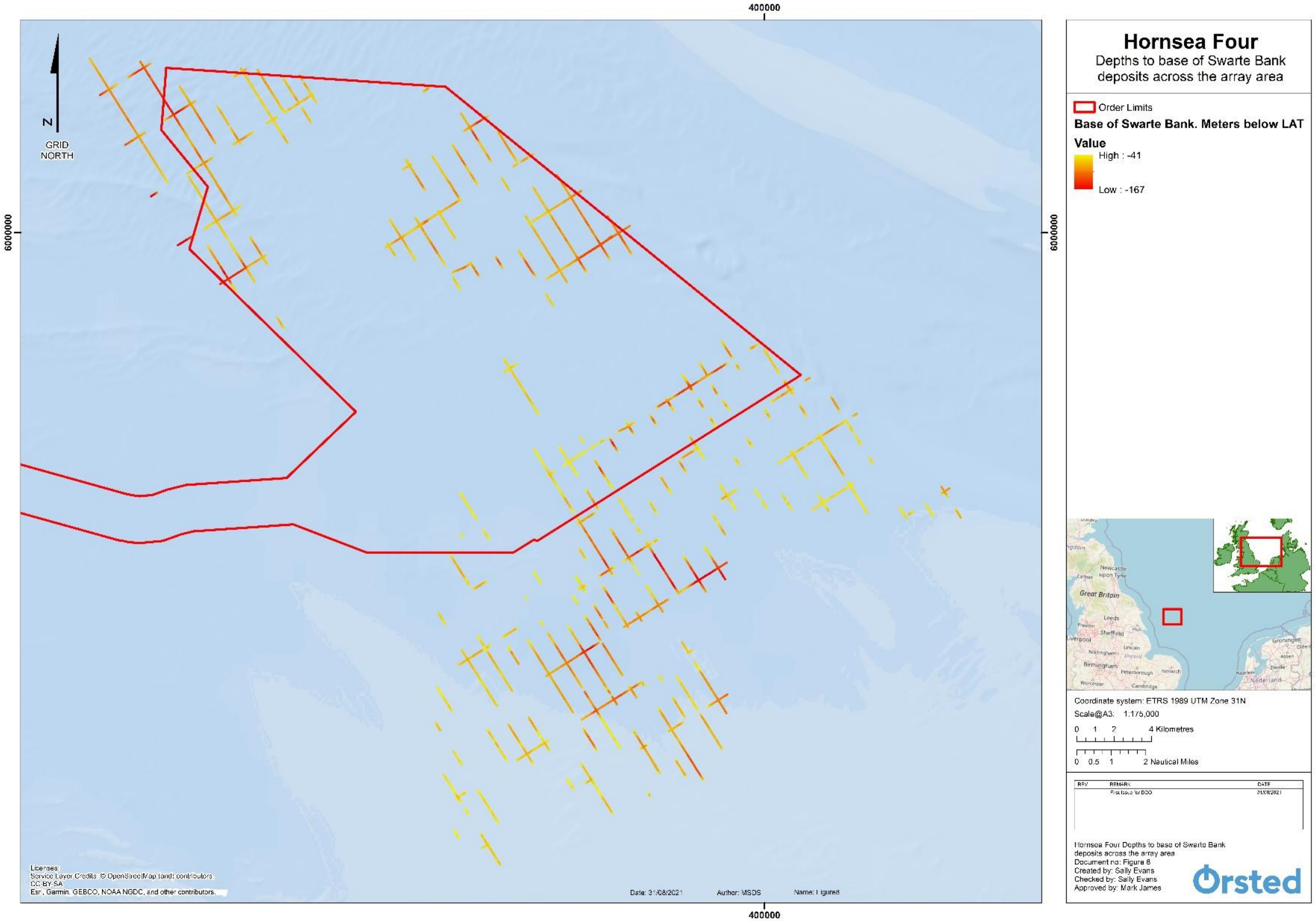

Figure 8: Depths to base of Swarte Bank deposits across the array area.

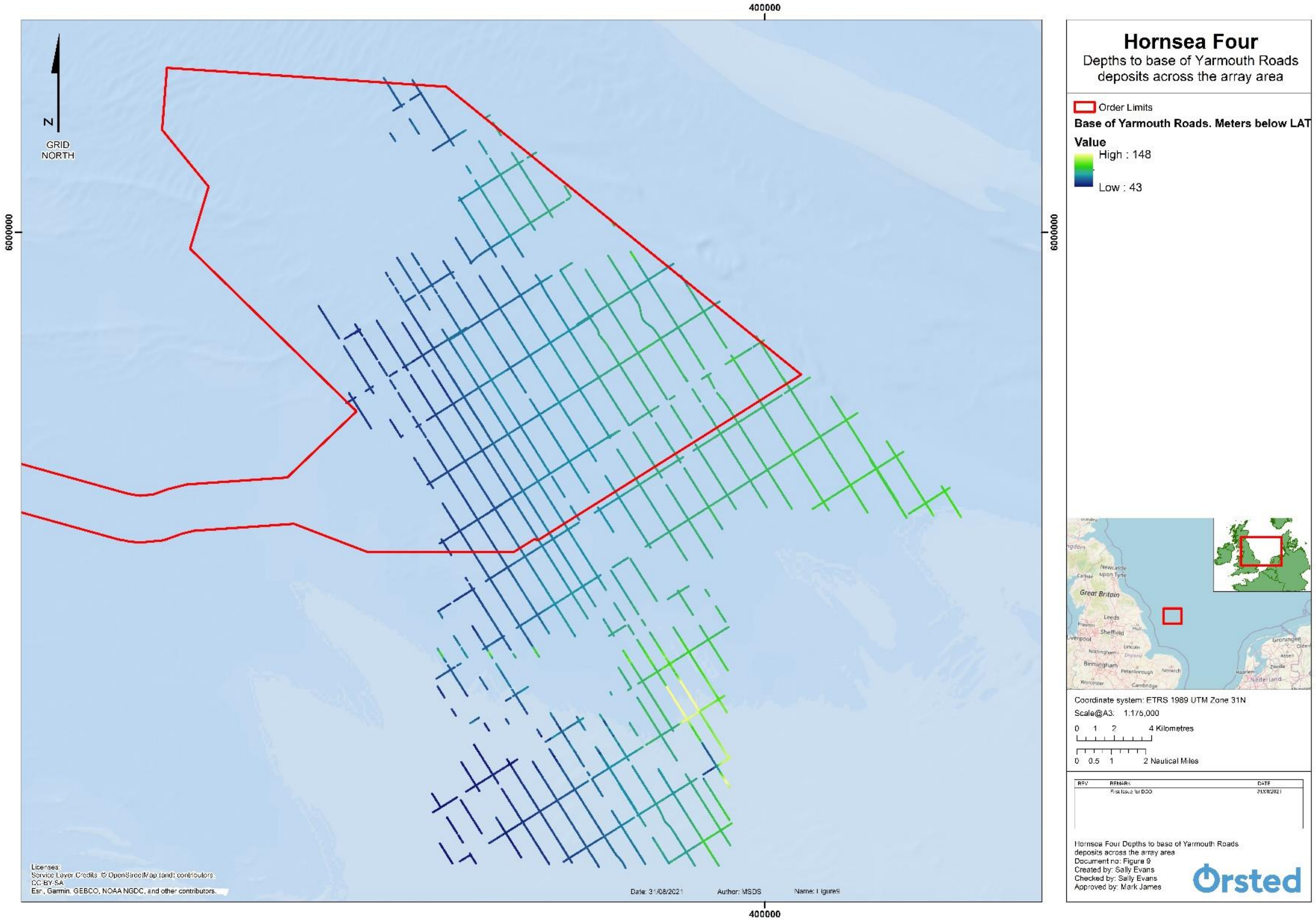

Figure 9: Depths to base of Yarmouth Roads deposits across the array area.

Export Cable Corridor

5.1.8 Interpretation of data from within the ECC has confirmed the extent and characteristics of a known seabed sand feature which is crossed by the Order Limits. This sand feature splits the ECC into two distinct regions; the inshore area and the offshore area (Figure 10). The horizons within these areas have been surveyed and mapped (Bibby Hydromap 2019; GeoSurveys 2019a, b) but as yet the specific formations have not been identified.

5.1.9 Within the inshore area six units have been defined. These include the base layer (i.e. the deepest layer identified) and five upper units. Offshore, the base layer is overlain by four units. The inshore and offshore units have not yet been correlated. The correlation between inshore and offshore units will be undertaken using data gathered as part of the geotechnical 1a campaign, and with additional seismic data which overlaps the areas, due to be collected in 2021.

5.1.10 The base layer in both the inshore and offshore areas may equate to the Bolders Bank or Yarmouth Roads formation, though this is not confirmed and will be confirmed as the ground model develops. The geotechnical 1a campaign and further seismic data due to be collected in 2021 will provide information which will be used to determine whether this is the case. Some of the upper units (such as unit 03 and 02 in the inshore area, and 11 and 12 in the offshore area) are characterised by channel incisions. Unit 01/10 is the uppermost deposit and is likely to equate to mobile seabed sediments. Professional experience of COARS and MSDS Marine shows that the mobile sediments may have channel systems of Holocene date at the base, and it is possible that undulations in the Holocene deposits may represent undulations in underlying moraines. Such depressions can form the focus for accumulation of organic sediments, and as such may have palaeoenvironmental potential. As the ground model is developed through further geophysical surveys and interpretation and the collection of geotechnical data the origin of the different deposits will be defined.

5.1.11 The depth of sediment varies along the export cable route. At the boundary between the ECC and the array area, the top of the bedrock of Mesozoic age is c. 10-20ms below seabed level.

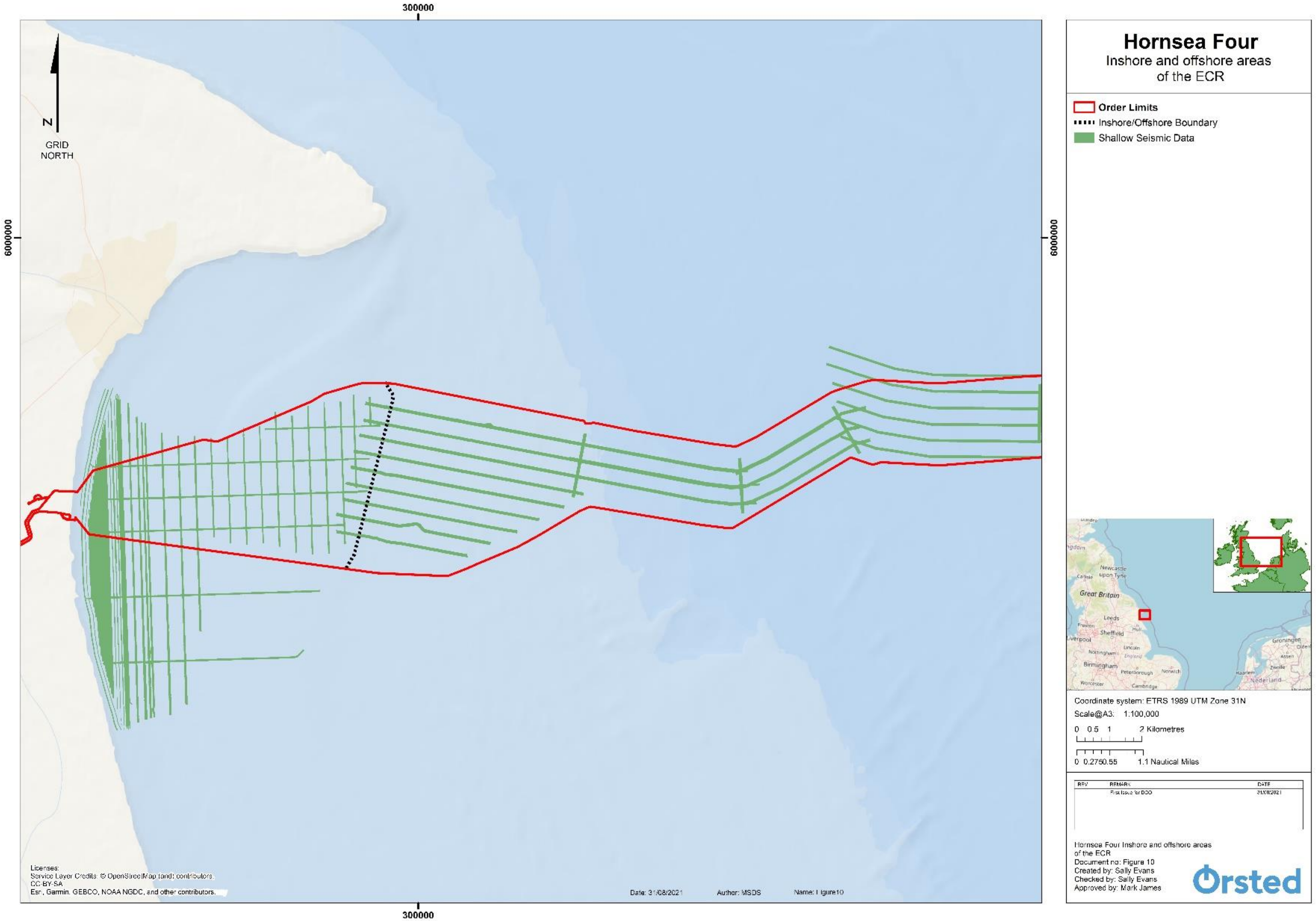

Figure 10: Inshore and Offshore areas of the ECC.

5.2 Archaeological input into geotechnical locations

5.2.1 MSDS Marine supported by Dr Michael Grant from COARS, are providing archaeological input into geotechnical work, to ensure that the Applicant works 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). This archaeological advice includes input into core locations which has been provided following a review of geophysical survey data. MSDS Marine and COARS provided input on these core locations for the array area and export cable route in a two-day workshop which took place in February 2019, and provided additional input following a revision of core locations ahead of the 2020 Geotechnical 1a campaign. The geotechnical positions which were targeted by the Geotechnical 1a campaign are mapped by Figure 11 and Figure 12, and include:

- 6 offshore boreholes, all within the array area, to depths of 30 – 45m below sea bed level. The purpose of the boreholes is to sample quaternary formations, chalk and earlier bedrock;
- 32 vibrocores up to 6m in depth including 8 within the array area and 24 along the ECC principally targeting quaternary formations;
- 36 seabed CPTs up to 6m in depth (accompanying each of the vibrocores, and at 4 additional positions) principally targeting quaternary formations; and
- 2 seabed CPTs and 4 downhole CPTs in association with boreholes to depths of 30-45m.

5.2.2 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 at this stage.

5.2.3 The deposits targeted by each core have been indicated within Table 4 below. The specific archaeological input was determined by the assessment of seismic profiles at each location. However, a key component of the overall strategy was to ensure that all deposits were targeted by geotechnical investigations which result in a physical sample. All deposits will be sampled, following this strategy, and Table 4 demonstrates which deposits will be targeted by each location. This will provide material for geoarchaeological assessment, and will enhance interpretations of the geophysical data which will feed into the ground model. The geotechnical 1a campaign has been designed to achieve this. All of the deposits will be sampled at one or more locations, to ensure all deposits and ground model interpretations have been ground-truthed. Table 4 sets out the different formations which will be targeted at each location within the array area. Figure 11 shows the positions of each core within the array area. Two locations fall outside of the current Order Limits, due to a reduction in the area covered by the Order Limits in July 2020.

Name	Type	Holocene	Botney Cut	Bolders Bank	Eem	Egmond Ground	H35	Swarte Bank	Upper Yarmouth Roads	Lower Yarmouth Roads	Chalk	Pre-Chalk
A2.05	45m BH & CPT	x		x						x	x	x
A1.13	40m BH & CPT	x						x	x	x	x	
A3.04	30m BH & CPT	x						x			x	x
A2.07	40m BH & CPT	x	x						x	x	x	
A2.02	30m BH & CPT	x										x
A4.01	30m BH & CPT	x		x						x		x
A4.02	VC & CPT	x				x		x			x	x
A1.06	VC & CPT	x					X Poss. Swarte Bank					x
A3.05	VC & CPT	x		x					x	x	x	x
A1.1	VC & CPT	x		x						x		x
A4.04	VC & CPT	x		x						x		x
A2.09	VC & CPT	x			x				x	x	x	
A4.07	VC & CPT	x				x		x		x	x	
A1.15	VC & CPT	x		x	x			x		x	x	
A2.06	CPT	x		x					x		x	x
A2.03	CPT	x		x			X Poss. Swarte Bank					x
A1.04	CPT	x										x
A1.01	CPT	x		x								x

Table 4: Summary of planned geotechnical locations in the array area and deposits to be targeted.

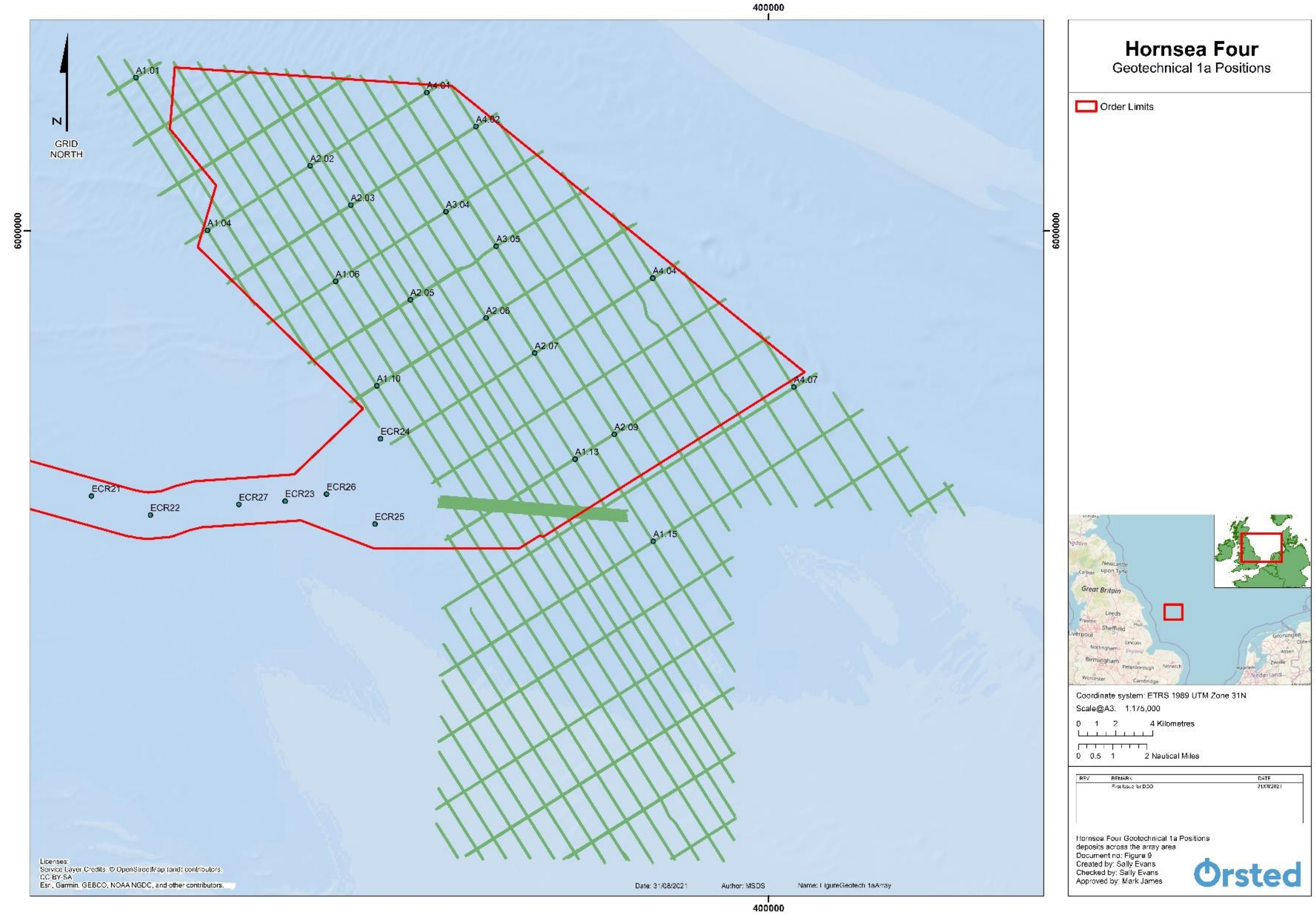

Figure 11: Geotechnical 1a positions relative to survey lines within the array area.

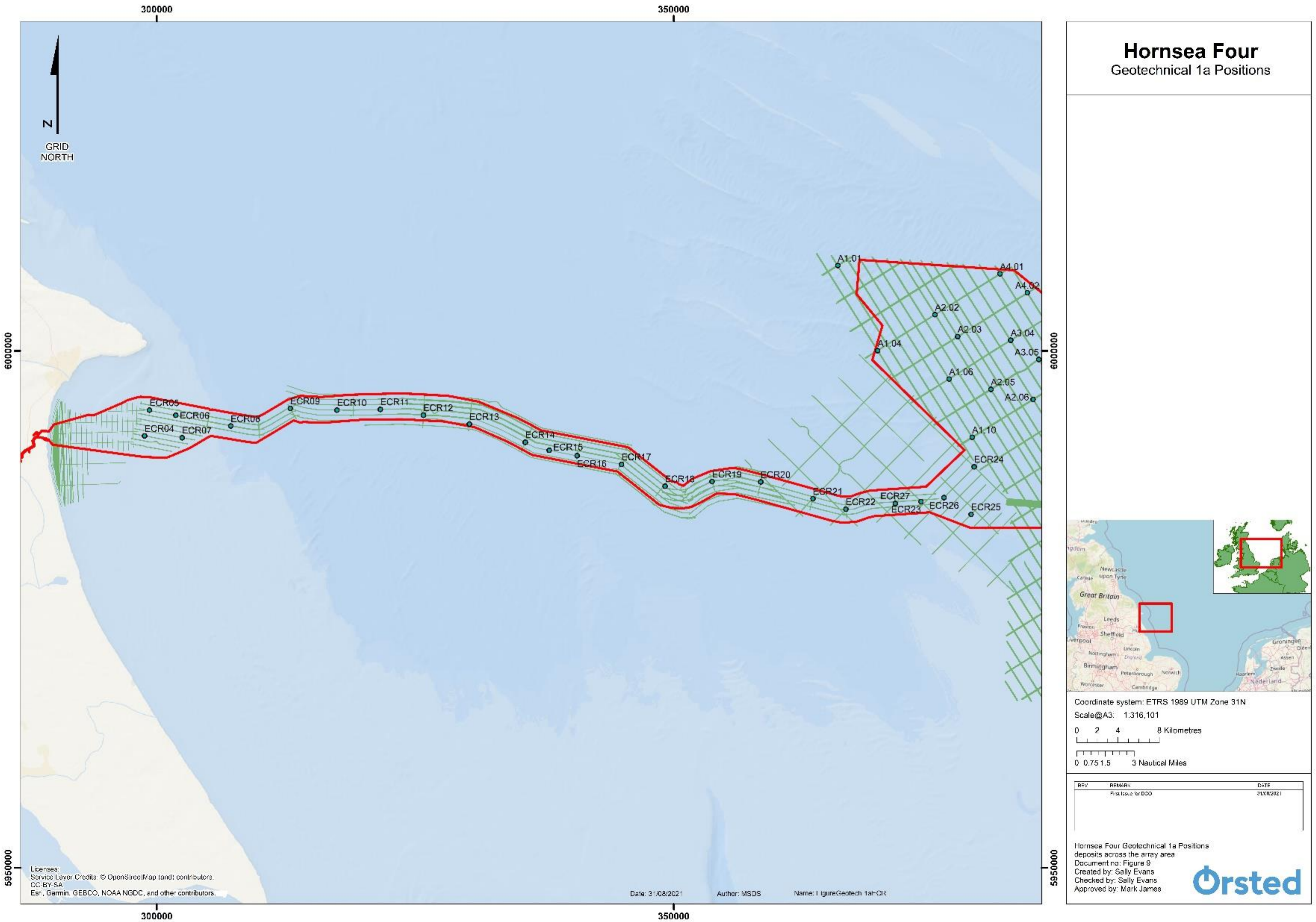

Figure 12: Geotechnical 1a positions relative to survey lines along the ECC.

5.2.4 The geotechnical 1a campaign also included the collection of vibrocores and CPT data along the offshore ECC. These locations have all had archaeological input in line with that given for the array area. The geotechnical 1a campaign included cores at *c.*5km intervals. Table 5 below indicates which deposits will be targeted by the geotechnical locations, and Figure 12 shows the location of each position.

<table>
<tr><th>New Name</th><th>OLD ID</th><th>Holocene (e.g. unit 10)</th><th>Possible very fine-grained unit</th><th>Channels (e.g. units 11 and 12)</th><th>Intermediate unit</th><th>Basal unit</th></tr>
<tr><td>ECR04</td><td>KP08X</td><td>x</td><td rowspan="5" colspan="4">Geophysical data for this area is sparse at present</td></tr>
<tr><td>ECR05</td><td>KP10X</td><td></td></tr>
<tr><td>ECR06</td><td>KP12X</td><td>x</td></tr>
<tr><td>ECR07</td><td>KP15X</td><td>x</td></tr>
<tr><td>ECR08</td><td>KP20X</td><td>x</td></tr>
<tr><td>ECR09</td><td>KP25X</td><td>x</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>ECR10</td><td>KP30</td><td>x</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>ECR11</td><td>KP35</td><td>x</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>ECR12</td><td>KP40</td><td>x</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>ECR13</td><td>KP45_2</td><td>x</td><td></td><td>x</td><td></td><td>x</td></tr>
<tr><td>ECR14</td><td>KP50_2</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td></tr>
<tr><td>ECR15</td><td>KP50_3</td><td>x</td><td>x</td><td></td><td>x</td><td>x</td></tr>
<tr><td>ECR16</td><td>KP55</td><td>x</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>ECR17</td><td>KP60</td><td>x</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>ECR18</td><td>KP65</td><td>x</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>ECR19</td><td>KP70</td><td>x</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>ECR20</td><td>KP75</td><td>x</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>ECR21</td><td>KP80</td><td>x</td><td></td><td>x</td><td>x</td><td></td></tr>
<tr><td>ECR22</td><td>KP85</td><td>x</td><td></td><td></td><td></td><td></td></tr>
<tr><td>ECR23</td><td>KP90</td><td>x</td><td></td><td>x</td><td>x</td><td></td></tr>
<tr><td>ECR24</td><td>KP95</td><td>x</td><td></td><td>x</td><td>x</td><td></td></tr>
<tr><td>ECR25</td><td>Extra 1</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>ECR26</td><td>Extra 2</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>ECR27</td><td>Extra 3</td><td>x</td><td></td><td></td><td>x</td><td>x</td></tr>
</table>

Table 5 Summary of possible geotechnical locations along the ECC and deposits to be targeted.

6.0 Archaeological and Palaeoenvironmental Potential

6.1.1 This section contains preliminary indications of possible areas of higher and lower archaeological potential. Results are likely to be revised following reporting of the geotechnical 1a survey, and future geotechnical campaigns, ongoing interpretations of SBP and seismic data (set out in Table 1 and Table 2), and refining of the ground model. From an archaeological and palaeoenvironmental perspective the geoarchaeological assessments which will accompany the geotechnical campaigns (as set out in Table 1 and Table 2 of this report, and Table 7 of the Outline Marine WSI (F2.4: Outline Marine Written Scheme of Investigation)) will draw on these updates to the ground model in their overall discussion of the palaeolandscape.

6.1.2 Overall potential is influenced by the extent and thickness of the deposits. In general, Quaternary deposits are thin within the western and northern part of the Hornsea Four array area. The northern area in particular has <10m of Quaternary deposits. Quaternary deposits are thickest in the south-eastern part of the array area, and within channel features, and thus archaeological potential is highest in these zones (Figure 13). Thicker deposits lie further south-east, beyond the Order Limits.

6.1.3 Those deposits which are thought to have heightened archaeological and palaeoenvironmental potential for *in situ* remains have been highlighted in green in Table 3. Holocene deposits which predate the marine inundation of the area, Botney Cut, Eem and Yarmouth Roads deposits are of particular interest.

6.1.4 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. The Marine Archaeology technical report associated with the Viking Link EIA also found evidence of palaeochannels within 2km of the Hornsea Four Order Limits (Figure 14; Wessex Archaeology 2017). A core taken from within one of these channels, shown on Figure 14, demonstrated that the channel fills had a fluvial origin. Radiocarbon dating demonstrated that the upper channel fills were laid down during the Mesolithic, around 9000BC, and lower fills dated to the Late Upper Palaeolithic with calibrated dates spanning 11,500-10,500 BC. There is potential for channel systems and fills of a comparable Late Devensian/Early Holocene date to be present within the Hornsea Four Order Limits. Botney cut channels have been mapped across the array area, though in particular from the southern parts of this area with less evidence for Botney cut channels to the north (see Figure 4). During the upcoming campaign, borehole 2.07 will target a Botney cut channel.

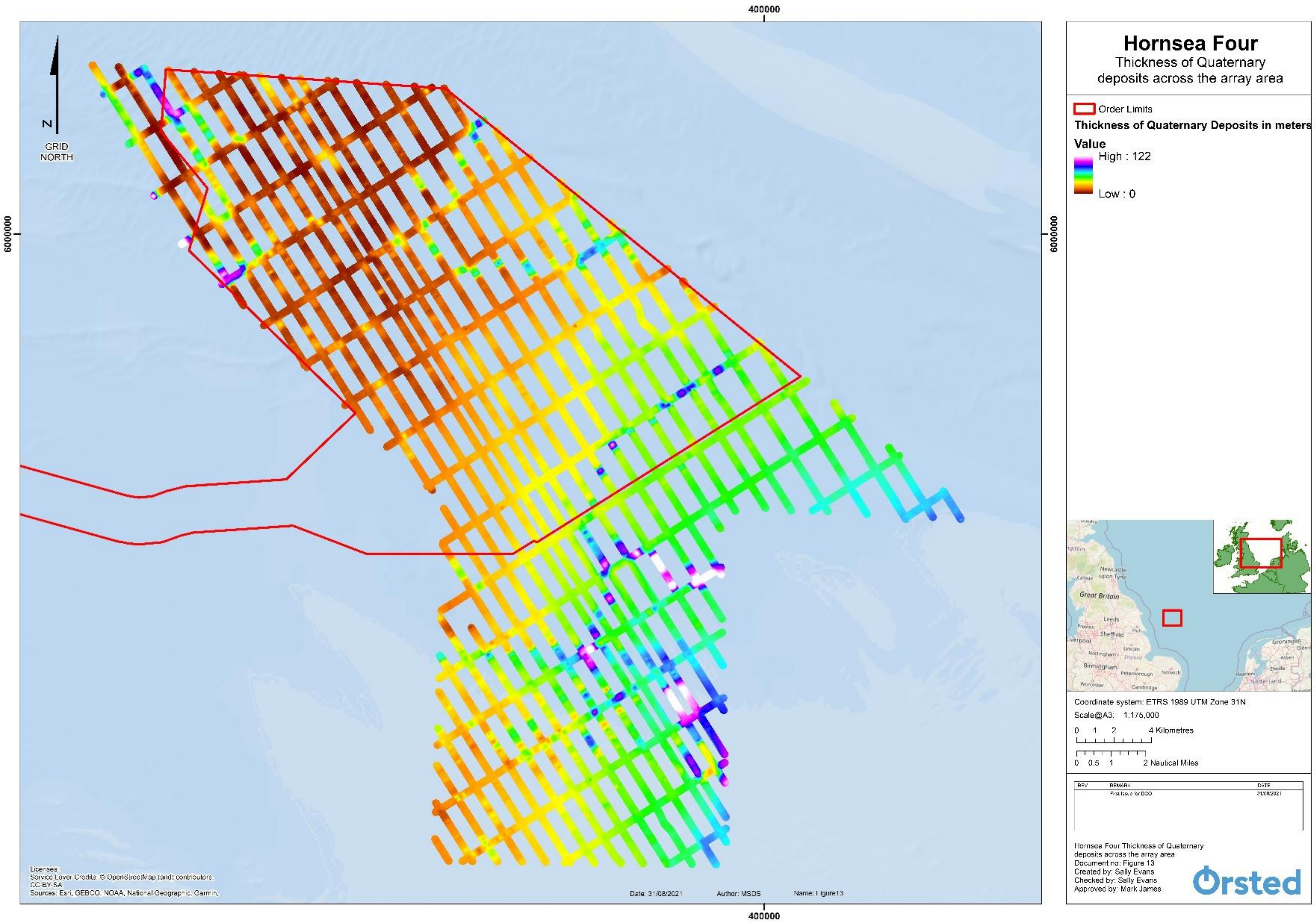

Figure 13: Thickness of quaternary deposits across the array area.

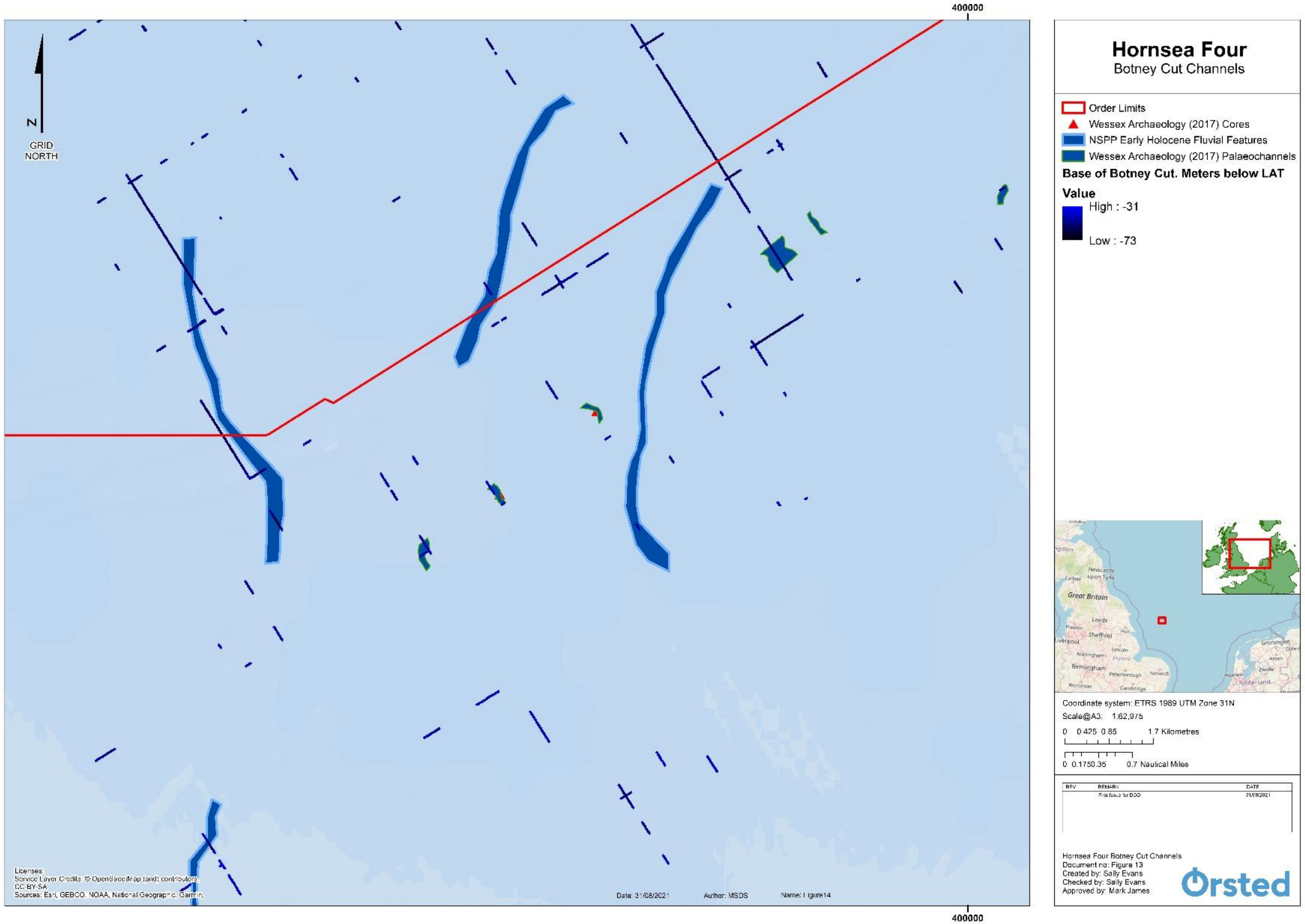

Figure 14: Botney Cut Channels.

6.1.5 The southern part of the array area includes evidence of the Eem formation (Figure 6) and Yarmouth Roads (Figure 9), though the latter also extends to the north eastern part of the array area, demonstrating the palaeoenvironmental and archaeological potential of these parts of array area. Future geotechnical campaigns, and in particular the boreholes (Table 4), will provide further insight into these deposits and their potential.

6.1.6 The Yarmouth Roads Formation is partially equated with the onshore Cromer Forest Beds sequence which have produced evidence of *in situ* archaeological and palaeoenvironmental remains dating to the Lower Palaeolithic. 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 Four array area (particularly within the southern part of the 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. It is the upper parts of the Yarmouth Road sequence that are thought to be contemporary with the Cromer Forest Beds (Wessex Archaeology 2017), and as such the upper parts of the formation, which in places have been found to hold organic remains, have particular archaeological and palaeoenvironmental potential. Uneroded surfaces in particular are associated with this potential, though in most areas the Anglian glaciation is likely to have eroded the upper layers. Within the Hornsea Four Order Limits, complex Upper Yarmouth Roads deposits have been identified, and will be targeted by boreholes 2.07 and 1.13 (though the latter has evidence of erosional surfaces), and by vibrocores and CPTs at 3.05 and 2.09, and by CPT 2.06. Lower Yarmouth Roads deposits, which in places have a complex 'layercake' signature have also been identified within the site, and will be targeted by boreholes 2.07, 4.01, 2.05, 1.13 and at Vibrocore and CPT locations 3.05, 4.04, 2.09, 4.07 and 1.15 and CPT locations 1.1 and 2.06.

6.1.7 Along the ECC, 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 export cable route at locations ECC14 and ECC15 (see Table 4 and Figure 4). Additionally, channel features or depressions have also been identified at ECC13, ECC21, and ECC23-26.

6.1.8 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.

6.1.9 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 3, with deposits of heightened potential archaeological interest including Holocene sediments, Botney cut, Eem formation and Yarmouth Roads. Additionally, although the bulk of deposits such as those which are fully marine (e.g. Holocene marine sands) or glacially derived (e.g. Bolders Bank), may not be of specific archaeological interest, sampling and dating these deposits can aid overall understanding of the changing palaeolandscape within the area such as the retreat of ice sheets and marine transgressions. Uneroded surfaces of such deposits which may have been aerially exposed may also hold archaeological potential, and archaeological finds may occur within secondary contexts.

7.0 Summary and Conclusions

7.1.1 The purpose of this report was to provide information on the palaeoenvironmental aspects of the ground model created for Hornsea Four.

7.1.2 The creation of the ground model is an iterative process. The specifications and survey methods employed by Hornsea Four will lead to the creation of a ground model with high vertical and horizontal resolution which is well placed to form the basis for understanding the palaeolandscape within the Order Limits.

7.1.3 Quaternary formations identified within the site on the basis of current evidence consist of Holocene marine sands, Botney Cut, Bolders Bank, Eem, Egmond Ground, Swarte Bank and Yarmouth Roads Formations. Pre-quaternary formations include the chalk and pre-chalk bedrock which are not of archaeological interest. The distribution of these formations within the Order Limits is set out by a series of figures within this report. Future geophysical surveys will improve the resolution in which these deposits are mapped.

7.1.4 Quaternary deposits extend across the Order Limits, although they are thickest within the southern part of the array area demonstrating a higher palaeoenvironmental and archaeological potential within this zone.

7.1.5 Botney cut channels are mapped across the array area, though with a greater concentration in the south. One channel to the south of the Order Limits has been investigated and found to have fills dating to the Late Upper Palaeolithic and Mesolithic periods (Wessex Archaeology 2017), indicating the potential for palaeoenvironmental remains of these periods within Botney Cut deposits. The southern part of the array area also has deposits of the Eem and Yarmouth Roads formations, with the latter also extending to the north-eastern part of the array area. Yarmouth roads deposits in particular appear to be extensive and thick in places, with multiple different internal reflectors indicating different phases. The Upper Yarmouth Roads deposits in particular are thought to equate to the onshore Cromer Forest Beds, which contain evidence of in situ archaeological and palaeoenvironmental remains dating to the Lower Palaeolithic, inferring the potential for comparable remains within the Order Limits where the Yarmouth Roads formation is present. Additionally, although the bulk of deposits such as those which are fully marine (e.g. Holocene marine sands) or glacially derived (e.g. Bolders Bank), may not be of specific archaeological interest, analysis of these deposits can aid overall understanding of the changing palaeolandscape within the area. Uneroded surfaces of such deposits which may have been aerially exposed may also hold archaeological potential, and archaeological finds may occur within secondary contexts.

7.1.6 The deposits identified along the ECC have yet to be interpreted, though fine- grained sediments and channel features have been identified, demonstrating areas of palaeoenvironmental potential.

7.1.7 The geotechnical 1a and future survey campaigns will target all formations identified within the Order Limits and geoarchaeological assessment which will follow will provide further insights into the palaeoenvironmental and archaeological potential of Hornsea Four.

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