RWE npower renewables

Triton Knoll Offshore Wind Farm Limited

TRITON KNOLL OFFSHORE WIND FARM

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TRITON KNOLL OFFSHORE WIND FARM
DESK-BASED ARCHAEOLOGICAL ASSESSMENT

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TRITON KNOLL OFFSHORE WIND FARM
DESK-BASED ARCHAEOLOGICAL ASSESSMENT

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Summary

0.1 Wessex Archaeology was commissioned by RWE npower renewables to carry out a desk-based assessment of the archaeological potential of the Triton Knoll Offshore Wind Farm (TKOWF). The export cable route linking the Offshore Wind Farm to shore has not yet been defined and therefore it has not been included as part of this assessment (although they are considered in relation to potential cumulative effects).

0.2 This assessment comprises an archaeological baseline study, including an archaeological assessment of geophysical and geotechnical data, and an assessment of the effects of the scheme upon archaeological receptors. This will ultimately form part of the Environmental Statement for the proposed TKOWF.

0.3 The combined results of the desk-based assessment of archaeological data sources and geophysical assessment produced a total of 147 sites of possible archaeological interest located within the study area. This comprises:

- 24 United Kingdom Hydrographic Office (UKHO) records, of which 15 have been verified with the marine geophysical data. Of the remaining nine, seven were not visible in the marine geophysical data, while two were located outside of the geophysical survey area;
- Three geophysical anomalies of anthropogenic origin and archaeological interest including: one previously unidentified wreck, one possible wreck and an area of wreck debris identified during the archaeological assessment of geophysical data;
- 120 further geophysical anomalies of potential anthropogenic origin and archaeological interest including areas of seabed disturbance, areas/items of debris, dark reflectors, bright reflectors, and isolated magnetic anomalies; and
- A number of channels of probable prehistoric date and potential archaeological interest within the sub-bottom profiler data.

0.4 The baseline study also revealed further potential for as yet undiscovered sites and material including:

- *In situ* sites and derived artefacts of prehistoric data;
- Prehistoric and later wreck material relating to documented losses and maritime activities; and

- The remains of crashed aircraft.

0.5 The impact assessment outlines the nature of the likely direct and indirect impacts on the known and potential archaeological sites during the course of the construction, operation and decommissioning of the TKOWF.

0.6 With the exception of two modern wrecks, the effects of all potential direct impacts on wrecks and geophysical anomalies of potential anthropogenic origin are judged to be of major adverse significance. The effects resulting from all potential indirect, cumulative and in-combination impacts are expected to be negligible.

0.7 It is not possible to assess the significance of impacts on potential archaeological sites as the magnitude of effects and the sensitivity of the receptor cannot be evaluated until further details regarding the presence/absence and nature of each receptor have been established. However, any damage or destruction to them will be permanent and effects are likely to be judged of major adverse significance. Each will need to be considered on a site by site basis if they are impacted by development.

0.8 Proposed mitigation measures include:

- Buffers around the extents of known wreck sites and further investigation of any identified anomalies that may be impacted by the scheme;
- Further examination of potential prehistoric deposits including Stage 3 to 5 geoarchaeological recording of core samples as they become available and archaeological input into any future sampling programme;
- In the event of impact to potential sites, the establishment of a formal protocol to ensure that any finds are promptly reported, archaeological advice is obtained, and any recovered material is stabilised, recorded and conserved;
- Watching briefs where seabed material is brought to the surface, for example during pre-lay grapnel runs or in the intertidal area during cable installation; and
- The archaeological assessment of any further geophysical survey undertaken for the TKOWF.

0.9 All mitigation measures should be detailed in a Written Scheme of Investigation once the final scheme layout has been established.

0.10 It is expected that the implementation of mitigation, based on the assessment outlined in this report will mean that the residual effects of the development on any archaeological receptors will be negligible.

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Acknowledgements

Records were provided by the United Kingdom Hydrographic Office (UKHO) and the National Monuments Record (NMR). The Ministry of Defence (MoD) was consulted regarding Protected Places and Controlled Sites under the Protection of Military Remains Act 1986.

The geophysical data were acquired by Osiris Projects and Gardline GeoSurveys Ltd.

Wessex Archaeology is grateful to the staff of all the above organisations for their co-operation during the project.

Victoria Cooper and David Howell carried out the assessment and compiled this report with contributions from Cristina Serra and Kevin Stratford. Amendments resulting from client and curator feedback were made by Andrea Hamel. Kitty Brandon prepared the illustrations. Euan McNeill managed the project for Wessex Archaeology and quality assurance was conducted by Steve Webster.

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1 INTRODUCTION

1.1 PROJECT BACKGROUND

1.1.1 Wessex Archaeology (WA) was commissioned by RWE npower renewables, to carry out a desk-based assessment (DBA) of the archaeological potential of the Triton Knoll Offshore Wind Farm (TKOWF). The site is located in the southern North Sea c. 33km off the Lincolnshire coast and 48km off the North Norfolk coast (**Figure 1**). The export cable route linking the Offshore Wind Farm to shore has not yet been defined and therefore it has not been assessed here (although they are considered in relation to potential cumulative effects).

1.1.2 The DBA comprised an archaeological baseline study for the TKOWF site including an archaeological assessment of marine geophysical data collected by Osiris Projects between July and October 2008 and Gardline GeoSurveys Ltd in 2009.

1.1.3 The DBA also included an assessment of the effects of the scheme upon the archaeological resource and will ultimately form part of the Environmental Statement (ES) for the TKOWF.

1.2 AIMS AND OBJECTIVES

1.2.1 The aims of this archaeological assessment were to review the known and potential archaeological receptors within the area that will be subject to impact from development and to propose mitigation. The objectives of the archaeological assessment were:

- To set out the statutory, planning and policy context relating to the historic environment within the study area;
- To provide an overview of the historic environment in the Offshore Wind Farm Study Area, based on existing archaeological records and secondary sources;
- To highlight known maritime sites that may be impacted by the proposed development, with particular reference to:
- Submerged prehistoric sites and derived artefacts;
- Shipwrecks, crashed aircraft and wreck material; and
- Geophysical anomalies of anthropogenic origin.
- To summarise the potential for the presence of hitherto unknown sites that may be impacted by the proposal, with particular reference to:

- Submerged prehistoric sites and derived artefacts;
- Palaeo-environmental features and deposits;
- Recorded losses of vessels and aircraft;
- Secondary sources related to volume and character of shipping; and
- To assess the effects of the TKOWF upon the known and potential archaeological receptors, evaluate the significance of the effects and outline mitigation measures to avoid, reduce, remedy or offset the identified effects.

1.3 LEGISLATIVE BACKGROUND

1.3.1 The Offshore Wind Farm Study Area lies within the UK continental shelf and UK Exclusive Economic Zone, outside England's territorial waters (up to 12 nautical mile limit from the low water mark).

1.3.2 Within England's territorial waters the UK has jurisdiction with regard to heritage. The continental shelf is governed by international legislation and guidance.

1.3.3 An outline of legislation, policy and guidance relevant to the marine historic environment can be found in **Appendix I**. This includes reference to:

- Protection of Wrecks Act 1973;
- Protection of Military Remains Act 1986;
- Ancient Monuments and Archaeological Areas Act 1979;
- Merchant Shipping Act 1995;
- Policy Statement 5: Planning for the Historic Environment 2010;
- Relevant codes of practice and guidance for seabed developers and the offshore renewable energy sector;
- Relevant guidance for coastal and seabed archaeology; and
- Relevant international conventions and treaties.

2 METHODOLOGY

2.1 INTRODUCTION

2.1.1 This assessment was carried out in a manner consistent with available guidance, including the Joint Nautical Archaeology Policy Committee (JNAPC) Code of Practice for Seabed Development, Historic Environment Guidance for the Renewable Energy Sector (Wessex Archaeology 2007), Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy (Oxford Archaeology 2008), National Policy Statements EN-1 and EN-3 (Department of Energy and Climate Change 2010a & b) and the Institute for Archaeologists' (IfA) Standard and Guidance for Desk-Based Assessment (Institute for Archaeologists 2008).

2.1.2 Although much of this assessment was derived from secondary sources this DBA also incorporated the archaeological interpretation of primary geophysical data. The methodology is outlined below.

2.2 STUDY AREA

2.2.1 The study area consists of the TKOWF site boundary plus a 1 km buffer (**Figure 2**). The buffer ensures that archaeological sites close to or just beyond the boundaries of the scheme, which might be affected by the development, are included in the assessment. Assessments of onshore works, the landfall location and a cable route corridor between the TKOWF are not included in this report.

2.2.2 Reference was also made to the wider region beyond the Study Area to provide context for the archaeological and historic environment of the area that will be affected by the proposed TKOWF.

2.3 DESK - BASED ASSESSMENT

2.3.1 The archaeological baseline was established through searches of third party data sources, from published and other readily available sources and by reviewing the results of marine geophysical surveys undertaken for the TKOWF.

2.3.2 Third party searches were carried out to obtain data concerning known sites (including ship and aircraft wrecks) and for documented losses (casualties) from the following sources:

- National Monuments Record (NMR) maintained by English Heritage;
- United Kingdom Hydrographic Office (UKHO);
- The Lincolnshire Historic Environment Record (HER);
- The Receiver of Wreck; and
- The Ministry of Defence (MoD) with respect to the Protection of Military Remains Act.

2.3.3 Further information was obtained from published sources and available unpublished reports relevant to the study area.

2.3.4 All records of known sites were combined into a gazetteer and plotted using the ArcGIS 9.3 Geographical Information System (GIS) software package. The Universal Transverse Mercator (UTM Zone 31N) co-ordinate system, based on the WGS84 datum, was used throughout. All records of known wrecks are listed in **Appendix II** and illustrated in **Figure 2**.

2.3.5 The use of GIS allowed spatial comparison of the data in relation to mapping, charts and bathymetry and facilitated interpretation of the known sites with respect to the available secondary sources.

2.3.6 Documentary information was compiled in a paper archive and used qualitatively to inform the archaeological baseline.

2.3.7 The archaeological baseline also included a discussion of the potential for discovering additional unknown archaeological remains, including:

- Shipwrecks and crashed aircraft; and
- Prehistoric landscapes and the artefacts and remains associated with them.

2.3.8 Archaeological potential was assessed both for individual sites and for groups of sites and for landscapes.

2.3.9 As the Lincolnshire HER data does not extend into the marine environment these sites were not incorporated into the project gazetteer and GIS but were used qualitatively to illustrate potential within the intertidal zone and offshore.

Chronology

2.3.10 The age of archaeological events which occurred within the Palaeolithic period are defined in terms of years Before Present (BP). The BP time scale is predominantly used to report raw radiocarbon ages which cannot be directly correlated with a calendar date due to the inconsistency of ^{14}C levels in the atmosphere. BP dates are commonly calculated in years before 1950.

2.3.11 During the Mesolithic period, radiocarbon dates can be correlated with a calendar date and from this period onwards, absolute (or calendar) dates are used, either Before Christ (BC) or *Anno Domini* (AD).

2.4 MARINE GEOPHYSICAL ASSESSMENT

2.4.1 Marine geophysical surveys for TKOWF were undertaken by Osiris Projects in 2008 and by Gardline GeoSurveys Ltd in 2009.

2.4.2 The aim of this assessment was to carry out an archaeological interpretation of the marine geophysical data acquired from the survey areas. The objectives were:

- To assess geophysical data in order to identify any material of archaeological interest lying within the limits of the survey areas;
- To locate, identify and characterise any previously unrecorded archaeological sites, and confirm the presence and condition of any known sites within the survey areas;
- To identify the presence of any sedimentary deposits of archaeological potential; and
- To propose future mitigation for material of archaeological interest within the survey areas.

2.4.3 The technical specifications and processing methodology for each of the marine geophysical surveys are outlined in **Appendix III**.

Data Audit

2.4.4 Although the data were not collected specifically for archaeological purposes, the audit considered the datasets suitable for archaeological assessment and interpretation. The data were assessed for quality and were rated as good to average using the criteria listed in **Table 1**.

Table 1: Criteria for assigning data quality rating

Data Quality	Description
Good	Data which are clear and unaffected by weather conditions or sea state. The dataset is suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provide the highest chance of identifying wooden wrecks and debris.
Average	Data which are affected by weather conditions and sea state to a slight or moderate degree. The dataset is suitable for the identification and partial interpretation of standing and partially buried metal wrecks, and the larger elements of their debris fields. Wooden wrecks may be visible in the data, but their identification as such is likely to be difficult.
Variable	This category contains datasets with the quality of individual lines ranging from good to average to below average. The dataset is suitable for the identification of standing and some partially buried metal wrecks. Detailed interpretation of the wrecks and debris field is likely to be problematic. Wooden wrecks are unlikely to be identified.

2.4.5 The Osiris Projects survey was carried out between July and October 2008 on board MV *Freja* and MV *Barinthus*. The geophysical datasets consisted of sidescan sonar, sub-bottom profiler (boomer), swathe bathymetry and magnetometer data.

2.4.6 The data audit considered the data quality to be 'good' on the basis that the data were clear and unaffected by weather conditions or sea state. The datasets were suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provided the chance of identifying wooden wrecks and debris.

2.4.7 The Gardline GeoSurveys Ltd survey was carried out between the 17th June and 4th August 2009 on board MV *Confidante*. The geophysical datasets consist of sidescan sonar, sub-bottom profiler, swathe bathymetry and magnetometer data.

2.4.8 The data audit considered the data quality to be 'average' to 'good'. A particular issue which adversely affected the quality of the sidescan sonar data were the weather conditions encountered during surveying. This resulted in 'snatching' on many of the sidescan sonar records, though the affect has not been detrimental to the data to a severe degree.

Interpretation

2.4.9 During the initial stage of interpretation anomalies were ascribed an archaeological 'flag' in order to record the geophysicists' initial assessment of the sidescan sonar anomaly. These 'flags' were ascribed as described in **Table 2**.

2.4.10 The form, size and/or extent of an anomaly is a guide to its potential to be an anthropogenic feature, and therefore of its potential archaeological interest. A single, small, but prominent anomaly may be part of a much more extensive feature that is largely buried. Similarly, a scatter of minor anomalies may define the edges of a buried but intact feature, or it may be all that remains as a result of past impacts from, for example, dredging or fishing. The application of a ratings system is therefore a means of prioritising sites in order to inform further stages of the interpretation process, and on its own is not definitive.

Table 2: Criteria for assigning archaeological potential rating

Flag	Description
High	Ascribed only where the geophysical anomalies clearly represent a wreck site or were very near to a previously known site.
Medium	Geophysical anomalies with no directly corroborating data but being of a size, shape or amplitude such as to suggest that they possibly relate to archaeological sites or features.
Low	Small, isolated, geophysical anomalies of uncertain origin, which are likely to be 'artefacts' in the data or natural features.
Very low	Anomalies that are known or are highly likely to be of modern origin, and which are Non-archaeological (e.g. moorings, etc)

2.4.11 The resulting anomalies of archaeological interest were assessed, compared with existing records of wrecks and obstructions obtained from the UKHO and NMR and grouped into sites using GIS. This process provided a unique ID number to be assigned to a single site (sometimes encompassing multiple anomalies and records).

2.4.12 When a known site was identified in the marine geophysical datasets the grouping and association with UKHO recorded losses was based on a comparison of UKHO site description and anomaly description and the distance separating them. A geophysical anomaly interpreted as a probable wreck site was matched to a UKHO wreck loss if it was within a 100m radius of the UKHO position. If the distance was between 100-150m the match was considered possible and open to further investigation.

2.4.13 The shallow seismic data were studied in order to detect any in-filled palaeo-channels, ravinement surfaces and peat/fine-grained sediment horizons that may be of archaeological interest. Features within the Triton Knoll survey areas were mapped and digital images created for illustration purposes.

2.4.14 The position and dimensions of any small reflectors which appeared to be buried material, such as a wreck site covered by sediment, were recorded into the gazetteer and an image of each anomaly acquired (**Appendix II**). It should be noted that anomalies of this type are rare as the sensors must pass directly over such objects in order to produce an anomaly.

2.4.15 Once all the geophysical anomalies and desk-based information had been grouped a discrimination flag was added to the record in order to discriminate against those which were not thought to be of an archaeological concern, using the criteria described in **Table 3**.

Table 3: Criteria for discriminating relevance of feature to proposed scheme

Non-Archaeological	U1	Not of anthropogenic origin
	U2	Known non-archaeological feature
	U3	Non-archaeological hazard
Archaeological	A1	Anthropogenic origin of archaeological interest
	A2	Uncertain origin of possible archaeological interest
	A3	Historic record of possible archaeological interest with no corresponding geophysical anomaly

2.4.16 All geophysical anomalies of known or possible archaeological potential are listed in **Appendix II** and illustrated in **Figure 2**.

2.4.17 The grouping and discrimination of information at this stage is based on all available information and is not definitive. It allows for all features of potential archaeological interest to be highlighted, while retaining all the information produced during the course of the geophysical interpretation and desk-based assessment for further evaluation should more information become available.

2.5 IMPACT ASSESSMENT

2.5.1 The methodology for this assessment takes account of guidelines set out in the COWRIE documents Historic Environment Guidance for the Offshore Renewable Energy Sector (Wessex Archaeology 2007) and Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy (Oxford Archaeology 2008). It also takes into account guidelines established by the National Policy Statements EN-1 and EN-3 (DECC 2010a & b).

2.5.2 There is a specific requirement to address the historic environment as part of the Environmental Impact Assessment (EIA) process. The requirements of EIA are defined in European Council Directives on Environmental Assessment 85/3378/EEC (amended in 1997 by Directive 97/11/EC), DETR Circular 02/99 Environmental Impact assessment and in *Explanatory Memorandum to The Marine Works* (*Environmental Impact Assessment Regulations 2007 No. 1518* prepared and issued by Defra.

2.5.3 The guiding principles for cultural heritage in EIA are presented in the COWRIE guidance (Wessex Archaeology 2007) and include:

- Assessing all beneficial and adverse effects on the cultural heritage resource, including direct, indirect, temporary, permanent and cumulative effects;
- Evaluate the significance of any effects on the cultural heritage resource to take account of both the intrinsic value of the resource and how much it will be changed;
- Use relevant international, national and local legislation and policy to explain the significance, and make explicit the basis for any statements concerning value or importance of a cultural heritage receptor;
- Consider a variety of approaches to mitigation, including design modification, appropriate investigation and recording measures; and
- Propose realistically achievable mitigation measures and fully monitor and document any agreed actions, including responsibility for their implementation.

2.5.4 The Rochdale Envelope approach is used as it produces a maximum impact assessment, giving flexibility to the developer to cope with the uncertainties, and giving security to DECC, the Infrastructure Planning Commission and other determining bodies that the environmental impact of the project would be no greater than that set out in this document. The Infrastructure Planning Commission, established in October 2009 under the Planning Act 2008, works to streamline the planning system for nationally significant infrastructure projects.

Significance

2.5.5 The potential effects of the TKOWF were assessed by evaluating the magnitude of impact against the sensitivity of the receptor.

2.5.6 In determining the magnitude of any given impact, the following have been considered:

- Spatial extent of the effect;
- Duration of the effect; and
- Frequency of the effect.

2.5.7 In terms of the sensitivity of the receptor, the following have been considered:

- Vulnerability of the receptor;
- Recoverability of the receptor; and
- Value/Importance of the receptor.

2.5.8 The value/importance of an archaeological receptor was assessed by examining the receptor's age, type, rarity, survival and/or condition, fragility and/or vulnerability, group value, documentation, associations, scientific potential and outreach potential. These factors helped to characterise a site

or feature, to assess how representative it was in comparison to other similar sites, and to assess its potential to contribute to knowledge, understanding and outreach. In most cases, statutory protection is only provided to a site or feature judged to be an above average example in regard to these factors.

2.5.9 The significance of an effect was assessed by combining the evaluations of the magnitude of a potential impact and the sensitivity of the feature affected as indicated in **Table 4**.

Table 4: Matrix of magnitude of impact and value/sensitivity of receptor used to derive the significance of effect

Magnitude of Impact		Significance of Effect		
	High	*Moderate*	*Moderate/Major*	*Major*
	Medium	*Minor/Moderate*	*Moderate*	*Moderate/Major*
	Low	*Negligible*	*Moderate*	*Moderate*
		Low	**Medium**	**High**
		Value and sensitivity of receptor		

2.5.10 The definitions of significance from the above matrix are outlined in **Table 5**.

Table 5: Definitions of significance used within this environmental statement

Significance	Definition
Negligible	Very slight change from baseline condition. Change barely distinguishable, approximating to the "no change" situation.
Minor Adverse	The effect is undesirable but of limited concern.
Moderate Adverse	The effect gives rise to some concern but it is likely to be tolerable (depending on its scale and duration).
Major Adverse	The impact gives rise to serious concern and is judged unacceptable
Minor Beneficial	The effect is of minor significance but has some environmental benefits.
Moderate Beneficial	The effect provides some gain to the environment.
Major Beneficial	The effect provides a significant positive gain to the environment.

2.5.11 It is generally accepted, in the case of archaeology, the unmitigated effects on the receptors are likely to be judged of 'major adverse' significance giving rise to 'serious concern and judged as unacceptable'. As an irreplaceable and non-renewable resource, archaeology and cultural heritage is highly sensitive to change and any impacts which damage or disrupt the receptor or its relationship with the wider environment will be permanent and negative. Recovery is limited to stabilisation or re-burial, limiting further impact.

2.5.12 In addition, it is often not possible to assess the importance of a receptor. For example, if the identity of a shipwreck is unknown, or there are a number of possibilities, its importance remains an unknown or can only be poorly defined. In such cases the importance of the receptor must be regarded as high until further data indicates otherwise.

2.5.13 The result is that frequently, in the case of an archaeological receptor, the significance of effect will be a combination of high magnitude impact against a high or medium sensitivity/value receptor. This will typically give rise to a major or moderate/major adverse effect.

2.5.14 However, a range of well tried mitigation options exist in relation to archaeology which can reduce the magnitude of the impact and thus reduce the significance of the effect to an acceptable level. The preferred method of mitigation is avoidance through the implementation of buffers around known archaeological features. In addition, the archaeological assessment of geological samples from cores to offset damage to sediments likely to contain prehistoric material and the use of finds protocols may be conditions of development. Archaeological assessment of any marine geophysical surveys, taken during the course of the development and its operational life, could enable the success of the mitigation strategies to be monitored.

Cumulative Impacts

2.5.15 The need to consider cumulative impacts is a requirement of the EIA process and was carried out in line with existing COWRIE guidance on cumulative impacts (Oxford Archaeology 2008). For the purpose of the Triton Knoll project, cumulative refers to all other wind farm projects and other marine projects, for example marine aggregate extraction. Projects included in the cumulative assessments are:

- Existing and planned Round One and Round Two offshore wind farms;
- Marine aggregate extraction licensed and proposed sites;
- Commercial fisheries activity;
- Subsea cables and pipelines, including the Triton Knoll export cables; and
- Oil and gas infrastructure and operations.

2.5.16 Previous developments have typically taken an avoidance approach to archaeology, so cumulative effects may be limited, although the potential exists.

2.6 CONSULTATION

2.6.1 RWE npower renewables received initial scoping comments from the archaeological curator, English Heritage, on 27 February 2009 and a scoping opinion from the IPC in September 2011 (incorporating comments from English Heritage).

2.6.2 The concerns expressed by English Heritage have been addressed in the desk-based and impact assessment presented in this report, broadly:

- Seabed forms and the archaeological assessment of geophysical data;

- Cumulative impacts;
- Future archaeological assessment of geophysical data;
- Written Scheme of Investigation; and
- Construction exclusion zones.

3 ARCHAEOLOGICAL BASELINE: PREHISTORY

3.1 INTRODUCTION

3.1.1 Current research indicates that hominin (humans and their early ancestors) populations were present in Britain from c. 700,000 BP, the start of the British Palaeolithic (Parfitt *et al* 2005). The Lower and Middle Palaeolithic saw the gradual evolution of an archaic human lineage from *Homo heidelbergensis,* through to *Homo neanderthalensis* (neanderthals) c.35,000 BP (Wenban-Smith 2002). Between 35,000-15,000 BP the neanderthals were gradually replaced in the UK and NW Europe by anatomically modern humans (*Homo sapiens*), a change which corresponds with the Upper Palaeolithic.

3.1.2 During this period the Offshore Wind Farm Study Area has been shaped by numerous periods of glaciation and marine transgressions and regressions, with oscillating periods of seafloor exposure as well as periods of ice coverage or marine inundation. Ice sheets would have affected the landscape through erosion by glaciers and glacial outwash and as a consequence of the three major glaciations over the past 700,000 years there have been long periods when this area and the North Sea Basin were exposed land with melt-water river channels and a rich ecosystem suitable for human occupation (Wenban-Smith 2002).

3.1.3 The Quaternary geology of the Offshore Wind Farm Study Area and the central North Sea in general reflect these repeated glacial / interglacial cycles with episodes of lodgement and ablation till deposition punctuated by episodes of erosion by glacial outwash and deposition of shallow marine sediments (Cameron *et al* 1992). Sequences are generally separated by marked erosion surfaces created by repeated ice sheet advance.

3.1.4 Sea level curves indicate that a gradual increase in sea level would have totally submerged the Offshore Wind Farm Study Area by c. 7,000 BP (Jelgersma 1979). As sea levels continued to rise the area between the Offshore Wind Farm Study Area and what is now the coast would have become increasingly inundated with only the current near-shore portion exposed by the later prehistoric period.

3.1.5 The erosive power of this most recent marine transgression will have been much less than during the previous glacial advances, so the potential remains for the preservation of relict land surfaces, post dating the last glacial maximum, across the survey area.

3.1.6 The Pleistocene deposits are overlain by a relatively thin sequence of Holocene seabed sediments of gravelly sands and sandy gravels. These generally form a relatively thin veneer over the underlying geology; though can thicken into areas of sand waves in isolated patches in the vicinity of the Offshore Wind Farm Study Area (Cameron *et al* 1992).

3.1.7 Assessment of the Triton Knoll sub-bottom profiler and geotechnical data has revealed deposits and features associated with periods of possible human

activity. The sections below discuss these results and outline the potential for the discovery of archaeological sites and material.

3.2 SUB-BOTTOM PROFILER AND GEOTECHNICAL RESULTS

Summary

3.2.1 An analysis of the shallow geology of the Offshore Wind Farm Study Area has been interpreted from the marine geophysical data, BGS boreholes and geology maps and reports (Cameron *et al* 1992, unpublished survey reports (Gardline GeoSurvey 2009; Osiris Projects 2009) and the results of borehole analysis undertaken for the TKOWF (Fugro GeoConsulting 2009; Wessex Archaeology 2009a, 2010).

3.2.2 Although the underlying shallow geology can be complex, the broad geological sequence can be summarised as follows in **Table 6**.

Table 6: Units identified within the sub-bottom profiler data

Unit	Description
6	Holocene gravelly sands / sandy gravels
5	Late Devensian till overlain by pebbly glaciolacustrine / glaciomarine muds (Botney Cut Formation)
4	Devensian sandy gravelly till (Bolders Bank Formation)
3	Hoxnian marine sand with layers of laminated clay (Egmond Ground Formation)
2	Early Hoxnian shallow marine laminated clays and silts with frequent organic material (Sand Hole Formation).
1	Upper Cretaceous (Campanian) Chalk

3.2.3 The sequence itself is often quite difficult to define, with the units generally being relatively thin and often containing laterally continuous internal reflectors.

3.2.4 Lying unconformably on top of the Cretaceous Chalk bedrock, the Sand Hole Formation is a shallow marine deposit of Early Hoxnian age (c. 420,000 BP). The age, location and composition of the unit indicate that it is potentially archaeologically important. The estimated age of the Sand Hole Formation, during the Hoxnian interglacial, coincides with a number of Lower Palaeolithic sites in Britain, mostly found associated with river deposits.

3.2.5 The Sand Hole Formation is laterally confined to a relatively small area of the Central North Sea (Cameron *et al* 1992), suggesting a localised area of low topography towards and into which fluvial systems would have naturally drained. This increases the possibility for both *in situ* and re-deposited archaeological material to be present both within the unit and around the area where it is found. In addition, the unit comprises fine laminated clays and silts, and has been shown to frequently contain preserved organic material (Fugro GeoConsulting 2009; Wessex Archaeology 2010), potentially important for dating and palaeo-environmental reconstruction purposes.

3.2.6 Overlying the Sand Hole Formation, the Egmond Ground formation represents a continuous transition from shallow to open marine conditions. This unit has again been identified by both geophysical data and ground truthing on the main wind farm site. As with the Sand Hole Formation,

Egmond Ground was deposited during the Hoxnian interglacial and so has the potential to contain both re-deposited archaeological material and *in situ* material where the marine transgression inundated previous land surfaces. However, due to its generally sandy composition, this formation is less likely to contain preserved palaeo-environmental evidence, though the occasional clay layers have been shown to contain some organic material (Fugro GeoConsulting 2009; Wessex Archaeology 2010).

3.2.7 Osiris Projects reported a large channel system present within the Egmond Ground formation, trending NNE – SSW across the western edge of the main wind farm site, which contained 'bank' deposits (Osiris Projects 2009). A continuation of this channel into the extended survey area to the north of the Offshore Wind Farm Study Area (**Figure 1**) cannot be identified by WA in the Gardline GeoSurveys data.

3.2.8 Overlying the Egmond Ground Formation lie the Devensian glacial till deposits of the Bolders Bank Formation. It has been suggested that Bolders Bank is a composite deposit, comprising a lodgement and an ablation till; Cameron *et al* 1992, and in some areas of the site this division has been identified in the geophysical data as a consistent internal reflector. The unit has been identified both on the geophysical data and by ground truthing on the main wind farm site (Fugro GeoConsulting 2009).

3.2.9 The Bolders Bank Formation has been observed to contain numerous sub and supra-glacial channel deposits at two different levels, one at the base of the formation and one at the internal reflector mentioned previously. These are generally NNE – SSW trending features, and are expected to contain similar sediments to the rest of the Bolders Bank unit (**Figure 3**).

3.2.10 As a sub-glacial deposit, Bolders Bank is of very low archaeological importance as it represents a period of time when the survey areas were either covered in ice, prohibiting human activity or close to the ice margin where very harsh conditions would have prevailed. The internal erosion surface and associated channels represents a potential land surface upon which hominins may have lived, however, any material in the channels is likely to be in a secondary context and subsequent glacial activity is likely to have removed much of the upper portion of the lodgement till. Any post-Hoxnian land surfaces are expected to have been eroded by the glacial advance across the landscape.

3.2.11 In certain areas, large channels have been cut through Bolders Bank and older deposits and are filled with sediments of the Botney Cut Formation (**Figure 3**). These are interpreted as subglacial melt water channels and proximal glaciolacustrine features formed during ice retreat after the last glacial maximum and are filled with glacial till overlain by glaciomarine sediments (Cameron *et al* 1992). The channel fill is often complex, with more than one stage of cut and fill visible.

3.2.12 It must be noted here that there appear to be inconsistencies regarding the precise stratigraphic position of the Botney Cut Formation. BGS report that it was created solely during the final retreat of the Devensian ice sheet,

although the survey on the main wind farm site (Osiris Projects 2008) has assigned the channels present within the Bolders Bank formation (described above) as also being Botney Cut. Although possibly created by similar processes (glacial melt water), and so potentially containing similar sediments, this interpretation would place the Botney Cut unit at three distinct layers (and so three different ages) within the stratigraphy.

3.2.13 For this report, only the youngest of these channels (i.e. those that are seen to incise through all of the Bolders Bank Formation) are interpreted as belonging to the Botney Cut Formation. This interpretation is supported by previous sampling on the main wind farm site, where boreholes located in areas interpreted as being Botney Cut channels did not retrieve any sediments associated with this formation (Fugro GeoConsulting 2009; Wessex Archaeology 2010).

3.2.14 Archaeologically, the potential of the Botney Cut Formation is again expected to be low, as the unit was again laid down in a period when the survey areas were either covered by ice, prohibiting human activity or close to the ice margin. The erosive power needed for such channel formation will have removed any post Hoxnian preserved land surfaces, artefacts or palaeo-environmental deposits, however, the channel fill has some potential for yielding palaeo-environmental data and the outside possibility of artefacts in a secondary and even less likely primary context.

3.2.15 Overlying the Pleistocene sediments are deposits of Holocene sandy gravel and gravelly sand, deposited since the recent marine transgression. These range in thickness from a thin veneer to a few metres, where they form localised bands of mobile sand waves. Whilst not expected to contain archaeologically important deposits, the areas of sand waves are potentially important as they could be covering wreck sites.

3.2.16 Some shallow channelling observed in the geophysical data could also be Holocene in date (**Figure 3**), from the period between the last glacial maximum and the final inundation of the survey areas, though without ground truthing it is difficult to distinguish these from older channel systems such as those attributed to the Botney Cut Formation. However, identifying deposits such as these is important, as they could potentially contain both re-deposited and *in situ* archaeological and palaeo-environmental material, especially from the Mesolithic period when the survey areas will have been dry land and suitable for habitation by human communities.

3.2.17 It should be noted that the Swarte Bank Formation (stratigraphically located between the chalk bedrock and Sand Hole Formation) is largely absent at the wind farm development site, only identified within a deep buried channel feature cut deeply into the underlying chalk bedrock towards the eastern edge of the site (Osiris Projects 2009).

3.2.18 The positions of all the major channel features identified on the geophysics data and described above are illustrated in **Figure 3**.

Study Area

3.2.19 Three separate geophysical surveys were undertaken within the Offshore Wind Farm Study Area in different areas, at different times, under different weather conditions and using different survey equipment. As each of these variables effect the interpretation of anomalies they will be discussed separately to clearly distinguish between the two datasets.

Original Area: Osiris Projects Data

3.2.20 Assessment of the Osiris Projects sub-bottom profiler data revealed a series of well-defined channels orientated in a NNE – SSW direction, produced by a combination of glacial outwash and glacio-fluvial processes. This interpretation was compared to that of Osiris Projects which assigns all these palaeo-channels to the Botney Cut formation (**Figure 3**). More than one sedimentary unit has been incised by glacial outwash or glacio-fluvial processes. The channels were observed within different levels of the stratigraphy, but originate within the Bolders Bank Formation and were seen to cut down into the underlying Sand Hole and Egmond Ground Formations (**Figures 4-9**).

3.2.21 Three of the 11 cores recorded by Fugro (2009) and archaeologically assessed by Wessex Archaeology (2009a) are located at points within these channels (**Figure 3**). However, none of these contained Botney Cut Formation.

3.2.22 Incisions carved by the Devensian ice sheets are visible on the swathe bathymetry data (**Figure 10**). TKOWF is located immediately east of Silver Pit, a 98 m deep elongated ice incision believed to have been carved by Devensian ice sheets, the edge of which is just visible on the western margin of the site (**Figure 10)**. Two other smaller incisions from the same origin remain partially filled and exposed towards the NW part of the survey area. With an approximate north-south orientation, they disappear under a thicker veneer of Holocene sands and gravels.

3.2.23 The Offshore Wind Farm Study Area shoals to the south east where sediment cover is greater and the appearance of south east to north west sand waves are noticeable (**Figure 10**). The greater sediment cover over this area of the project area has implications for the detection of archaeological sites, which may be presently buried, in full or in part. This change in sediment volume is noticeable again in the sub-bottom profiler data, which reveal a veneer of Holocene sands and sandy gravels overlaying the Botney Cut Formation.

Extension Area: Gardline GeoSurvey Ltd Data

3.2.24 The extended survey area to the north of the Offshore Wind Farm Study Area (**Figure 1**) contains the full stratigraphic sequence summarised above. The Sand Hole and Egmond Ground Formations are present as blanket deposits across most of the survey area, the exception being in the far west where the survey area crosses over the edge of the Silver Pit. This large bathymetric depression deep cuts through the entire stratigraphic sequence, exposing the Cretaceous Chalk bedrock in the bottom (**Figure 11**).

3.2.25 The top of the Sand Hole and Egmond Ground Formations are generally fairly flat and located around 10m below seabed and 20m below seabed respectively. This increases in some areas where the formations are incised by the Bolders Bank and Botney Cut channels.

3.2.26 The Bolders Bank Formation has also been observed as a blanket deposit over the whole area, and contains numerous generally NNE – SSW trending channels (**Figure 12**). Only two of these features, one in the far east of the area (trending NE – SW) and one in the far west have been interpreted as Botney Cut channels, with the rest assigned as internal to the Bolders Bank.

3.2.27 The Botney Cut channel in the far west is located along the side of the Silver Pit (**Figure 11**), suggesting that it was originally a sub-glacial tunnel valley that was then re-eroded during the recent marine transgression.

3.2.28 Trending in the same direction as the Silver Pit, two smaller glacial tunnel valleys have been identified and are now known to extend south from approximately the centre of the survey area to the northern section of the main wind farm site (ABPmer, Geology Review appended to the TKOWF Environmental Statement).

3.2.29 The Holocene sediments across the extended survey area to the north of the Offshore Wind Farm Study Area (**Figure 1**) comprise a thin veneer with no localised accumulations or sand waves. However, a number of possible shallow Holocene channels, generally trending north to south, have been identified (**Figure 12**).

Offshore Fan Area: Gardline GeoSurvey Ltd Data

3.2.30 The Offshore Fan Area extends to the south-west from the TKOWF site. The majority of the area is outside of the Offshore Wind Farm Study Area, however, the north-eastern-most part of the area falls within the study area.

3.2.31 A full stratigraphic sequence has been identified across the offshore fan survey area. The Sand Hole and Egmond Ground Formations are again present as blanket deposits, though are seen to gradually shallow and thin towards the SW. The depths to the tops of these units are generally approximately 10 m and 20 m below seabed respectively, though this can change considerably over areas where large sand waves are present. The units are only occasionally incised by channelling from younger units.

3.2.32 The Bolders Bank Formation is again visible as a blanket unit, thinning towards the SW. Only two major channels are present within this unit, one intermittently trending NNE – SSW across most of the area, and one trending NW – SE across the SW part of the area. Both converge towards the southernmost end of the fan area.

3.2.33 Only small, occasional remnants of any Botney Cut channels have been identified, mainly in the SW of the area.

3.2.34 The Holocene sediment cover is much more variable than observed across the north of the survey area, with the central part of the area dominated by

large east to west trending sand waves up to a few metres in height. The SW portion of the area also sees a thickening of the superficial Holocene deposits. Very little evidence exists for the presence of Holocene channels, however, with the sole possibility being a small, uncertain area towards the NE.

3.3 PREHISTORIC POTENTIAL

3.3.1 The assessment of the sub-bottom profiler data and the shallow geology within the Offshore Wind Farm Study Area has revealed a number of deposits and features with archaeological potential.

3.3.2 The discussion below outlines this potential for prehistoric material with regard to three main phases:

- **Pre-Devensian**: (c.700,000–48,000 BP) covering the period from the earliest evidence of hominin occupation of the UK and to the onset of the last glaciation, and corresponding to the Lower and Middle Palaeolithic;
- **Devensian**: (c.48,000–13,000 BP) covering the period up to and including the last glacial maximum and corresponding to the Early Upper Palaeolithic which saw the replacement of neanderthals by modern humans; and
- **Post-Devensian**: (c.13,000 BP–43 AD) covering the period of re-inhabitation of the UK by modern humans following the last glacial maximum through to the final Holocene inundation of the Offshore Wind Farm Study Area and corresponding with the Late Upper Palaeolithic, Mesolithic and later Prehistoric periods.

Pre-Devensian

3.3.3 Although the survival of pre-Anglian ice age land surfaces has been suggested in offshore contexts off the Norfolk coast (Wessex Archaeology 2008a) and the Thames Estuary (Emu *et al* 2009) there is no indication that any such deposits survive within the Offshore Wind Farm Study Area. Although isolated pockets of pre-Anglian deposits may be present, these are unlikely, except by chance, to be identified within the practical limits of survey.

3.3.4 The earliest deposits are the Sand Hole Formation and Egmond Ground Formation, identified across the Offshore Wind Farm Study Area. Dating to the Hoxnian interglacial (c. 420,000 to 380,000 BP), the formation of these deposits coincide with a number of Lower Palaeolithic sites in Britain.

3.3.5 As the Anglian ice sheets retreated and the climate ameliorated the North Sea basin formed a wide terrestrial landscape that joined the UK to Europe and which is likely to have been both a conduit for hominin passage to and from the UK and a focus of settlement and occupation. The routes taken by these early populations into the UK are speculative, but there are two clear possibilities: westwards via the proto-Rhine valley onto the southern edge of a huge north-facing bay at the southern end of the North Sea, into which the proto-Thames and Bytham rivers discharged, or from the south, via the proto-

Somme river valley and across the Weald-Artois chalk ridge into southern England (Stringer 2006).

3.3.6 Although rising sea levels would ultimately have approached today's level, for periods of tens of thousands of years large areas of the southern North Sea basin would have remained exposed as a broad plain crossed by a number of major rivers and their tributaries, rich in natural resources and very attractive to hominin populations (Stringer 2006).

3.3.7 Palaeolithic archaeological evidence is dominated by discoveries of stone artefacts. For example, hand-axes from this period have been found in Lynford and Little Cressington in Norfolk (Wymer 2005a) and a flint flake with trimmed edge interpreted as part of the Clactonian industry (c. 400,000 BP), was found in Hunstanton in 1951. The only find of human remains from this period is from Swanscombe, Kent (Wymer 1999).

3.3.8 Both Sand Hole and Egmond Ground deposits have the potential to contain both re-deposited and *in situ* archaeological material. The Sand Hole Formation has been shown to contain preserved organic material (Fugro GeoConsulting 2009; Wessex Archaeology 2010), potentially important for dating and the process of palaeo-environmental reconstruction. While the sandy Egmond Ground is less likely to contain preserved palaeo-environmental evidence, the occasional clay layers within the unit have been shown to contain some organic material.

3.3.9 During the Middle Palaeolithic hominins are absent from the archaeological record leading to the conclusion that Britain may have been uninhabited at this time, possibly due to the Ipswichian sea level rise that cut Britain off from the continent (Wymer 1999; Stringer 2006). By c. 60,000 BP, however, Britain was once again populated, probably by neanderthals, who occupied much of the midland and southern UK for the next 30,000 years (Stringer 2006).

3.3.10 Deposits relating to the Wolstonian (c. 380,000 BP – 130,000 BP) glacial and Ipswichian (c. 130,000 BP – 110,000 BP) interglacial periods appear to have been eroded by the Devensian ice sheet. Across the Offshore Wind Farm Study Area, Egmond Ground deposits are directly overlain by the Devensian till deposits of the Bolders Bank formation. As with the pre-Anglian land surfaces, any isolated pockets of Wolstonian or Ipswichian age that do survive are unlikely, except by chance, to be identified within the practical limits of survey.

Devensian

3.3.11 The Devensian period coincides with the first appearance in the UK of fully modern humans (*Homo sapiens sapiens*) c. 40-30,000 BP (Stringer 2006). Their arrival is marked in the archaeological record by a new stone tool technology which includes finely made leaf points, specialised tools like chisels and burins made on long thin stone blades and tools made from bone. This "Upper Palaeolithic" culture also sees the first evidence for modern human behaviour with representational art (cave paintings),

decorated burial of the dead, body adornment (beads, pendants, etc.) and new levels of social complexity (Stringer 2006).

3.3.12 Lincolnshire HER records the discovery of a mammoth tooth at Ingoldmells (HER 41635) dated to the Upper Palaeolithic while a mammoth tusk has been recovered from material dredged from aggregate licence Area 408, approximately 90km east of the Humber estuary (Wessex Archaeology 2006b). This tusk is the most northerly example of a *Mammuthus primigenius* fossil from an offshore context and has been dated to a mean age of 44,040±330 BP. The presence of large herbivores indicates that the environment of the southern North Sea was sufficient to support human populations and the large game they hunted.

3.3.13 A number of artefacts recovered from the aggregate dredging Licence Area 240 on the East coast, about 13km off Great Yarmouth in 25-27m of water, suggest that the archaeological material of this date may survive in association with incised channels. The assemblage comprised hand axes, flakes, cores and faunal remains (Wessex Archaeology 2009b). Preliminary assessment and dating indicates that these are mid to late Devensian in date and are associated with a channel deposit with clays and organic material, possibly a floodplain associated with an earlier incised channel. However, such deposits have not been identified within the Triton Knoll Offshore Wind Farm Study Area.

3.3.14 *Homo sapiens* and the neanderthals are believed to have co-existed in the UK and across much of Europe for c. 15,000 years. With the approach of the glacial maximum, however, the neanderthals disappear from the archaeological record, becoming extinct throughout the world during this period. By c. 22,000 BP increasingly harsh conditions also appear to have forced modern human populations out of the UK (Stringer 2006).

3.3.15 The advance of ice across the landscape is expected to have removed any early Devensian land surfaces. The Devensian glacial till deposits of the Bolders Bank Formation directly overlie the Egmond Ground Formation across the Offshore Wind Farm Study Area. Numerous NNE-SSW trending channels have been identified and described above. However, the Bolders Bank Formation is of low archaeological potential as the area would have been covered by ice or subject to very harsh climatic conditions at the time it was laid down.

3.3.16 Likewise, the Botney Cut Formation, which fills large subglacial melt water channels cut through the Bolders Bank Formation, is also of low archaeological importance. The lower Botney Cut till deposits are overlain by glaciolacustrine and glaciomarine muds. Human populations are expected to be absent from the area at this time and, hence, the potential for the discovery of archaeological artefacts is negligible, however, these sediments could yield useful palaeo-environmental data.

Post-Devensian

3.3.17 Following the Devensian glacial maximum c. 18,000 BP the ice began to melt and large areas of the North Sea basin were freed from ice, bisected by large

rivers carrying the glacial meltwater. As conditions grew milder and large game migrated back into the temperate southern North Sea basin these rivers would have become focal points for human settlement and activity from c. 12,500 BP. The Offshore Wind Farm Study Area would have been situated on dry land at the SW edge of what has come to be known as 'Doggerland', the extensive, now submerged landscape between the UK and Europe (Coles 1998; Gaffney *et al* 2009).

3.3.18 The extent of modern human occupation in Britain shortly after the Devensian glaciation is believed to have been very limited (Wymer and Robins 1994). *In situ* worked flint from Titchwell on the north Norfolk coast, is thought to date to 12,000-10,000 BP, belonging to a late Upper Palaeolithic tradition of tool making. The flint was recovered from peat deposits exposed by marine erosion, suggesting similar potential elsewhere in the region.

3.3.19 During the early Holocene 'Doggerland' is thought to have consisted of low lying fresh and brackish water wetlands and lagoons supporting animals such as deer and aurochs (Murphy 2005). The site would probably have been situated in a mixed woodland landscape (Ellis 1993:20), the type of terrain thought to have been favoured by Mesolithic (c. 10,500-6,000 BP) hunters and fishers who would have hunted the game and used the waterways to navigate through the landscape (Wymer 2005b).

3.3.20 The Mesolithic is characterised by a new microlithic stone tool industry accompanied by the increased use of sophisticated bone and antler tools and the development of constructed settlements. For example, microliths and distinctive Mesolithic long blades have been found in Norfolk, particularly along waterways, suggesting occupation by small groups of hunter gatherers during this period (Wymer 2005b).

3.3.21 Across the Offshore Wind Farm Study Area Holocene deposits overlying the Pleistocene sediments are dominated by marine sands and gravels deposited since the post-Devensian inundation. It is unlikely that these deposits will contain substantial prehistoric material apart from isolated artefacts. Artefacts dating from the last 10,000-12,000 years have been found in submerged contexts across the now submerged North Sea basin, with known sites on the Viking Bank, in Denmark, at Hartlepool, on the Dogger Bank and Brown Ridge and off the Yorkshire coast (Flemming 2002). Of particular note is the "Colinda Point", a prehistoric antler harpoon point in 1931 found in a block of peat between the Lemen and Ower banks. The point was radiocarbon dated to 11740 $\pm$ 150 BP.

3.3.22 Neolithic flint tools/flakes have been recovered from the shoreline in Chapel St Leonard by Skegness (Lincolnshire HER 41616, 41613) and it is possible that similar artefacts may have eroded from the coastline and now lie offshore. Early Neolithic flint axes have been found in the North Sea around Brown Banks. It is possible that these may have been lost at sea but it has also been suggested that they were deliberately deposited on the Brown banks which may have existed as small islands during low tide (Coles 1999). Deposition of Neolithic material is reported from offshore contexts as far north as Denmark.

3.3.23 Some shallow channelling observed in the Offshore Wind Farm Study Area may be Holocene in date although it is difficult to distinguish these from older channel systems. Flemming (2002) observes that on the flanks of the Silver Pit there may be valley structures that may preserve archaeological material. The identification of surviving pre-inundation deposits, potentially containing both re-deposited and *in situ* archaeological and palaeo-environmental material, should be regarded as a key consideration should there be any further geotechnical survey.

3.3.24 As outlined above, sea level curves indicate that a gradual increase in sea level would have totally submerged the Offshore Wind Farm Study Area by 7,000 BP, during the Mesolithic (Jelgersma 1979). The area between the Offshore Wind Farm Study Area and what is now the coast would have become progressively submerged from this point onwards, with only the current near-shore portion exposed by the later prehistoric period.

3.3.25 Due to the effects of localised erosion and accretion it is difficult to establish the precise date that the current shoreline was reached. During the Roman period the shoreline lay further inland than that of today with subsequent accretion and marsh reclamation accounting for its current position.

3.3.26 Several “submerged forests” associated with Mesolithic to early Neolithic material have been discovered near shore within the Yorkshire, Lincolnshire and Norfolk intertidal zones, for example, at Trusthorpe, Hartlepool Bay (Waughman *et al* 2005), Titchwell (Wymer and Robins 1994) and between Mablethorpe and Sutton on Sea.

3.3.27 There may also be potential for *in situ* nearshore/intertidal sites of Bronze Age and Iron Age date. For example, the discovery of the Bronze Age ‘Seahenge’ monument within the intertidal zone further to the south at Holme in Norfolk, indicates that further discoveries could be made along the coast. Lincolnshire HER records two Bronze Age findspots on the coast at Chapel St Leonards, a flint scraper (41614) and a flint dagger (41622) indicating human presence in the area at this time.

3.3.28 There are also a number of Iron Age salt working sites recorded along the Ingoldmells coast (Lincolnshire HER 41658, 41660, 41661, 41662, 41663, 41667, 43347, 41664, 43341, 45836), evidence of which may continue into the intertidal zone. These Iron Age salterns represent the start of a regionally important salt production industry which continued into the Roman and medieval periods.

4 ARCHAEOLOGICAL BASELINE: MARITIME

4.1 INTRODUCTION

4.1.1 The UK has a long maritime history, the result of a complex tapestry of maritime and coastal activities and patterns of shipping and sea use since at least the Mesolithic.

4.1.2 From the discussion of prehistoric archaeology above it is clear that the Offshore Wind Farm Study Area was inundated and became a fully marine environment during the Mesolithic. Any subsequent human activity can thus be expected to be of a maritime nature and related to seafaring and the human exploitation of the sea.

4.1.3 In contrast to the limited evidence of prehistoric archaeology, shipwrecks are a common feature around the entirety of the UK coast. Large numbers of wreck sites are known and accurately charted in UK waters, while even greater numbers of shipping casualties are recorded in documentary sources.

4.1.4 The precise location of most of the wrecks in UK waters is not known, nor is the full extent of the UK's shipwreck and maritime archaeological resource. Although the majority of wreck sites lie relatively close to the coast, many others will be scattered across the UK's continental shelf. Hence, specific knowledge of the UK's maritime archaeology is minimal, particularly with regard to older wrecks.

4.1.5 The following section outlines the known wrecks and geophysical anomalies within the Offshore Wind Farm Study Area and summarises the key periods of the UK's maritime history, with reference to the maritime archaeological potential.

4.1.6 Maritime sites are defined for the purposes of this assessment as either wrecks (seagoing vessels or aircraft) or material that has been accidentally or deliberately lost overboard from a vessel or aircraft.

4.2 KNOWN WRECKS

4.2.1 The combined results of the geophysical assessment and UKHO data search produced a total of 147 sites of possible archaeological interest located within the Offshore Wind Farm Study Area (**Appendix II, Figure 2**). The distribution of these sites is summarised in **Table 7**.

Table 7: Distribution of sites of possible archaeological interest

Site Category	Number of Sites
UKHO records identified during geophysical assessment	15
UKHO records not identified during geophysical assessment	7
UKHO records outside geophysical survey area	2
Wrecks identified during geophysical assessment not in UKHO	1
Possible wrecks identified during geophysical assessment not in UKHO	1
Wreck debris identified during geophysical assessment not in UKHO	1
Further geophysical anomalies of likely anthropogenic origin	120
Total	147

4.2.2 The Receiver of Wreck data search, for droits in the general area, produced 49 records relating to items of wreck. However, as the reports from the public are rarely accompanied by accurate positional information, it has not proved possible to confirm the location of any of these reports. Therefore, these records do not form part of this assessment.

4.2.3 The UKHO data comprised 24 records, of which 15 have been verified by the marine geophysical data. Two of the wrecks lie outside the geophysical survey area within the study area buffer zones.

4.2.4 The UKHO classified the 24 records as 'Live' wrecks of known and unknown identity, 'Dead' wrecks and foul grounds. **Table 8** lists these sites by classification.

Table 8: UKHO wreck classifications

Wreck type	Total
Live wrecks – known identity	10
Live wreck – unknown identity	9
Dead wreck – known identity	1
Live foul ground / Obstruction	3
Dead unidentified feature	1

4.2.5 Records classified as 'Live' by the UKHO represent wrecks and obstructions on the seabed, whose presence has been verified through survey work undertaken by or on behalf of the Royal Navy. Records classified as 'Dead' by the UKHO represent sites that have not been found after repeated surveys. However, unless such a wreck has been physically removed from the seabed it should be assumed that debris or wreck remains may still exist, exposed or buried. Records classified as 'Foul ground' are anomalies that have been initially identified during UKHO surveys but not verified as wrecks.

4.2.6 These records are discussed below. Further information, including site dimensions, can be found in the gazetteer (**Appendix II**).

Live Wrecks - Known Identity

4.2.7 WA7002 is the probable wreck of HMS *Cape Spartel*, a British steam trawler with a gross tonnage of 346 tons. Originally a fishing vessel, it was taken over by the Admiralty in 1939 for use as a mine sweeper and was subsequently bombed and sunk by German aircraft on 2nd February 1942. The wreck was dispersed in the 1940s. The UKHO located a broken wreck

during survey in 1994 and in 2002 divers reported a steel vessel, well broken up with standing boilers. Wreckage included degaussing cable and some ammunition. The remains were visible in the 2008 Osiris Project sidescan sonar and magnetometer datasets (**Figure 13**).

4.2.8 WA7007 is the wreck of the *Royal Scott*, a British steamship lost on 10th June 1941, after it struck a mine. The ship was carrying an unspecified general cargo. The UKHO records state that it was on passage from London to Feith, however Larn states that the *Royal Scot* was bound for Leith (Larn 1997), which is probably more accurate, considering that the HMS *Pintail* (WA7011) was in the vicinity and attempted a rescue.

4.2.9 The wreck of the *Royal Scott* (WA7007) has been identified in repeated UKHO surveys. In 1978 the site was reported to be heavily silted, in 1982 the wreck was found to be not intact with debris scattered in two distinct areas and in 1993 the wreck was lying in loose sandy sediment with no scour. The 2008 Osiris Projects survey showed a large area of wreckage and four detached pieces of debris were identified in the sidescan sonar and magnetometer datasets (**Figure 14**).

4.2.10 WA7011 is the wreck of HMS *Pintail* a British corvette that was sunk by mine on 10 June 1941 with the loss of all 54 crew onboard. HMS *Pintail* was escorting the Thames/Forth convoy (FN44) when the *Royal Scott* struck an acoustic mine. The HMS *Pintail* raced to help when it too struck a mine and blew up (http://www.wartimememories.co.uk/ships/pintail.html).

4.2.11 The wreck has been identified in repeated UKHO surveys. In 1978 the site was reported to be heavily silted, in 1982 the site was described as a large area of debris scatter with no scour and in 1993 the wreckage was lying in loose sandy sediment with a scattering of minor items nearby. In 2002 divers reported that the wreck appears dispersed and a number of artefacts were identified including ammunition, a piece of ceramic plate with an MOD crest and several valves, one stamped 1939 with an MOD arrow.

4.2.12 A seafloor disturbance with three pieces of debris was identified in the 2008 Osiris Projects sidescan sonar and magnetometer datasets (**Figure 14**). There are few remains left and these are fairly dispersed.

4.2.13 WA7012 is the wreck of HMS *Loch Alsh*, a British steam trawler built for the Loch Fishing Company and requisitioned for use as a minesweeper in 1939. The vessel was attacked by German aircraft and foundered whilst under tow in 1942. The remains were dispersed in the 1940s. The wreckage was not found during survey in 1993 and the record was amended to 'Foul'. There was no geophysical signature at this location in the 2008 Osiris Projects sidescan sonar data although an isolated magnetometer anomaly 150m north may represent the buried remains of this wreck.

4.2.14 WA7078 is the wreck of *Dromore Castle*, a British steam ship mined whilst in ballast on passage from London to Leith in 1941. The vessel was dispersed in the 1940s. UKHO survey in 1990 reported a wreck with no elevation and in 1992 local divers confirmed the remains as those of the *Dromore Castle*. The

wreck was not found in 1992 and 1993 and was amended to 'Foul'. No remains were identified during the WA assessment of marine geophysical data.

4.2.15 The *Fittonia* WA7079 was a British steam trawler lost on 2nd September 1914 after it struck a mine. A small buried wreck was identified at this location during a UKHO survey in 1994. This was not identified during the WA assessment of marine geophysical data suggesting it may be buried within the sand.

4.2.16 WA7080 is the wreck of the *Petroswift* a British motor launch lost on 24th September 1998. It was a fibreglass-hulled vessel measuring 10.7m in length. The site lies on the edge of the survey area and was not noted during assessment of geophysical data.

4.2.17 *Shepherd Lad* (WA7113) was a British motor trawler which sank in 1972. The wreck was identified on the 2009 Gardline GeoSurveys Ltd. sidescan sonar and swathe bathymetry data, and is associated with a very small (29nT) magnetometer contact (**Figure 15**). The structure is very broken up and unrecognisable as a vessel, though still exhibits significant height, and comprises one central large contact with a limited area of debris in the immediate vicinity. A curvilinear target, possibly a length of rope or chain, is visible on one of the sonar images. Seabed sediment cover in the area of the wreck is expected to be minimal, so it is unlikely that much of the structure is buried. The wreck was identified approximately 60m SSE of the given UKHO location.

4.2.18 WA7121 is recorded by the UKHO as probably the *Flashlight*, a British steamship on passage from Seaham to London with a cargo of coal when it was bombed and sunk by German aircraft in 1941. In 1947 survey revealed scour but no trace of the wreck suggesting that the wreck had buried itself. The wreck was identified but not fully investigated during survey in 1983. This wreck was not identified during the assessment of geophysical data. However, the description of this wreck provided by UKHO is very similar to that of wreck WA7122, situated approximately 150m to the NE, and it is possible that they represent the same structure (**Figure 16**).

4.2.19 WA7137 is recorded by the UKHO as possibly the *Cavehill*, a British steamship lost on 23rd October 1921, while on passage from Newcastle Upon Tyne to Amsterdam, when it sprang a leak and foundered. Survey in 1982 showed the wreck to be inverted and collapsed with the engines presenting the highest point, protruding c. 6m above the seabed, and considerable debris is reported around the wreck. In 1996 local divers reportedly recovered a ship's bell, with "London" engraved on it, from the wreck.

4.2.20 The wreck was identified on both the sidescan sonar and swathe bathymetry data, and is associated with a 1651nT magnetometer contact (**Figure 17**). The structure appears fairly broken up and possibly in two pieces, though does still exhibit height and areas of structure. It is difficult to determine from the geophysics data which way up the wreck lies, though the UKHO state that it is inverted. A large debris field has not been identified, though isolated

dark reflectors seen scattered in the vicinity could possibly be related debris. Swathe bathymetry data indicate the wreck is located within an area of scoured seabed approximately 130m x 50m and 0.5m deep, and is orientated approximately NW – SE.

Live Wrecks – Unknown Identity

4.2.21 WA7000 was identified in the 2008 Osiris Projects sidescan sonar and magnetometer datasets as a wreck and detached debris (**Figure 13**). This location is 65m from a loss reported by the UKHO as a metal wreck of unknown identity. In 1992 divers reported a partially buried and well flattened, steel vessel with a large mast lying across the wreck. Broken wreckage in loose sandy sediment was identified by UKHO survey in 1993.

4.2.22 WA7001 was identified in the 2008 Osiris Projects sidescan sonar and magnetometer datasets as a wreck and piece of detached debris (**Figure 13**). The site was surveyed by the UKHO in 1983 and 1994 and reported as a dispersed and broken wreck. In 2002 divers reported an engine, condenser and boilers with a large amount of half buried plate.

4.2.23 WA7003 is a well defined, partially buried, unknown wreck identified by UKHO survey in 1994. The 2008 Osiris Projects sidescan sonar and magnetometer datasets showed a wreck and bright reflector at this location (**Figure 13**).

4.2.24 WA7004 is reported by UKHO surveys in 1983, 1992 and 1993 as a collapsed wreck with two upstanding boilers. The wreck is of unknown identity but was thought to be of WWI age. Diver survey in 2002 recorded a well broken, old, collapsed steam ship with some winches and items standing 1-2m high and the two boilers standing 4-5m high. Aft of the boilers the hull is inverted with the keel topmost and iron propeller lying c. 5m from the stern. The wreck was identified in the 2008 Osiris Projects sidescan sonar and magnetometer dataset (**Figure 14**).

4.2.25 WA7005 comprises a wreck and two pieces of associated wreck debris identified in the 2008 Osiris Projects sidescan sonar and magnetometer datasets (**Figure 14**). These remains lie c. 10m from an unknown, partially broken wreck reported by the UKHO in 1994.

4.2.26 WA7006 comprises a wreck reported at this location in 1990 and confirmed by the UKHO in 1994 as a broken wreck of unknown identity. A wreck and bright reflector were identified at this location in the 2008 Osiris Projects sidescan sonar and magnetometer datasets (**Figure 14**).

4.2.27 WA7010 comprises a highly ferrous area of seafloor disturbance identified in the 2008 Osiris Projects sidescan sonar and magnetometer datasets. This location lies c. 28m away from a wreck reported in 1990 as protruding 5m above the seabed, confirmed as a well defined wreck by the UKHO in 1994.

4.2.28 WA7033 comprises a large structure, possibly part of a wreck or modern debris, identified in the 2008 Osiris Projects sidescan sonar dataset. This location is 4m from a UKHO record of a steel lattice construction with

attached ropes reported by divers in 1992. This is possibly the remains of an industrial Flare Stack.

4.2.29 WA7122 was reported by the UKHO in 1983 as an unknown wreck, intact with high points at either end, the mid section apparently missing or buried in the seabed. The wreck was identified on the 2009 Gardline GeoSurveys Ltd sidescan sonar and swathe bathymetry data, and is associated with a 1281nT magnetometer contact (**Figure 16**). Either ends of the structure appear upright and still exhibit significant height, though the wreck is either broken in two or partially buried in the centre. Due to reduced sediment cover in the area, it is more likely to be either broken or badly degraded than buried. Swathe bathymetry data show the structure to be located within a large scour, approximately 80m x 150m and 1m deep, and to be orientated approximately NNE – SSW. The wreck was identified approximately 40m NNE of the given UKHO position and may be part of the *Flashlight* (WA7121) which was bombed in 1941 and lies 150m to the NE.

Dead Wreck

4.2.30 WA7085 is the wreck of the *Rheno*, a British steam trawler which sank in a collision in 1908. The wreck was not found through repeated surveys and was amended to 'Dead'. WA7085 lies within the Offshore Wind Farm Study Area buffer zone outside the marine geophysical survey area.

Live Foul Grounds and Obstructions

4.2.31 WA7081 is reported by the UKHO as a small sonar contact and was charted as an obstruction. The dimensions (16m x 5m x 1.9m high) suggest that this could be representative of a small vessel. However, this was not identified during the WA assessment of marine geophysical data.

4.2.32 WA7082 is reported by the UKHO as a minor significant contact less that 1m in width and 1m in length and lying in loose sandy sediment. This was not identified during the WA assessment of marine geophysical data.

4.2.33 WA7083 was recorded as a wreck in 1958 but was not found in 1993 and amended to 'Foul'. The wreck lies within the Offshore Wind Farm Study Area buffer zone outside the marine geophysical survey area.

Dead Unidentified Feature

4.2.34 WA7084 is an undefined feature incorrectly shown in this position and amended to 'Dead'.

4.3 FURTHER GEOPHYSICAL ANOMALIES

4.3.1 In addition to the wrecks described above, a total of 123 additional geophysical anomalies have been identified during the assessment of geophysical data. These include dark reflectors, bright reflectors, debris, seafloor disturbances, wrecks and isolated magnetic anomalies. The archaeological significance of these sites cannot be established or confirmed until further investigation clarifies their origin. These sites are illustrated in **Figure 2** and their descriptions detailed in **Appendix II**.

4.3.2 The sites are classified in **Table 9**.

Table 9: Classification of geophysical anomalies

Anomaly classification	Number of Anomalies
Previously unidentified wreck	1
Seabed Disturbance – likely to represent remains of a shipwreck	1
Debris – likely to be wreck debris	1
Bright reflector	8
Dark reflector	35
Debris	59
Magnetic	13
Rope / Chain	1
Seafloor disturbance	4
Total	**123**

4.3.3 These anomalies are discussed below. As outlined above, three separate geophysical surveys were undertaken within the Offshore Wind Farm Study Area that are subject to variable factors which effect the interpretation of anomalies. Hence, they will be discussed separately to clearly distinguish between the two datasets.

Original Area: Osiris Projects Data

4.3.4 The assessment of marine geophysical data identified a total of three dark reflectors in the sidescan sonar data. These are WA7024-7026, three objects of varying sizes and of uncertain origin. They have been interpreted as objects of likely anthropogenic origin and of possible archaeological interest.

4.3.5 A total of eight sites, WA7016-7023, were identified as bright reflectors in the sidescan sonar data. These had no apparent magnetic signature and no structural detail could be distinguished. This is mainly due to their acoustic origin. This type of anomaly is produced by absorbed or refracted acoustic energy rather than reflected energy. Such objects, which absorb acoustic energy, are likely to be made of aluminium, which was used in the construction of WWII aircraft, amongst many other objects. This material is also non-magnetic.

4.3.6 A total of 37 sites, WA7027-WA7032, WA7034-WA7064, were identified as isolated pieces of debris or patches of material of varying dimensions. These have been interpreted as probable objects of anthropogenic origin and possible archaeological interest. Sites WA7028 and WA7058 may be pieces of debris associated with the unidentified wreck site WA7004. Sites WA7043 and WA7045 may be pieces of debris associated with the unidentified wreck WA7005, and site WA7048 may be debris associated with wreck site WA7003 also of unknown identity. Sites WA7040 and WA7041, together with bright reflector WA7018 and seafloor disturbance WA7013, may represent the remains of a wreck site or part of the unidentified wreck site WA7000, which lies 250m to the E. Site WA7057 may be associated with seafloor disturbance WA7015, nearly 280m E. WA7015 comprises of a group of four elongated mounds the largest of which measures 13.9m x 3m.

4.3.7 Site WA7009, an additional seafloor disturbance consisting of a dark reflector patch with debris in the centre, was identified in the sidescan sonar lying approximately 390m east of the probable wreck site WA7008. Site WA7008 consists of a boat-shaped mound of debris/structures with no hull outline identified in the sidescan sonar data (**Figure 14**). The site has been interpreted as a probable wreck site for which there is no UKHO listed wreck loss record. Sites WA7008 and WA7009 may be part of a wreck site, or two separate sites.

4.3.8 WA7014 consists of a seafloor disturbance and a group of six bright reflectors. This site was identified in isolation and is not associated with any other site.

4.3.9 The assessment of magnetometer data identified a total of 13 isolated magnetic anomalies (WA7065-WA7077) that could not be associated with records provided by the UKHO or anomalies identified in the sidescan sonar data. The total magnetic amplitude of these anomalies indicates an anthropogenic origin of possible archaeological interest.

4.3.10 In addition to the isolated magnetometer anomalies detailed above, the magnetometer data revealed a series of linear patterns throughout the study area. All but one are believed to be non-anthropogenic. The evident linear feature crossing the study area in a NE-SW direction, as illustrated in **Figure 18**, is a charted pipeline. Strong magnetic features such as these may mask objects of smaller magnetic amplitude. These features are otherwise of no archaeological interest.

Extension Area: Gardline GeoSurvey Ltd Data

4.3.11 A total of 52 sites of potential archaeological interest were identified across the Extension Area and are illustrated in **Figure 2**.

4.3.12 Site WA7154 is classified as an area of seafloor disturbance. It comprises a cluster of small, angular dark reflectors with shadows and is associated with a large dark reflector (WA7155, below). This could be a natural feature, or could represent a partially buried structure (though the thin sediment cover in the area suggests this is not the case) or small scatter of anthropogenic debris. The lack of a magnetometer signal associated with this site suggests that any debris present is likely to be non-metallic in nature.

4.3.13 One anomaly (WA7119) has been interpreted as a length of rope or chain. The contact is a curvilinear reflector with a small shadow and is possibly associated with both a small magnetometer contact (45nT) and an area of possible debris (WA7118, below). These features could all indicate the presence of the remains of a structure, though, due to the thin sediment cover in the area, it is likely that what is visible on the surface is all that remains rather than the visible remains of a buried structure.

4.3.14 Twenty anomalies (WA7102, WA7105-WA7108, WA7110, WA7112, WA7117, WA7118, WA7124, WA7127- WA7129, WA7135, WA7138-WA7140 and WA7151-WA7153) were classified as pieces or areas of debris. Of these, two (WA7155 and WA7118) have been previously mentioned as

being associated with other contacts, increasing their potential to be anthropogenic debris. Sites WA7102, WA7110, WA7112, WA7127, WA7128, WA7129, WA7138, WA7152 and WA7153 are isolated dark reflectors with shadows but without any real visible structure, but are generally more unusually shaped and more likely to be debris than isolated boulders. None have associated magnetometer contacts and so if they are pieces of debris they must be non-ferrous in nature. WA7124 is a large dark reflector interpreted as possible debris associated with wreck WA7122, whilst WA7139 and WA7140 are possibly debris related to wreck WA7137.

4.3.15 WA7135 is a relatively small dark reflector, but is associated with a 22nT magnetometer contact and so is likely to be a piece of metallic debris. Similarly WA7151, a large elongated reflector with a large shadow, is also tentatively associated with a very small 8nT magnetometer contact, and so is also potentially at least partially metallic. WA7105 and WA7106 are pieces of possible debris adjacent to one another, but without any magnetometer contact. WA7107 is an unusual curved reflector with a shadow, and associated with a large dark reflector with a shadow (WA7108). These do not have any associated magnetometer contacts, and so are probably non-ferrous in nature. Their unusual appearance and association indicate they could possibly represent the remains of a structure. WA7117 is a complex area of debris with numerous linear contacts extending from a central point, and could possibly represent a mooring or anchoring point with the mooring equipment still attached to the seabed (**Figure 19 (A)**). The lack of a magnetic contact in the vicinity indicates any structure remaining on the seabed is probably non-ferrous.

4.3.16 The remaining 30 anomalies (WA7100, WA7101, WA7103, WA7104, WA7109, WA7111, WA7114- WA7116, WA7120, WA7123, WA7125, WA7126, WA7130- WA7134, WA7136, WA7141- WA7150 and WA7155) have been classified as dark reflectors. These are generally isolated, round, dark reflectors with shadows of various sizes that do not appear to have any structure but could be either natural rocks or boulders or pieces of anthropogenic debris. None of these contacts are associated with magnetometer contacts, so any debris is likely to be non-ferrous in nature. A few of these contacts are of note, however. WA7000 is associated with some possible fishing gear, so is likely to be modern fishing gear and of reduced archaeological potential. WA7030 and WA7031, and WA7142 and WA7143, are two sets of closely associated contacts that could represent a spread of anthropogenic debris. WA7132 and WA7133 are isolated dark reflectors and are very similar in appearance. Despite being approximately 50m apart, they are similar enough to possibly be the same feature, separated in the data by a temporary error in positioning.

Offshore Fan Area

4.3.17 A total of five sites of potential archaeological interest have been identified across the Offshore Fan Area, within the Offshore Wind Farm Study Area and are illustrated in **Figure 2**.

4.3.18 Three sites across the survey area (WA7156, WA7157 and WA7168) have been classified as pieces of possible debris. Site WA7157 is a rectilinear spread of approximately 10 dark reflectors, with additional possible linear contacts and seabed scars (**Figure 19 (B)**). The feature is very well defined, of an unusual shape, and is easily identified on the swathe bathymetry data (though it has no associated magnetometer contact). The origin of the feature is unknown, but it is likely to be an area of debris or a partially buried structure. A nearby large contact (WA7156) is also probably related to this debris. WA7168 is visible as a dark reflector with large shadows, likely to be non-metallic debris.

4.3.19 The remaining two sites (WA7167 and WA7169) have been classified as dark reflectors. They are single dark reflectors with shadows, but without magnetometer contacts, which could be either natural rocks or boulders or pieces of non-ferrous debris.

4.3.20 Additionally, three pipelines were observed crossing the offshore fan survey area: PL929 (Theddlethorpe to Murdoch MD 26" gas), PL930 (Theddlethorpe to Murdoch MD 4" chemical) and PL816/817 (Pickerill A to Theddlethorpe 24" chemical). These were not observed on the sidescan sonar data, but were visible in the magnetometer and swathe bathymetry records, and are located in the NW corner of the survey area trending approximately NE – SW. As recent features these are not important archaeologically, but obviously need to be considered in developing the Triton Knoll project.

4.4 MARITIME POTENTIAL

4.4.1 The above sections outline the known wrecks and geophysical anomalies within the Offshore Wind Farm Study Area. However, there is additional potential for the unidentified anomalies to represent as yet undiscovered wrecks, and the Holocene deposits identified across the area, while forming only a thin veneer in places reach up to a few meters in some areas where they form localised bands of mobile sand waves, which may incorporate buried wrecks. The archaeological potential is discussed below.

Overview of Maritime Potential

Early Prehistoric

4.4.2 Although evidence for Palaeolithic maritime activities does not exist in the UK, examples from elsewhere in the world suggest that early modern humans did undertake maritime activities (Johnstone 1980; Lourandos 1997). During the late Upper Palaeolithic c.13,000 BP it is postulated that simple watercraft, such as hide-covered log or boat rafts, were used for coastal journeying and fishing (McGrail 1987, 2004).

4.4.3 There are indications that water craft were used for activities such as trade, fishing and transport from the Mesolithic onwards. The earliest examples of watercraft in northern Europe comprise logboats dated to the Mesolithic (McGrail 2004). However, discoveries of such vessels are rare and current knowledge and understanding of early prehistoric maritime activities is

limited, primarily based on indirect evidence for movement of non-local goods and through comparison with modern use of basic craft such as logboats and rafts.

4.4.4 Discoveries of early prehistoric watercraft and evidence for maritime activities are rare and, as such, must be regarded of very high importance. It is probable that, at times when the Offshore Wind Farm Study Area was inundated, maritime activities were taking place and it is possible that material relating to these activities may be preserved. However, the lack of Holocene deposits suitable for the preservation of such material indicates that such discoveries are unlikely.

Later Prehistoric and Roman

4.4.5 During the Neolithic (4,000 BC to 2,400 BC) indirect evidence for cross channel movement of goods and/or people is indicated by the introduction of non-native species of sheep and goats and cereals such as barley and wheat (May 1976). Neolithic artefacts and material of non-UK origin have been found at various sites indicating that transport by sea may have been taking place (Breen and Forsythe 2004) and the presence of deep water fish in shell middens at Neolithic sites demonstrate that marine fishing was also carried out at this time (Ellmers 1996). As with the Mesolithic, logboats are the only archaeological examples of watercraft from this period (McGrail 2004).

4.4.6 During the Bronze Age (2,400 BC to 700 BC) significant advances in technology and vessel size increased the opportunities for coastal voyages and cross channel trade. Securely dated logboats have been discovered in Lincolnshire, namely the Brigg log boat (1,034 BC to 634 BC) and the Short Ferry boat (1,046 BC to 646 BC) (May 1976). Evidence of sewn plank boats from the Bronze Age has been discovered to the north of the Offshore Wind Farm Study Area at Brigg, North Ferriby and Kilnsea (Van de Noort 2003) and to the south at Dover (Clark 2002). Evidence from the distribution of trade items during the Bronze Age, from continental NW Europe, Ireland and the Scottish archipelago, supports the theory of established open-water maritime trade routes around the UK (Fenwick and Gale 1998; Muckelroy 1980).

4.4.7 During the Iron Age (700 BC to AD 43) there is evidence from the southern coast of Lincolnshire that salt was an important trade commodity and other imports included fine pottery, metalwork and wine or other luxuries from Spain (Hutcheson 2005). Discoveries in north and west Norfolk of gold and silver torcs, amongst the finest decorated metal objects known from Iron-Age Britain, suggests that people living in this area were able to obtain large quantities of gold by controlling the flow of North Sea trade in and out of the Wash. Iron Age logboats have been found at Hasholme in Yorkshire and Poole in Dorset, for example, but plank-built boats are also likely to have been in regular use in the waters around England. Trading ports investigated at Mount Batten in Plymouth and Hengistbury in Dorset, and Roman accounts of the Veneti people based in Brittany, suggest that the Iron Age people of the UK were using sea-going sailing ships.

4.4.8 During the Romano-British period there is evidence that ships travelled the east coast of Britain and that the role of coastal forts to safeguard trade may have been just as important as their role in defending against seaborne raiders (Allen and Fulford 1999). Tacitus described the activities of the British fleet in the north of Britain in the 1st century AD and there appears to have been a significant increase in maritime traffic from the Hadrianic period onwards (2nd century AD).

4.4.9 Excavated examples of Romano-British (AD 43 – AD 410) vessels show that larger, iron fastened, plank-built ships were in use, capable of far reaching ocean voyages, although it is likely that smaller local craft continued in use. The Blackfriars boat (Marsden 1994) and, the Barlands Farm boat (Nayling and McGrail 2004) represent examples of substantial seagoing trading ships. Other examples of vessels of this period have been found at New Guy's House in London (Marsden 1994), St. Peter Port, Guernsey (Monaghan and Rule 1993) and on the Continent.

4.4.10 Roman remains found on the coast at Chapel St Leonard, Anderby and Ingoldmells, including coins, ceramics, and evidence for salt working (Lincolnshire HER 43341, 45836, 45838, 41602, 41607, 41608, 41612, 41615, 41623, 41625, 43342, 43825, 45834, 45835), show that there was substantial Roman activity in the region and, as such, the area is likely to have seen associated maritime traffic. This potential is further demonstrated by the discovery of a sherd of Roman pottery, possibly from a bowl, within material from aggregate licence Area 107, c 6km to the south of the Offshore Wind Farm Study Area.

4.4.11 It is likely that during the later Prehistoric and Roman periods vessels would have navigated close to the coast, rather than across the Offshore Wind Farm Study Area. However, there is still potential for artefacts or wreck material relating to maritime activity during this period to lie within Holocene deposits.

Early Medieval and Medieval

4.4.12 The volume and nature of shipping activity following the collapse of the Roman Empire is poorly understood with the period commonly referred to as the 'Dark Ages' (AD 410 – AD 1066). However, an influx of material goods from north west Europe and Scandinavia demonstrates maritime connections during the Anglo-Saxon period (Penn 2005). This expansion of trade routes saw the introduction of Scandinavian-style clinker-built vessels. The key examples of early medieval vessels from the UK are the Sutton Hoo ship (c. AD 600) from Woodbridge, Suffolk (Steffy 1994) and the Late Saxon Graveney Boat found in North Kent.

4.4.13 From the 6th century Norfolk was occupied by the East Angles, one of the first areas to be settled by early medieval farmers. Subsequently, 'Viking' settlement is demonstrated by place name evidence and material culture such as Thor's hammers/pendants, trefoil brooches, Scandinavian type weights and ingots (Pestell 2005). The name Skegness has its origins during the Danish period of settlement with *Skaeg* meaning beard and *naes* meaning nose or 'headland'. The Viking settlement at Skegness was washed

away by the sea, therefore there is some potential for Viking period remains to be recovered from the sea bed near to shore.

4.4.14 Coastal trade and fishing were important with the mouths of streams and natural havens exploited as moorings on an otherwise exposed coast (Buglass and Brigham 2007). However, the medieval period saw the expansion of maritime trade routes both around the UK and with the European mainland. Powerful trading confederations emerged, such as the Hanseatic League in North Germany and the Baltic. The English Channel and North Sea was the artery for increasing trade between the UK and Europe and the dramatic increase in shipping around UK waters meant greater chances for maritime casualties. The level of shipping passing through the Offshore Wind Farm Study Area during this period is likely to have been high enough to suggest that there is potential for archaeological remains to exist.

4.4.15 During the 13th and 14th centuries the shallow draught descendants of Scandinavian vessels were replaced by more capacious, deep-draught vessels. These changes were linked to the changing nature of maritime activity – wide, international-scale bulk trade – and saw the development of the large merchant vessels needed to accommodate bigger cargos (Kemp 2002). An example of such a vessel is the Newport ship, discovered during construction activities on the banks of the River Usk in 2002, and probably built in the middle of the 15th century (Nayling 2003).

4.4.16 Knowledge of vernacular boat types from Lincolnshire is lacking although there are records of the development of a wide range of ships and boats were in use along the Norfolk coast with local vessel types evolving to suit the environment and to meet local needs. For example, the Norfolk Keel, from the Anglo-Saxon word *ceolae*, meaning seagoing, was a clinker built (overlapping planks), double ended open boat with a shallow draft (Greenhill and Mannering 1997). The majority of fishing vessels during the 14th century were open craft that did not exceed 20 tons and would stay close to the shoreline (Wilcox 2009). With a crew of five or six they had small sails but were mainly driven using oars thus restricting the distance they could travel from their home port.

4.4.17 Linked to the growth in trade was the development of the important medieval ports of the southern North Sea, such as Hull, Boston and Kings Lynn, which were at the centre of this trade and from which vessels would have crossed the Offshore Wind Farm Study Area on a regular basis. The international nature of the trade can be seen by the documentary evidence from the port of Kingston Upon Hull where during the 14th and 15th centuries only half the vessels that berthed in the port were English-owned (Allison 1969).

4.4.18 During the late medieval period, the development of reliable navigation techniques and aids was to have a profound influence on ship development. Ship owners could now plan long oceanic voyages and greater distances could be travelled, with ever-expanding trade routes (Kemp 2002). This period saw the advent of European maritime exploration on a global scale as

vessels from Europe reached first the New World and then mapped the spice routes to the Far East.

4.4.19 The medieval period therefore saw a large increase in the amount of shipping that would have traversed the Offshore Wind Farm Study Area.

Post-medieval and Modern

4.4.20 Post-medieval and modern shipwreck remains are better represented in the known archaeological record than earlier periods (see 'Documented Losses' below), but the wrecks that have been archaeologically investigated are only a tiny fraction of the numbers likely to have been lost and an even smaller fraction of the overall volume of shipping from the period (Wessex Archaeology 2008b).

4.4.21 A substantial volume of traffic would have passed through the Offshore Wind Farm Study Area from an early date, including colliers carrying coal from Newcastle to London from the 16th century (Kirby and Hinkkanen 2000). Cloth seals recovered at Theddlethorpe indicate a 17th century wool trade while live oyster storage pits have been identified at Huttoft, Chapel St Leonard and Ingoldmells with possible oyster beds at Skegness (Buglass and Brigham 2007). Natural havens and inlets were still being exploited although the post-medieval period saw a dramatic increase in national and international trade and the emergence of prosperous trading settlements. For example, between 1716 and 1793 there was an 18 fold increase in shipping tonnage entering Kingston upon Hull (Kirby and Hinkkanen 2000).

4.4.22 In the 19th century a massive increase in industrial output, a growing demand for imported raw materials, food and consumer goods and the development of an integrated global transport system resulted in a dramatic rise in the volume of maritime trade and fishing in UK territorial waters. Bulk cargoes such as coal appeared on the market in very large quantities and passengers, notably emigrants, were carried in huge numbers. Between 1840 and 1887 sea trade grew by an average of 4.2 % per year.

4.4.23 During the late 18th and early 19th centuries, coastal and international trade were dominated by wooden sailing vessels such as schooners, brigs, brigantines and snows (Breen and Forsythe 2004). The period following 1815, however, saw dramatic revolutions in ship design as metal replaced wooden hulls and steam replaced sail as the principle means of propulsion (Lambert 2001). Tramp sail and then steamships dominated maritime trade in the 19th and early 20th centuries while the later 20th century saw the introduction of further specialisation and new vessel types, such as bulk and container vessels.

4.4.24 The strengths of wooden construction and sail, however, were such that both continued to be used into the 20th century. A number of vernacular boats types would have been active in the region, locally built, often regionally varied in design and regionally specific to conditions and task (Greenhill 1993). For example, double ended boats, ideal for beach launch and recovery, and believed to be unique to this stretch of coast, have been excavated at Sutton on Sea and Mablethorpe (Buglass and Brigham 2007).

4.4.25 Five wrecks were revealed on the beach at Mablethorpe in 1997 after the sea removed large amounts of sand from the coast as a result of sea defence works. The wrecks included a 19th century fishing vessel and the *Acorn*, an ice barge which sailed between Grimsby and Norway supplying ice to the Grimsby Ice Company (www.lincolnshire.gov.uk/section.asp?docId=28064andcatId=2293). There are historical records relating to the practice of buying ships for salvage and running them aground at high tide. The ships would be used as a maritime museum during the summer with salvage continuing during the winter. This indicates potential for further discoveries along the Lincolnshire coast.

4.4.26 During WWI and WWII, large numbers of steam trawlers and drifters were bought or hired by the Admiralty to supplement the Royal Navy. Dozens of these small vessels were lost because of enemy action, some sunk by torpedoes or gunfire from submarines. In addition, systematic attempts to destroy British coastal trade saw large numbers of merchant vessels targeted through enemy action. The distance between the coast of Norfolk and the coasts of German occupied France and Holland was relatively short and between 1939 and 1941 ships were lost off Norfolk almost daily.

4.4.27 This period saw a dramatic increase in the volume of shipping traffic in the waters of the UK, which resulted in numerous casualties and losses, with collision becoming such a problem that it prompted some of the first international conventions. Possibly the greatest contributory factor to losses during this period were the two World Wars. Warships, submarines and U-boats were all lost but by far the greatest losses during both World Wars were amongst merchant vessels and thousands of military and other aircraft (discussed below).

Documented Losses

4.4.28 The NMR holds records of Documented Losses for which no grid reference can be confirmed. Instead, these records are attached to arbitrary points called Named Locations (NLOs), which have been chosen to represent general loss locations, and do not (except by chance) relate to actual seabed remains.

4.4.29 There are no NLOs within the Offshore Wind Farm Study Area. However, this is likely due to the nature of the dataset, as Named Locations are generally situated closer to the shore. An examination of seven NLOs located between the Offshore Wind Farm Study Area and the coast reveals 111 Documented Losses, which are listed in **Appendix IV**, and summarised in **Table 10**. As the positional data for the NLOs represents general loss locations rather than actual seabed remains, they have not been illustrated on any of the figures.

Table 10: Documented losses by location

Easting	Northing	No. of Losses
323407	5896891	4
324002	5897802	38
333839	5908580	2
337049	5904757	24
337843	5911788	8
355610	5911584	35
	Total	**111**

4.4.30 The Documented Loss of the *Fittonia* (WA7079) can be matched to its known location, as it has also been recorded by the UKHO. The actual remains of the vessel lie approximately, 33km from the NLO position which clearly demonstrates the arbitrary nature of the NLOs.

4.4.31 **Table 11** summarises the documented losses by their date of loss:

Table 11: Documented losses by date of loss

Date	No. of Losses
1700 to 1749	1
1750 to 1799	17
1800 to 1849	33
1850 to 1899	23
1901 to 1913	7
1914 to 1918 WWI	16
1919 to 1938	2
1939 to 1945 WWII	11
1946 to Present	0
Unknown	**1**
Total	**111**

4.4.32 The distribution of losses according to date demonstrates a rise in the number of records after 1800, consistent with more accurate reporting after this date. The lack of documented losses prior to 1700 is not an indication that vessels were not lost before this date. Records of maritime casualties were not systematically kept until the 18th century and are dependent on reports being made at the time of loss and the survival of such records.

4.4.33 The table also shows the high number of losses during the two World Wars. Of the 16 WWI shipwrecks 12 were lost due to an act of war, nine reported as mined and three torpedoed. Of the 11 WWII documented losses, two were mined and one torpedoed. The remaining eight losses relate to records of crashed aircraft.

Aircraft Losses

4.4.34 Although the records of aircraft losses at sea are extensive, they are seldom tied to exact locations. Aircraft remains on the seabed are also often ephemeral and not easily distinguishable in standard geophysical surveys. As a result, sites have historically been infrequently found and identified.

4.4.35 Aviation archaeology has become an increasing concern in recent years, partly because of national policy, such as English Heritage's guidance note *Military Aircraft Crash Sites* (English Heritage 2002) which recognises the

importance of 20th century wartime heritage and makes the case for recognising the importance of aircraft crash sites, specifically with regards to existing and planned development proposals which may have an impact on such sites.

4.4.36 In addition, all military aircraft crash sites are automatically protected under the Protection of Military Remains Act 1986 (**Appendix I**) and a licence is needed for any disturbance or works.

4.4.37 Recently, numerous aircraft wrecks have been discovered as a result of aggregate dredging operations and during survey work associated with wind farm development around the UK (Wessex Archaeology 2008c) and it is increasingly clear that these remains not only survive on the seabed, but are fairly widespread.

4.4.38 The aviation resource may be categorised into three broad chronological divisions (Wessex Archaeology 2009c), as follows:

- **Pre-1939**: A period of intense and rapid development of a new technology. While at least 119 different aircraft models were used by the military in the UK during this period, examples of only 24 survive today anywhere in the world. This, alongside the fragility of the airframes and the relative scarcity of flights over water deem any aircraft remains dating to this period of special interest;
- **1939-1945**: Advances in technology in this period greatly extended the reliability and range of aircraft and enabled aircraft to increasingly undertake long-range flights, some of which may have taken place across the Offshore Wind Farm Study Area. In the East Coast region this period can further be subdivided into the Battle of Britain phase (pre 1941), the British Strategic Bombing phase (1941-1943), with many RAF bombers based in East Anglia and Lincolnshire and the Allied Strategic Bombing Phase (1943-1945) with the addition of large numbers of the US Army Air Force based in East Anglia. This period is marked by the highest number of aircraft (and human) casualties in the history of aviation and as such has special significance; and
- **Post-1945**: This period is characterised by the rapid development of jet propulsion technology and its use in both military and civilian aviation applications.

4.4.39 The first fixed wing powered flight across the channel took place in 1909 and by WWI planes had already come to play an important role in the defence of Britain with the founding of the Royal Flying Corps in 1912 and the Royal Naval Air Service in 1914. A total of 28 fixed wing aircraft and 15 airships were lost by the German Imperial Air Service and Navy during raids on Britain during WWI, in addition to 34 aircrew from British Home Defence Squadrons lost in the same period (Wessex Archaeology 2009c). In 1918 the two arms of British air defence were merged to form the RAF and in the interwar years the British government engaged in a massive programme of rearmament with the construction of more than 100 permanent airbases.

Recent work has identified 217 RAF losses off the coast of Norfolk during WWII and the post war period (Wessex Archaeology 2008b).

4.4.40 From the 1920s and 30s there was also a significant increase in commercial civil aviation with the establishment of services to a number of European and worldwide destinations (Wessex Archaeology 2008c). The Department of Transport's Air Accident investigation Branch (AAIB) records 20 civil aircraft lost at sea around Britain between 1920 and 1939 (Wessex Archaeology 2009c). Between 1946 and 1994 the AAIB list 120 civil aircraft lost at sea, most of which comprise light aircraft or in more recent years helicopters associated with the North Sea oil and gas industry.

4.4.41 Some of the bright reflectors identified in the sidescan sonar data assessed above (section 5.3) may relate to aircraft remains. For example, eight anomalies, WA7016-WA7023, without magnetic signatures are likely to be made of aluminium, which was used in the construction of WWII aircraft, amongst many other objects.

4.4.42 A brief analysis of RAF WWII Air/Sea Rescue operation distribution maps indicates that a large number of recorded operations took place within the vicinity of the Offshore Wind Farm Study Area, including the eight WWII losses recorded by the NMR (Wessex Archaeology 2008c). These aircraft losses are summarised in **Table 12**. Further details can be found in **Appendix IV**.

Table 12: Documented Losses of aircraft

NMR ID	Description	Nationality	Date of Loss	NLO Easting	NLO Northing
1323066	BLENHEIM MK IV R3765	British	1940	355610	5911584
1354050	HAMPDEN MK I X3062	British	1941	333839	5908580
1354038	HAMPDEN MK I X3021	British	1941	355610	5911584
1354135	SPITFIRE MK I X4353	British	1942	337049	5904757
1354212	WELLINGTON MK IV Z1285	British	1942	355610	5911584
1354383	WHITLEY MK VII Z6960	British	1942	355610	5911584
1404780	DORNIER DO217M-1 (6045) U5+GK	German	1943	355610	5911584
1404778	DORNIER DO217K-1 (4412) U5+BA	German	1943	355610	5911584

4.4.43 Whilst the mapped location of these operations is not wholly reliable, they provide a useful guide to the general frequency of these operations in the area and, thus, the potential for the presence of aircraft remains in the Offshore Wind Farm Study Area.

5 IMPACT ASSESSMENT

5.1 OVERVIEW OF DEVELOPMENT: ROCHDALE ENVELOPE

5.1.1 This impact assessment is based upon the TKOWF Rochdale Envelope which describes the realistic worst case construction, operational and decommissioning phase scenarios. It focuses on the impacts arising directly from activities in the TK Offshore Wind Farm Study Area. The export cable route has not yet been defined and is not considered here – although it is assessed in relation to potential cumulative impacts.

5.1.2 **Table 13** sets out the project dimensions which are considered to represent the realistic worst case for the archaeological impact assessment, based on details from the Triton Knoll Offshore Wind Farm Project Description (as set out in Volume 1: Chapter 6 of the ES).

Table 13: Rochdale Envelope worst case scenarios

Development footprint
Maximum construction footprint of 2.45 km^2 (1.8% of site) from: • 240 x 5 MW multi-bucket suction caisson and prepared ground (and scour protection); (1.2km^2)[1]. • Eight substation foundations, prepared ground and scour protection (0.03km^2). • Four met masts gravity bases and prepared area (and scour protection) (0.01km^2) • Jack up barge seabed footprint for 240 turbines (~0.60km^2). • 400 km inter-array and 75km inter-substation cable installation (trenching and anchor barge footprint ~0.53km^2) • Placement of pipeline crossing infrastructure (<0.01km^2) Decommissioning footprint of vessel seabed contacts all at new locations (jack up barge (~0.60km^2); cable lay anchor barge (up to ~0.28km^2)): ~0.88km^2. ~0.6% of site)
Penetration below seabed
Maximum piling depth 60 to 70m (applies to the following turbine foundation types: 8 MW concrete monopile (60m), 8MW jacket piles (70m), 8 MW tripod (60m)); piling of foundations for 8 x substations and 4 x met masts. Maximum number of piles arises from the use of 333 x jacket foundations which would give rise to 1,332 piles (to 60m penetration); 8 x substations (48 piles to 50m penetration); 5 x met masts on jacket foundations (20 piles to 60m penetration)
Spoil and scour
Maximum spoil disposed of *in-situ* within the wind farm area arising from the installation of 240 x 5 MW concrete monopile; 8 x offshore substations; 4 x met masts; 475km of inter-array and inter-substation cables In addition sediment released as a result of scour around the wind farm structures may also result in smothering of wreck sites. Release of up to circa 1100m^3 of scoured sediment per turbine foundation (45m diameter Gravity Base Foundation). Maximum spoil disposed of off-site at a licensed disposal site: 2,040,778 m^2 (arising from 333 x 3.6 MW conical/flat gravity base foundations).

[1] Scour protection would be placed within the prepared ground footprint and thus does not contribute to the total seabed loss area.

5.1.3 For the purposes of this assessment a minimum cable burial of 1 m has been assumed although actual cable depth has yet to be determined and may vary subject to geological conditions.

5.1.4 Once operational the TKOWF will require regular maintenance at different times throughout its lifetime.

5.1.5 At the end of the wind farm's design life decommissioning may be undertaken that broadly follows a reverse programme of the construction process. It is currently assumed that piled foundations are likely to be cut below seabed level (abrasive jet cutter or abrasive diamond wire cutting) with the protruding section being removed. In the case of gravity structures it may be preferable to leave the bases in place although for the purposes of assessment removal has been assumed.

5.2 CONSTRUCTION AND DECOMMISSIONING PHASES

Impact

5.2.1 Potential direct impacts comprise both direct damage to archaeological deposits and material and the disturbance or destruction of relationships between deposits and material and their wider surroundings.

5.2.2 Predicted direct impacts during construction comprise damage, disturbance or destruction of submerged prehistoric archaeology, shipwrecks and crashed aircraft from:

- Seabed preparation prior to foundation installation;
- Installation of foundations for turbines, substations and met masts;
- Placing of scour protection around foundations;
- Installation of the inter array and inter substation cables (burial through ploughing, trenching or rock cutting);
- Seabed contact by the legs of jack-up crane vessel and/or anchors of other vessels.

5.2.3 Predicted indirect impacts during construction comprise:

- Increased erosion to submerged prehistoric archaeology, shipwrecks and crashed aircraft uncovered as a result of changes in scour or sedimentation; and
- Increased protection afforded to submerged prehistoric archaeology, shipwrecks and crashed aircraft buried as a result of changes in scour or sedimentation.

5.2.4 Predicted direct impacts during decommissioning comprise damage, disturbance or destruction of submerged prehistoric archaeology, shipwrecks and crashed aircraft from:

- Removal of foundations, scour protection or cables; and

- Seabed contact by the legs of jack-up crane vessel and/or anchors of other vessels.

Magnitude of Impact

5.2.5 The magnitude of direct impacts on archaeological sites and findspots during construction will be high.

5.2.6 Although the overall percentage of seabed impacted by the TKOWF is low, the spatial extent of individual components is moderate to high in comparison to the sites or findspots they may potentially impact. Archaeological receptors range in size from particles of palaeo-environmental data through to single artefacts and artefact scatters to sites and landscapes. As such, any of the sources of direct impact listed above have the potential to destroy entire receptors as well as damaging a receptor or its relationship with the wider environment.

5.2.7 However, the key consideration with regard to archaeological receptors is that all direct impacts are permanent. Once a receptor is destroyed or damaged or its context is altered, it is not possible to repair or reinstate lost data. Hence, the impact from the temporary footprint of a jack up barge is of the same magnitude as a turbine foundation with a long term presence.

5.2.8 The magnitude of all indirect impacts to archaeological sites and findspots during construction will be low as follows:

- The magnitude of the impact resulting from increased covering of archaeological receptors from remobilised sediments will be low. Modelling (ABPmer Triton Knoll Physical Processes Impact Assessment (technical report Volume 3: Annex D of the ES)) predicts a maximum depositional depth of only 6mm at turbine foundations and 0.4mm along inter-array cable routes;
- The magnitude of the impact from increased scouring potential will be low. Modelling (ABPmer Triton Knoll Physical Processes Impact Assessment Technical Documentation for Consultation appended to the TKOWF Environmental Statement) predicts scouring to be very localised around foundation structures and the scour depths to be negligible; and
- As the predicted changes to scour and sedimentation are predicted to lie within the boundaries of natural variation the magnitude of increased erosion/protection will be low.

5.2.9 The magnitude of direct impacts on archaeological sites and findspots from the removal of foundations, scour protection or cables during decommissioning will be low.

5.2.10 However, this will depend on the methods employed to remove components at the end of the wind farm's working life. No further direct impacts will occur if foundations and cables are left in place. If they are removed it is reasonable to assume that, as a result of construction impacts, any potential damage will already have occurred. Consequently, if provision is made for

methods of removal which minimise further impact to a wider area, then the effect of such impacts will be low.

5.2.11 The magnitude of direct impacts on archaeological sites and findspots from the legs of jack-up crane vessels and/or the anchors of other vessels deployed during decommissioning will be high.

5.2.12 Although the spatial extents of such impacts are likely to be small when considering percentage of seabed, the footprint may be high in comparison to the sites or findspots they may potentially impact. Moreover, as all direct impacts are permanent the effect must be considered to be high.

Sensitivity of Receptor

5.2.13 All archaeological receptors have the potential to be damaged or destroyed if they are directly impacted during the construction or decommissioning of the TKOWF. As such, all sites and material should be regarded as vulnerable.

5.2.14 All damage to archaeological sites or material is permanent and recovery is limited to stabilization or re-burial, limiting further impact. As such, the recoverability of any archaeological receptors should be regarded as negligible.

5.2.15 There are no sites within either study area that are currently subject to statutory protection. However, there are eight documented losses of WWII aircraft at Named Locations between the Offshore Wind Farm Study Area and the coast, and if the remains of these aircraft were to be discovered they would be automatically protected under the Protection of Military Remains Act 1986. Until further data indicate otherwise, the importance of these receptors must be regarded as high.

5.2.16 Seven of the known wrecks within the Offshore Wind Farm Study Area were lost due to acts of war. Five were lost after striking a mine (WA7002, WA7007, WA7011, WA7079 and WA7078) and two were bombed by German aircraft (WA7121 and WA7012). The military associations of such vessels indicate that their importance may be regarded as high. However, further information will aid a full assessment of the importance of these wrecks.

5.2.17 Three of these vessels were in active service at their time of loss (WA7002 HMS *Cape Spartel*, WA7011 HMS *Pintail*, WA7012 HMS *Loch Alsh*) and could potentially be protected under the Protection of Military Remains Act 1986 (**Appendix I**). While all crashed military aircraft are automatically protected under this act, vessels must be individually designated.

5.2.18 The modern wrecks WA7080 *Petroswift* and WA7113 *Shepherd Lad* may be regarded as having low archaeological importance.

5.2.19 The available information suggests that the wreck of the *Cavehill* (WA7137) may have medium archaeological importance as a wreck of an early 20th century steamship with some structure remaining. However, further

information, if it becomes available, may show this wreck to have higher importance.

5.2.20 It is not possible to assess the importance of the wreck site or unidentified feature classified as 'Dead' by the UKHO (WA 7084, WA7085). Although no remains have been identified at these locations by repeated survey it is possible that remains may be fragmentary or buried.

5.2.21 The current level of data available for wrecks of unknown identity and geophysical anomalies of possible anthropogenic origin is insufficient to assess importance. As such the importance of each site must be regarded as potentially high until further information becomes available.

5.2.22 It is not possible to apply a definitive assessment of importance to potential sites. However, the rarity of *in situ* or derived Palaeolithic and Mesolithic material means that any finds of this date will be of high importance (English Heritage 1998). Intertidal sites dating to the Neolithic and later Prehistoric periods also be of high importance.

5.2.23 While the archaeological assessment has identified the potential for wrecks, aircraft and prehistoric land surfaces of potentially high importance at various locations across the proposed development, each will need to be considered on a site by site basis if they are impacted by development.

Significance of Effects

5.2.24 All direct impacts to the modern wrecks WA7080 *Petroswift* and WA7113 *Shepherd Lad* will result in moderate adverse effects upon the receptor.

5.2.25 Direct impacts to WA7137 *Cavehill* will result in effects upon the receptor which are moderate/major adverse in significance.

5.2.26 Direct impacts to all other known and unknown wrecks and geophysical anomalies of potential anthropogenic origin will result in effects of major adverse significance.

5.2.27 It is not possible to fully assess the significance of effects caused by the direct impacts to potential archaeological sites. However, as any damage or destruction of these sites will be permanent, the effects of direct impacts are likely to be judged of major adverse significance. Each will need to be considered on a site by site basis if they are impacted by development.

5.2.28 According to the definitions of significance outlined in **Table 4** all indirect impacts will result in effects of moderate significance. However, as changes in scour and sedimentation which may cause increased erosion/protection are predicted to lie within the boundaries of natural variation the effects of the impacts are likely to be considered tolerable.

Mitigation Measures

5.2.29 The primary aim of the precautionary principle is the prevention of damage to receptors by proactively putting in place protective measures, rather than

attempting to repair damage (which may be irreversible) after it has occurred (Wessex Archaeology 2007: 6).

5.2.30 Exclusion zones placed around all discrete sites or more extensive areas identified within an EIA prohibit development related activities within their extents and have been widely applied in offshore contexts to sites and anomalies with known or potential archaeological significance.

5.2.31 However, as the marine historic environment of the UK is still largely unknown and poorly documented, it is often not possible to fully assess the extent or importance of an archaeological site. In many instances, therefore, to assist developers with planning a scheme layout, the implementation of buffers around sites may be more appropriate.

5.2.32 Buffers around the extent of the sites are recommended for the 18 wrecks classified as 'A1' (anthropogenic origin of archaeological interest) and the 9 wrecks classified as 'A3' (historic record of possible archaeological interest with no corresponding geophysical anomaly) (**Table 14**). Although 'Dead' or 'A3' wrecks represent a location where no remains have been found through repeated survey, remains may still be present, either fragmentary or buried. These buffers are illustrated in **Figure 20**.

5.2.33 Wreck material can often be spread over a wide area in the vicinity of a wreck site and the buffers are expected to incorporate such material within their boundaries. The final scheme layout will take account of these buffers, which may evolve as the project progresses subject to scheme design and additional subsequent surveys that may be required and, if impacts cannot be avoided, measures to reduce, remedy or offset disturbance will be agreed.

5.2.34 A further 120 geophysical anomalies (rated A2) were identified as of potential anthropogenic origin and archaeological interest although the geophysical signatures were not clear enough to identify what they represent. Hence these anomalies would require further archaeological investigation to confirm or deny their origin (**Figure 20**).

5.2.35 In order to facilitate the design of the development scheme, buffers are not currently proposed for these anomalies. However, these sites should be assessed on a case by case basis once the development scheme has been established and then appropriate action can be taken in respect of only those likely to be impacted. Particular consideration should be paid to eight sites (WA7016-WA7023) with geophysical anomalies that suggest the presence of aluminium, a material used in the construction of WWII aircraft, among other things.

Table 14: 'A1' and 'A3' wrecks assigned temporary buffers

Class	WA_ID	Name	Easting	Northing
A1	7000	Unknown Wreck	358669	5929559
	7001	Unknown Wreck	360758	5922924
	7002	HMS *Cape Spartel* (probably)	356473	5928616
	7003	Unknown Wreck	356618	5926628
	7004	Unknown Wreck	358290	5930371
	7005	Unknown Wreck	356313	5925949
	7006	Unknown Wreck	359501	5926617
	7007	Royal Scott	359523	5931081
	7008	Unknown Wreck	353624	5930355
	7009	Seafloor disturbance	354000	5930276
	7010	Unknown Wreck	358323	5925858
	7011	HMS *Pintail*	359241	5930998
	7012	HMS *Loch Ash*	365281	5921765
	7028	Debris	358095	5930354
	7033	Unknown Wreck	359665	5929037
	7113	*Shepherd Lad*	352443	5933579
	7122	Wreck	353911	5933750
	7137	*SS Cavehill* (possibly)	356662	5933874
A3	7078	Unobserved Wreck	358760	5929143
	7079	Unobserved Wreck	359255	5929050
	7080	*Petroswift*	348475	5928131
	7081	Unobserved Wreck	359496	5927219
	7082	Unobserved Wreck	362386	5926121
	7083	Unknown	365799	5922476
	7084	Unobserved Wreck	353464	5932056
	7085	*Rheno*	347342	5930765
	7121	*SS Flashlight*	353792	5933655

5.2.36 Where preservation *in situ* is not practicable, disturbance of archaeological sites or material should be offset by appropriate and satisfactory measures, also known as preservation by record. In these circumstances, the effects of the development can be remedied by carrying out excavation and recording prior to the impact occurring (Wessex Archaeology 2007). The impact of the development may also be remedied by restabilising sites that have been destabilised, but not destroyed, or by offsetting damage to a site by detailed analysis and safeguarding of otherwise comparable sites elsewhere.

5.2.37 It is possible that previously unknown archaeological sites or material may only be encountered during the course of the installation and/or decommissioning of a scheme. For example, the discovery of an unknown, partially buried wreck (WA7008) during the archaeological assessment of geophysical data, and the presence of sand waves which could bury additional sites, emphasise the potential for the discovery of further finds.

5.2.38 To minimise the effects of impacts upon the potential archaeological resource, the Offshore Renewables Protocol for Archaeological Discoveries (http://www. wessexarch.co.uk/projects/marine/tcerenewables) will be adopted which will provide for the reporting of archaeological discoveries during the course of the development. The Protocol for Archaeological Discoveries (PAD) is a system for reporting and investigating unexpected archaeological discoveries encountered during construction and installation work, with Wessex Archaeology providing guidance and advising industry

staff on how to implement to protocol. This protocol further makes provision for the institution of temporary exclusion zones around areas of possible archaeological interest, for prompt archaeological advice and, if necessary, for archaeological inspection of important features prior to further construction in the vicinity. It complies with the Merchant Shipping Act 1995, including notification of the Receiver of Wreck, and accord with the JNAPC Code of Practice for Seabed Developers.

5.2.39 Watching briefs may be appropriate where seabed material is brought to the surface, for example during pre-lay grapnel runs.

5.2.40 A number of channels with probable archaeological potential have been identified across the Offshore Wind Farm Study Area although in some cases the origin and date of these channels is unclear. English Heritage has recommended that an objective for any further survey work and analysis include archaeological interpretation and recording. Therefore, where additional geotechnical work is planned in these areas to provide engineering design data, provision should be made for the complete recovery of cores that will also aid interpretation of these channels, in particular to identify channels believed to be of Holocene date that may contain pre-inundation prehistoric material and/or organic deposits,. These cores should be subject to the five stage assessment outlined in **Appendix V**. The objectives of this scheme of analysis take into account current research in line with the requirements of English Heritage and/or the Department of Culture Media and Sport

5.2.41 This impact assessment has highlighted how the current level of data available for many wrecks and geophysical anomalies prohibits a full understanding of the sites and is insufficient to assess importance. Therefore, where appropriate to a potentially significant impact, further geophysical, geotechnical and ROV/diver survey programmes should be designed inclusive of archaeological objectives to assist further site evaluation and to support further advice concerning mitigation.

5.2.42 It is anticipated that a scheme specific Written Scheme of Investigation (WSI) will be prepared, in agreement with English Heritage, once the final development scheme is established. The WSI will be prepared by a body affiliated to a professional association such as the I*f*A for the TKOWF as recommended by standard guidance (including COWRIE 2007) and will be in accordance with the model clauses for archaeological WSIs developed by The Crown Estate (Wessex Archaeology and the Crown Estate 2010). It will set out the design and implementation of mitigation with regard to both known sites identified in this report and as yet undiscovered sites or material encountered during the course of installation and/or decommissioning. It will include information about areas of high archaeological potential such as palaeochannels, as English Heritage has recommended that an objective for any further geotechnical survey work and analysis should include interpretation and recording, in line with the COWRIE guidance for Offshore Geotechnical Investigations and Historic Environment Analysis (Gribble and Leather 2011). The WSI will also set out procedures for watching briefs, preservation by record, offsetting damage, and how to handle the discovery

of previously unidentified material. Once the final development layout has been established, the WSI can be finalised and methodologies for any further work can be assessed and incorporated. Mitigation specific to any further identified impacts will be established. Through consultation, English Heritage stressed the importance of producing an archaeological WSI, prepared with their agreement.

Residual Impact

5.2.43 It is expected that the implementation of these approaches to mitigation, based on the assessment outlined above, will mean that the residual effects of the development on any archaeological receptors will be negligible.

Future Monitoring

5.2.44 The archaeological assessment of any further geophysical survey undertaken for the TKOWF will facilitate monitoring of archaeological sites and allow an evaluation of the applied mitigation. This monitoring regime should be detailed in the scheme WSI that will be required prior to the commencement of the construction works.

5.3 OPERATIONAL PHASE

Impact

5.3.1 Predicted direct impacts comprise damage, disturbance or destruction of submerged prehistoric archaeology, shipwrecks and crashed aircraft from:

- Anchors of vessels deployed during periodic overhauls and scheduled and unscheduled maintenance; and
- Seabed contact of the legs of jack-up crane vessels in the event of turbine component replacement.

5.3.2 Indirect impacts can include changes to currents, sediment transport and erosion patterns. Predicted indirect impacts comprise:

- Increased erosion to submerged prehistoric archaeology, shipwrecks and crashed aircraft uncovered as a result of changes in scour or sedimentation; and
- Increased protection afforded to submerged prehistoric archaeology, shipwrecks and crashed aircraft buried as a result of changes in scour or sedimentation.

5.3.3 The magnitude of effect and sensitivity of receptors is the same as that outlined above for the construction and decommissioning phases. Likewise, direct impacts to the modern wrecks WA7080 *Petroswift* and WA7113 *Shepherd Lad* from the operation of TKOWF will result in effects of moderate adverse significance while all other effects of the direct impacts that result in damage or destruction to a receptor will be of major adverse significance.

5.3.4 In addition, while indirect impacts will result in effects of moderate significance, as changes in scour and sedimentation are predicted to lie

within the boundaries of natural variation these effects are likely to be considered tolerable.

Mitigation Measures

5.3.5 Mitigation will follow that outlined above for the construction and decommissioning phases where relevant.

Residual Impact

5.3.6 It is expected that the implementation of these approaches to mitigation, based on the assessment outlined above, will mean that the significance of any residual effects of the development on any archaeological receptors will be negligible.

Future Monitoring

5.3.7 The archaeological assessment of any further geophysical survey undertaken for the TKOWF will facilitate monitoring of archaeological sites and allow an evaluation of the applied mitigation. This monitoring regime should be detailed in the scheme WSI that will be required prior to the commencement of the construction works.

5.4 CUMULATIVE IMPACTS

5.4.1 Cumulative impacts are those that result from incremental changes to the historic environment and can include recurrent impacts and also the concept of setting. The cumulative assessment considers the effect of the footprint of the development alongside indicative footprints for other developments in order to identify areas where cumulative impacts on a given receptor have the potential to occur. For the purpose of the TKOWF project, cumulative refers to all other wind farm projects and other marine projects, for example marine aggregate extraction.

5.4.2 The proposed TKOWF lies c. 11km from the nearest Round Two Offshore Wind Farm (Race Bank) and is the 10th Round One/Round Two development in the Greater Wash Strategic Environmental Assessment Area. The site also lies immediately adjacent to a licensed marine aggregate site (Area 440) and an existing subsea pipelines bisects the site (**Figure 18**).

5.4.3 The wind farm projects considered as part of the cumulative impact assessment are:

- Lynn (Centrica): Operational;
- Inner Dowsing (Centrica): Operational;
- Lincs (Centrica): under construction – started 2011);
- Sheringham Shoal (Statoil Hydro): under construction - started 2011;
- Dudgeon East (Warwick Energy): In planning (construction predicted 2013-2015);

- Humber Gateway (E.ON UK Renewables): consented (construction predicted 2012-2013);
- Race Bank (Centrica): In planning (construction predicted 2013-2014);
- Docking Shoal (Centrica): In planning (construction predicted 2015-2016);
- Westermost Rough (DONG): consented (construction predicted 2012-2014); and
- Hornsea – Round 3 wind project (EIA stage).

5.4.4 The other marine projects considered as part of the cumulative impact assessment are:

- Operational marine aggregate extraction areas:
- Area 440 (Westminster Gravels);
- Area 441 (1) and (2) (Westminster Gravels);
- Area 105 (Cemex UK Marine);
- Area 102 (Cemex UK Marine);
- Area 354 (Cemex UK Marine);
- Area 106 (a), (b) and (c) (Hanson Aggregates Marine Ltd);
- Area 107 (Cemex UK Marine);
- Area 197 (United Marine Dredging); and
- Area 408 (Coal Pit/Sole Pit) (Hanson Aggregates Marine Ltd).
- Subsea Cables and Pipelines:
- The Triton Knoll offshore export cables
- PL816/PL817 Pickerall A to Theddlethorpe (Perenco UK Ltd);
- PL929 Theddlethorpe to Murdoch MD 26in gas line (Conoco Philips); and
- PL930 Theddlethorpe to Murdoch MD 4in MEOH line (Conoco Philips).
- Oil and Gas:
- Amethyst East Field (BP);
- Amethyst Well 47/146-10 (BP); and
- Pickerill Field (BP).
- Commercial fisheries: Within the area (various fleets from Norfolk, Lincolnshire and Yorkshire as well as non-UK vessels).

5.4.5 All of the above wind farms and some of the aggregate extraction areas have been subject to archaeological assessments that have identified known wrecks and assessed geophysical data as part of an attempt to identify

previously unknown losses. These assessments have also assessed the potential for the presence of submerged prehistoric archaeology, through geophysical and geotechnical surveys.

5.4.6 With regard to known archaeological sites and geophysical anomalies of potential anthropogenic origin the principle means of mitigation is avoidance, for example, as detailed in the archaeological protocol for Lynn and Inner Dowsing (Wessex Archaeology 2006c). Consequently the cumulative direct impact is negligible. Any direct impacts from the anchors or nets of commercial fishing vessels are also likely to be negligible.

5.4.7 It is not possible to predict the cumulative impacts to potential archaeological sites, including maritime and prehistoric sites, although further geophysical and geotechnical surveys that can identify these features prior to impact may help to minimise potential impacts. Moreover, each offshore wind farm will likely have a scheme specific WSI and formal protocol for dealing with potential discoveries thereby reducing the significance of potential impacts.

5.4.8 Subsea cables and pipelines impact the seabed and a shallow section immediately below the seabed. Although these cables are long, and therefore cover a long stretch of seabed, their impacts are generally limited to the immediate surroundings. Additional impact from cable or pipe-laying or repair vessels is also likely to have occurred. However, overall, the localised impacts of these developments are unlikely to have adverse cumulative effects on archaeological receptors. This same conclusion is applied to the potential cumulative effects arising from the installation of the export cables from the TKOWF towards the Lincolnshire coast. It is noted that the application for a consent to install the export cables will require an EIA to be completed which would include a full archaeological assessment.

5.4.9 The oil and gas developments are also unlikely to have adverse cumulative effects on archaeological receptors. Overall, oil and gas developments have little direct impact on archaeological receptors on or immediately under the seabed. Amethyst comprises two main wellhead platforms and two additional satellite platforms, and began operation in 1989 (www.bpnsi.com). Pickerill Field comprises 12 appraisal wells and 15 high angle wells, and was built between 1984 and 1992 (Werngren *et al.* 2003). Impact to the seabed is limited to the satellite platform legs and the impact from the pipeline. Although the pipeline is long, and therefore covers a long stretch of seabed, the impacts are limited to a narrow corridor of the seabed. Additional impact is also likely from anchorages for repair or service vessels. However, these sites have been in operation for around two decades, and any impact has likely already occurred.

5.4.10 The effects of any future port/harbour dredging operations would be archaeologically assessed on an individual basis, and recommended mitigation measures would minimise their effects on the archaeological receptors. Therefore, the cumulative effects are expected to be negligible.

5.4.11 There has been fishing activity across the area over a long period of time, from both UK and non-UK vessels, and the seabed baseline already reflects

previous impact from trawl nets and anchors, for example the localised areas of trawl scars that were visible along the cable route in the geophysical survey data. Over the last century, the level of fishing and the number of vessels has decreased, and the majority of fishing in the area presently comprises a small number of vessels involved in potting, with even lower levels of demersal and beam trawling (Volume 4 F). Some areas within TKOWF will be lost to large fishing vessels, although smaller vessels will likely return to the area once construction is completed. As the level of impact is decreasing, the cumulative effects from the anchors or nets of commercial fishing vessels are expected to be negligible.

5.4.12 Commercial shipping has minimal impact on the seabed, and any impact is largely concentrated in areas such as the Humber Deep Water Anchorage to the north-west. Therefore, the cumulative effects of commercial shipping are expected to be negligible.

5.4.13 As far as Wessex Archaeology is aware, there are no marine waste disposal sites within the near vicinity of TKOWF, and the small scale ones along the coast, for example to the north-east of the Wash, would have little interaction with TKOWF. Therefore the cumulative effects are expected to be negligible.

5.4.14 Localised, project specific studies have indicated little change in sedimentation and scour from wind farm construction. The physical processes assessment carried out by ABPmer (ABPmer Triton Knoll Physical Processes Impact Assessment (technical report Volume 3: Annex D of the ES)) for TKOWF indicates that the construction will have negligible cumulative impact on the values of bed stress at Race Bank and Docking Shoal Offshore Wind Farms (the only schemes which Triton Knoll might have had any physical processes interaction). The report also concludes that the potential for overlapping sediment plumes with dredging areas is unlikely to cause bed level changes above natural variation. Hence, the cumulative impact is predicted to be negligible. However, further geophysical studies, undertaken during the working life of the project, should be archaeologically assessed to confirm that changes do not exceed those predicted by modelling.

5.4.15 The percentage of the seabed that is subject to permanent negative direct impacts from the foundations of wind farms and gas facilities is very small. Therefore, the potential cumulative impact of the construction of offshore wind farms upon any submerged prehistoric deposits that may survive off the Norfolk/Lincolnshire coast will likewise be small.

5.4.16 A positive cumulative effect of offshore developments is the accumulation of archaeologically interpreted geophysical and geotechnical data regarding submerged and sub-bottom, prehistoric land surfaces and palaeo-environmental evidence. However, any positive effect must be demonstrated by the completion of studies to professional archaeological standards, and the results produced must be made publicly available. In order for this positive effect to occur, the developer is required and responsible for ensuring that copies of any archaeological assessment reports, agreed with EH, are deposited with the National Monuments Record through the submission of an EH OASIS (Online Access to the Index of Archaeological

Investigations) form with a digital copy of the report. It is anticipated that any evidence derived from the TKOWF project will contribute to this body of data.

Visual Impact

5.4.17 Visual impact is dealt with under cumulative impacts as it is related to visibility of the TKOWF and other wind farms in the area. A full assessment of changes to the "setting" is provided in the Seascape and Visual Impact Assessment, of the TKOWF Environmental Statement (Volume 2: Chapter 9).

5.4.18 As stated in the seascape and visual impact assessment, the TKOWF is located 33km east from the nearest landfall on the Lincolnshire coast, 48km north of the nearest landfall on the Norfolk coast, and 39km south east of the nearest landfall on the Yorkshire coast. It later explains that from a meteorological context, 'data for the Wash area indicates that it would be rare for the visibility to extend beyond 16km'. Taking both the distance to the development and the weather conditions into account, it is apparent that there will be a negligible effect on the setting of any features of the terrestrial Historic Environment and that the TKOWF does not represent a significant additional impact.

5.5 CONCLUSIONS

5.5.1 Key impacts and mitigation are summarised in **Table 15**.

5.5.2 Without mitigation, potential direct impacts to all but three of the known and unknown wrecks and geophysical anomalies of potential anthropogenic origin will result in effects of major adverse significance. However, with mitigation in place, the residual effect will be negligible (**Table 15**).

5.5.3 Without mitigation, potential direct impacts to the wreck *Cavehill* (WA7137) will be of moderate/major adverse significance and to the modern wrecks WA7080 *Petroswift* and WA7113 *Shepherd Lad* will be of moderate adverse significance. However, with mitigation in place, the residual impact will be negligible (**Table 15**).

5.5.4 All indirect impacts arising from changes in scour and sedimentation are assessed as being of moderate significance although, as changes in scour and sedimentation are predicted to lie within the boundaries of natural variation, these impacts are likely to be considered tolerable.

5.5.5 It is not possible to fully assess the significance of impacts to potential archaeological sites. However, as any damage or destruction of these sites will be permanent, impacts will be of major adverse significance but reduced to negligible with appropriate mitigation measures. If such sites are confirmed, and are likely to be impacted by the development, each will need to be considered on a site by site basis.

5.5.6 The main form of mitigation will be through avoidance with the implementation of buffers around the extents of known wreck sites.

5.5.7 In order to facilitate the design of the development scheme, no buffers are currently proposed for geophysical anomalies identified as of potential anthropogenic origin and archaeological interest. However, these sites should be assessed on a case by case basis in the scheme specific WSI once the development scheme has been established.

5.5.8 Where avoidance is not practicable, disturbance of archaeological sites or material should be offset by appropriate and satisfactory measures outlined in the scheme specific WSI.

5.5.9 To assist further site evaluation and to support further advice concerning mitigation further geophysical, geotechnical and ROV/diver survey programmes should be designed inclusive of archaeological objectives where practicable. In particular, further examination of potential prehistoric deposits is recommended including Stage 3 to 5 (**Appendix V**) recording of existing cores and the collection of further cores to clarify the potential for Holocene deposits within identified channels.

5.5.10 Mitigation against any impacts to potential sites or material will include a formal protocol to ensure that any finds are promptly reported, archaeological advice is obtained, and any recovered material is stabilised, recorded and conserved. Watching briefs may be appropriate where seabed material is brought to the surface and if trenching is undertaken in the intertidal zone.

5.5.11 The cumulative impacts upon marine archaeology will be negligible; this includes visual impact on the setting of (onshore) historic monuments.

5.5.12 The archaeological assessment of data resulting from geophysical survey undertaken for the TKOWF during its working life will facilitate monitoring of archaeological sites and allow an evaluation of the applied mitigation.

Table 15: Key impacts and proposed mitigation

Impact	Activity	Significance	Proposed mitigation	Residual impact
Direct impacts causing damage to archaeological deposits and material and the disturbance or destruction of relationships between deposits and their wider surroundings during construction	Seabed preparation Installation of turbine foundations Installation of meteorological monitoring substations Placing of scour protection Installation of cables Legs of jack-up crane vessel and/or anchors of other vessels	Moderate/major adverse significance	Avoidance of known wrecks through implementation of appropriate buffers Design of scheme layout to minimise impact to geophysical anomalies of potential anthropogenic origin and archaeological interest Preservation by record where preservation in situ not possible Archaeological assessment of further geophysical data and/or geotechnical assessment of cores to clarify and identify potential prehistoric sites Implementation of formal protocol to deal with unknown sites and material encountered during course of development Watching briefs where seabed material is brought to the surface and if trenching is undertaken in the intertidal zone	Negligible
Indirect impacts causing increased erosion to submerged prehistoric archaeology, shipwrecks and crashed aircraft uncovered as a result of changes in scour or sedimentation	Changes to water quality, currents, sediment transport and erosion patterns during installation of foundations and cables	Negligible	Archaeological assessment of additional geophysical data to monitor sites following construction	Negligible

Indirect impacts causing increased protection to submerged prehistoric archaeology, shipwrecks and crashed aircraft buried as a result of changes in scour or sedimentation	Changes to water quality, currents, sediment transport and erosion patterns during installation of foundations and cables	Negligible	Archaeological assessment of additional geophysical data to monitor sites following construction	Negligible
Direct impacts causing damage to archaeological deposits and material and the disturbance or destruction of relationships between deposits and their wider surroundings during decommissioning	Removal of foundations, scour protection or cables	Negligible/ moderate adverse significance	Provision made for methods of removal to minimise further impact	Negligible
	Legs of jack-up crane vessel and/or anchors of other vessels	Moderate/major adverse significance	Avoidance of known sites through implementation of appropriate buffers	
Direct impacts causing damage to archaeological deposits and material and the disturbance or destruction of relationships between deposits and their wider surroundings during operation	Anchors of vessels deployed during periodic overhauls and scheduled and unscheduled maintenance	Moderate/major adverse significance	Avoidance of known sites through implementation of appropriate buffers	Negligible
	Legs of jack-up crane vessels in the event of turbine component replacement			
Indirect impacts causing increased erosion/protection to submerged prehistoric archaeology, shipwrecks and crashed aircraft as a result of changes in scour or sedimentation	Changes to water quality, currents, sediment transport and erosion patterns during working life of wind farm	Negligible	Archaeological assessment of additional geophysical data to monitor sites during the working life of wind farm	Negligible

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APPENDIX I: MARINE HISTORIC ENVIRONMENT LEGISLATION AND PLANNING GUIDANCE

NATIONAL LEGISLATION AND PLANNING GUIDANCE

The table below outlines the current legislation and guidance applicable to archaeological sites within England's territorial waters.

Legislation and Guidance	Policy Text
Protection of Wrecks Act (PWA) (1973): Section One	Wrecks and wreckage of historical, archaeological or artistic importance can be protected by way of designation. It is an offence to carry out certain activities in a defined area surrounding a wreck that has been designated, unless a licence for those activities has been obtained.
Protection of Wrecks Act (1973): Section Two	This provides protection for wrecks that are designated as dangerous due to their contents and is administered by the Maritime and Coastguard Agency through the Receiver of Wreck.
Protection of Military Remains Act (1986)	Under the Protection of Military Remains Act (1986), all aircraft that have crashed in military service are protected. The MoD also has powers to protect vessels that were in military service when lost. The MoD can designate 'controlled sites' around wrecks whose position is known and can designate named vessels as 'protected places' even if the position of the wreck is not known.
Ancient Monuments and Archaeological Areas Act 1979 (as amended)	This Act is primarily land based, but in recent years it has also been used to provide some level of protection for underwater sites. Scheduled Monuments and Areas of Archaeological Importance are afforded statutory protection by the Secretary of State, and consent is required for any major works. The law is administered by English Heritage and the Department of Culture, Media and Sport.
Merchant Shipping Act (1995)	This Act sets out the procedures for determining the ownership of underwater finds that turn out to be 'wreck', defined as any flotsam, jetsam, derelict and lagan found in or on the shores of the sea or any tidal water. It includes ship, aircraft, hovercraft, parts of these, their cargo or equipment. If any such finds are brought ashore, the salvor is required to give notice to the Receiver of Wreck that he/she has found or taken possession of them and, as directed by the Receiver, either hold them pending the Receiver's order or deliver them to the Receiver.

Legislation and Guidance	Policy Text
Policy Statement 5: Planning for the Historic Environment (2010)	Policy Statement 5 sets out the Governments overarching aim that the historic environment and its heritage assets should be conserved and enjoyed for the quality of life they bring to this and future generations. The objectives with regard to planning are to deliver sustainable development, conserve England's heritage assets in a manner appropriate to their significance and to contribute to our knowledge and understanding of our past by ensuring that opportunities are taken to capture evidence from the historic environment and to make this publicly available, particularly where a heritage asset is to be lost.
England's Coastal Heritage: a statement on the management of coastal archaeology (1996)	This statement sets out a number of principles for managing coastal archaeology. These include the promotion of preservation *in situ*, that finds should be managed in accordance with the principles which apply to terrestrial archaeological remains, that marine and terrestrial remains must be considered seamlessly, that a precautionary approach should be adopted and that planning policy should be applied to the treatment of sub tidal archaeological remains in order to secure best practice.
European Landscape Convention (2000)	The European Landscape Convention (2000) became binding on the UK from 1 March 2007. Its principal clauses require the Government to protect and manage landscapes and to integrate landscape into regional and town planning policies including its cultural, environmental, agricultural, social and economic policies. The Convention applies to the entire territory of the UK and includes land, inland water and marine areas. It is not regarded as applying to sea areas regulated by the UK that lie beyond territorial waters.
Code of Practice for Seabed Developers, Joint Nautical Archaeology Policy Committee 2006	This voluntary code provides a framework for seabed developers similar to the principles found in current policy and practice on land. The aim of the Code is to ensure a best practice model for seabed development. The Code offers guidance to developers on issues such as risk management and legislative implications.
COWRIE: Historic Environment Guidance for the Offshore Renewable Energy Sector (WA, 2007)	Of relevance to the offshore renewable energy sector, this guidance is intended to promote the development of best practice in relation to the marine historic environment. It is also intended to promote an understanding of conservation issues arising from the effects of offshore renewable energy projects on the historic environment.

Legislation and Guidance	Policy Text
COWRIE: Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy (Oxford Archaeology, 2008)	This report provides guidance for the assessment of cumulative impacts on the historic environment from offshore renewable energy projects. It outlines the cumulative (additive / changes) and synergistic (impact interactions) effects that should be considered.
Revised Draft Overarching National Policy Statement for Energy (EN-1) (DECC 2010a)	Provides guidance on the importance of the historic environment within energy development applications and with regards to decisions made by the Infrastructure Planning Commission (IPC)
Revised Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) (DECC 2010b)	Along with EN-1, this National Policy Statement (NPS) provides the primary basis for decisions by the (IPC) on applications for renewable energy infrastructure. It outlines different types of cultural heritage features that must be considered during the impact assessments, and provides guidance for the production of the impact assessment and development of mitigation measures
Identifying and Protecting Palaeolithic Remains: Archaeological Guidance for Planning Authorities and Developers (English Heritage 1998)	This draws attention to the importance of Palaeolithic remains and states that they must be considered in line with planning policy when potentially affected by development proposals.
Military Aircraft Crash Sites (English Heritage 2002)	This provides archaeological guidance regarding the significance and future management of military aircraft crash sites. It outlines the importance of aircraft crash sites and indicates that they should be considered where they are affected by development proposals.
The scope of Strategic Environmental Assessment of North Sea areas SEA3 and SEA2 in regard to prehistoric remains (2002)	Suggestions are made in these documents for the discussion of protocols and a reporting regime for the commercial sector, regarding prehistoric archaeological remains: 'The ideal structure would require or encourage the industry and its sub-contractors to check whether their activities are in archaeological prospective zones, and to identify, and report, when their activities positively detect prehistoric artefacts, or, in the case of acoustic surveys, provide very strong evidence. If this can be achieved at minimal or acceptable cost/delay to industry, then there is a positive advantage in allowing operators to start activities in zones of archaeological potential, while avoiding positively identified sites, if any.' (section 8.6)

LEGISLATION AND POLICY FOR THE UK CONTINENTAL SHELF

Beyond the UK's territorial waters heritage is generally subject to international legislation and policy. There are two exceptions. The Merchant Shipping Act (1995) covers wreck found or taken into possession outside UK waters, and stipulates that if brought into UK waters, finds must be reported to the Receiver of Wreck. In addition,

the provisions of the Protection of Military Remains Act (1986) regarding Controlled Sites are applicable in international waters, though they are only enforceable with respect to British-controlled ships, British citizens and British companies.

Current international law is unequivocal that wrecks do not form part of the natural resources of the Continental Shelf that coastal states are entitled to regulate. However, some indirect regulation is possible, arising from the environmental controls placed on the regulated exploitation of natural resources. In particular, as Continental Shelf activities are subject to Environmental Impact Assessment under European Directives (85/337/EEC and 97/11/EC), the effects of those activities on the archaeological heritage have to be addressed and mitigation proposed.

Relevant international legislation and policy is outlined in the table below.

Legislation and Guidance	**Policy Text**
United Nations Convention on the Law of the Sea (1982)	The United Nations Convention on the Law of the Sea (1982) was ratified by the UK in 1997. Article 303 stipulates that 'states have the duty to protect objects of an archaeological and historical nature found at sea and shall co-operate for this purpose'. Article 303 also provides for coastal states to exert a degree of control over the archaeological heritage to 24 nautical miles, though the UK has not introduced any measures to implement this right.
European Convention on the Protection of the Archaeological Heritage (Revised) (1992) (the Valletta Convention)	The Valletta Convention was ratified by the UK Government in 2000 and came into force in 2001. The convention binds the UK to implement protective measures for the archaeological heritage within the jurisdiction of each party, including sea areas. Insofar as the UK exerts jurisdiction over the Continental Shelf, then it would appear that the provisions of the Valletta Convention apply to that jurisdiction.
UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001)	The UNESCO Convention was concluded in 2001, and is a comprehensive attempt to codify the law internationally with regards to underwater archaeological heritage. The UK abstained in the vote on the final draft of the Convention, however, it has stated that it has adopted the Annex of the Convention, which governs the conduct of archaeological investigations, as best practice for archaeology. Although the UK is not a signatory, the convention entered into force on 2nd January 2009 having been signed or ratified by 20 member states.
International Council of Monuments and Sites Charter on the Protection and Management of Underwater Cultural Heritage (1996) (the Sofia Charter)	The Charter upon which the Annex of the UNESCO Convention is largely based includes a series of statements regarding best practice, intending 'to ensure that all investigations are explicit in their aims, methodology and anticipated results so that the intention of each project is transparent to all'. The UK is a member of the International Council of Monuments and Sites.

APPENDIX II: GAZETTEER OF KNOWN WRECKS AND GEOPHYSICAL ANOMALIES

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7000	Unknown Wreck	358669	5929559	A1	153.7	49.1	2.2	Wreck and detached debris identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 8429nT. The wreck is believed to be the UKHO recorded loss of a metal wreck of unknown identity (record position 65m away). The wreck is broken up.	6000, 2011	UKHO – 9089 Live
7001	Unknown Wreck	360758	5922924	A1	102.5	39.5	3.9	Wreck and a piece of detached debris identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 1726nT. The wreck is believed to be the UKHO recorded loss of a wreck of unknown identity (record position only 8m away). Circumstances of loss unknown. The wreck is well broken up and the engine/boiler is the highest point on the wreck.	6001, 2023	UKHO – 9077 Live
7002	HMS *Cape Spartel* (probably)	356473	5928616	A1	58.4	22.1	5.2	The probable wreck remains of HMS *Cape Spartel*, a British Steam trawler bombed and sank by German aircraft have been identified during the assessment of sidescan sonar and magnetometer datasets with a total magnetic amplitude of 679nT. The largest piece of detached wreck debris measures 9.2m x 5.2m x 0.8m. HMS Cape Spartel was built in 1929 by Cochrane & Sons Ltd and had a gross tonnage of 346 tons. The vessel is reported to be well broken up.	6002, 2015	UKHO - 8672 Live
7003	Unknown Wreck	356618	5926628	A1	53	8.6	2.1	Wreck and bright reflector identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 602nT. The piece of associated debris measures 3.6m x 1.9m The find is believed to be the UKHO recorded wreck loss of unknown identity. Circumstances of loss unknown. The wreck is well defined and partly buried.	6003, 2019	UKHO - 9156 Live

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7004	Unknown Wreck	358290	5930371	A1	70.6	28	4	Wreck identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 468nT. The wreck is believed to be UKHO recorded wreck loss of a steam ship of unknown identity Circumstances of loss are unknown. The wreck is broken up, two objects with height may represent the engine boilers.	6004, 2010	UKHO - 9036 Live
7005	Unknown Wreck	356313	5925949	A1	73.4	21.2	3.8	Wreck and two pieces associated wreck debris were identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 420nT. The wreck remains are believed to be the UKHO recorded wreck loss of unknown identity (approximately 10m from UKHO record) for which circumstances of loss are also unknown. This is a partially broken up wreck.	6005, 2021	UKHO - 9157 Live
7006	Unknown Wreck	359501	5926617	A1	83.9	28.2	3.3	Wreck and a bright reflector identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 415nT. The piece of associated debris measures 3.6m x 1.7m. The site is believed to be the recorded UKHO metal wreck loss of unknown identity. Circumstances of loss are also unknown. The wreck is broken up.	6006, 2018	UKHO - 9090 Live
7007	Royal Scott	359523	5931081	A1	46.5	15.5	0.6	Large area of wreckage and four detached pieces of debris were identified in the sidescan sonar and magnetometer datasets. The main wreck structure was not ensonified as it lies outside the survey area. The largest piece of debris measures 15.1m x 10.8m x 0.9 and the smallest piece 4.1m x 2.9m x 0.2m. The wreck remains are believed to be the Royal Scott as recorded by the UKHO (position 39m north). The Royal Scott was a British Steam Ship that was sank by mine on passage from London to Feith. Built in 1930 by Caledonian SB & E Co Ltd, Dundee with dimensions of 79.6m in length, 11.6m beam, 5.2m draught with a gross tonnage of 1444 tons. At the time of loss it was owned by London & Edinburgh shipping Co Ltd whilst carrying 400 tons of general cargo.	6007, 2008	UKHO - 8684 Live

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7008	Unknown Wreck	353624	5930355	A1	27.6	10.1	0.8	Partially buried wreck. No hull outline, only boat shaped mound of debris/structures identified in the sidescan sonar data.	6008	-
7009	Seafloor disturbance	354000	5930276	A1	42.1	12.3	0.3	Seafloor disturbance identified in the sidescan sonar data. The site is near a suspected wreck site also identified in the sidescan sonar data. The site mainly consists of a dark reflector patch with a centred piece of debris with height. This seafloor disturbance is likely to represent the remains of a shipwreck.	6009	-
7010	Unknown Wreck	358323	5925858	A1	65.9	92.3	2.7	Seafloor disturbance identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 1031nT. This highly ferrous site is likely to represent the visible remains of a recorded UKHO wreck loss of unknown identity (approximately 28m away). Circumstances of loss unknown.	6010, 2022	UKHO – 9087 Live
7011	HMS *Pintail*	359241	5930998	A1	45.2	65.5	0.6	A seafloor disturbance with three pieces of debris were identified in the sidescan sonar and magnetometer datasets with a total magnetic amplitude of 492nT. The pieces of debris measure 5m x 1.2m, 5.7m x 0.9m and 3.7m x 2m x 0.6m. The site is believed be the UKHO recorded loss of HMS *Pintail* (position 25m south). This British Corvette sank by mine with the loss of all 54 crew onboard. Built in 1939 by W Denny & Brothers with dimensions of 68.3mx7.7mx1.8m with a displacement of 580. There are little remains left, and these are fairly dispersed.	6011, 2009	UKHO – 8683 Live
7012	HMS *Loch Ash*	365281	5921765	A1	-	-	-	Whilst there has been no evident remains on the sidescan sonar data for the wreck of the HMS *Loch Alsh* anywhere around the UKHO recorded loss of HMS Loch Ash, an isolated magnetometer anomaly with a total magnetic amplitude of 1880nT may represent the buried remains of this wreck. This distinct anomaly lies 150m north of recorded loss. The position error is plausible for the time. HMS Loch Ash was a British Steam Trawler, attacked and sunk by German aircraft whilst under	6012, 2025	UKHO - 8658 Live

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
								tow. Built in 1926 by Cook, Welton & Gemmell for the Loch Fishing Co. Was requisitioned in 1939 from when it was used as a minesweeper. Build dimensions of the vessel were 42.7m x 7.3m x 4m and it had 358 gross tonnage. The UKHO surveys did not find the wreck during their 1993 surveys and it was therefore amended to foul ground.		
7013	Seafloor disturbance	358345	5929508	A2	37.2	25.9	0.4	Patch of bright reflectors and other pieces of debris in the vicinity identified in the sidescan sonar data. Site possibly associated with nearby wreck site.	6013	
7014	Seafloor disturbance	361093	5928643	A2	64	56	-	A seafloor disturbance including a group of six bright reflectors were identified in the sidescan sonar data; the largest object measuring 9.6m x 5.4m and smallest measures 1.9m x 0.8m.	6014	-
7015	Seafloor disturbance	356721	5931472	A2	70	30	-	A seafloor disturbance including a group of four elongated mounds were identified in the sidescan sonar; the largest object measuring 13.9m x 3m and smallest 6.2m x 5.5m.	6015	-
7016	Bright reflector	352138	5928773	A2	3	2	-	A bright reflector identified in the sidescan sonar data and interpreted as a possible piece of debris together with WA7047.	6016	-
7017	Bright reflector	353420	5927548	A2	4.8	1.3	-	A bright reflector were identified in the sidescan sonar data and interpreted as a possible piece of debris.	6017	-
7018	Bright reflector	358413	5929567	A2	5.5	8.2	-	A patch of bright reflectors were identified in the sidescan sonar data and interpreted as a debris field of possible archaeological interest.	6018	-
7019	Bright reflector	353021	5928347	A2	47.3	19.4	-	Seafloor disturbance with a group of bright reflectors were identified in the sidescan sonar data and interpreted as a debris field of possible archaeological interest.	6019	-
7020	Bright reflector	365164	5922374	A2	9.8	1.7	-	A piece of debris was identified in the sidescan sonar data and interpreted as an object of possible archaeological interest.	6020	-
7021	Bright reflector	358737	5922629	A2	-	-	-	One of three objects identified in the sidescan sonar data; the largest measuring 5.1m x 3.2m. Objects are found amongst sand waves and may be part of a larger site.	6021	-
7022	Bright	351064	5927046	A2	14.6	17.1	-	Patch of material identified in the sidescan sonar	6022	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
	reflector							data		
7023	Bright reflector	351945	5926549	A2	2.3	2.8	-	Large bright reflector, one of two objects in area of sand waves identified in the sidescan sonar data.	6023	-
7024	Dark reflector	358389	5926723	A2	9.9	3.5	0.3	Angular object with point of height identified in the sidescan sonar data.	6024	-
7025	Dark reflector	361837	5920707	A2	4.3	3.1	-	Object of possible archaeological interest identified in the sidescan sonar data.	6025	-
7026	Dark reflector	359641	5925790	A2	23.6	13.7	-	Object of angular character in an area of seafloor disturbance identified in the sidescan sonar data	6026	-
7027	Debris	360311	5922520	A2	13.4	10.4	0.6	Patch of material identified in the sidescan sonar data.	6027	-
7028	Debris	358095	5930354	A1	5.4	1.7	0.3	Clear object with height identified in the sidescan sonar data near a wreck site. Likely to be wreck debris.	6028	-
7029	Debris	355056	5925143	A2	2.3	1.6	1.1	Two objects of unknown origin with a prominent shadow and of similar dimensions and lying 6metres apart were identified in the sidescan sonar data.	6029	-
7030	Debris	359177	5922455	A2	1.9	1.5	0.6	A group of three objects: two objects of similar dimensions lying 4m apart and a third (the largest) lying 12metres SE from them (2.6m x 08m x 02m) were identified in the sidescan sonar data	6030	-
7031	Debris	353503	5927478	A2	-	-	-	Two object of possible archaeological interest lying side by side were identified in the sidescan sonar data. Largest measures 6.8m x 3m x 1.1m and smallest measures 4.1m x 3m x 0.8m	6031	-
7032	Debris	352129	5928797	A2	4.5	1.8	0.5	Debris near to other objects identified in the sidescan sonar data	6032	--
7033	Unknown Wreck	359665	5929037	A1	32.3	5.6	2.6	Large structure possibly part of a wreck or modern debris was identified in the sidescan sonar data only 4m from the UKHO record for the loss of a metal ship possibly a *Flare Stack*, and it is therefore likely to be the same site. The circumstances of loss are unknown. The vessel was built using steel lattice construction material.	6033, 2014	UKHO – 8674 Live
7034	Debris	358419	5922891	A2	4.8	4.2	1	Debris found amongst sand waves was identified in the sidescan sonar data	6034	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7035	Debris	358361	5922948	A2	3.2	2	0.5	Debris identified in the sidescan sonar data	6035	-
7036	Debris	358421	5923019	A2	7	1.3	0.4	Thin and elongated object identified in the sidescan sonar data	6036	-
7037	Debris	358519	5922869	A2	3.1	1	0.4	Thin and elongated object amongst sand waves was identified in the sidescan sonar data.	6037	-
7038	Debris	360529	5921661	A2	7.7	1.2	0.4	Linear feature with one point of height identified in the sidescan sonar data. It may be a cable or pipe and therefore no archaeological potential.	6038	-
7039	Debris	365862	5920118	A2	8.9	4.1	0.5	Debris identified in the sidescan sonar data	6039	-
7040	Debris	358277	5929487	A2	6.4	3.6	0.5	Object near seafloor disturbance identified in the sidescan sonar data	6040	-
7041	Debris	358423	5929607	A2	5.2	3.4	0.8	Debris of unknown origin but near a seafloor disturbance was identified in the sidescan sonar data.	6041	-
7042	Debris	365834	5920120	A2	4.6	7.4	0.9	Debris identified in the sidescan sonar data	6042	-
7043	Debris	356156	5925934	A2	8.6	1.5	0.5	Debris possibly associated with nearby wreck site identified in the sidescan sonar data	6043	-
7044	Debris	356430	5924686	A2	5.2	2.8	1.7	Large object in an area of debris or rocks identified in the sidescan sonar data	6044	-
7045	Debris	356414	5926141	A2	10.5	2.4	1	Debris possibly associated with nearby wreck site identified in the sidescan sonar data	6045	-
7046	Debris	352935	5928278	A2	12.2	1	0.2	Object near patch of material was identified in the sidescan sonar data	6046	
7047	Debris	352152	5928862	A2	15.5	6.7	0.6	Patch of material with two objects in the vicinity identified in the sidescan sonar data	6047	-
7048	Debris	356360	5926529	A2	5	0.4	0.3	Largest of a group of debris identified in the sidescan sonar data	6048	-
7049	Debris	360878	5923931	A2	4.6	1.5	0.6	Debris identified in the sidescan sonar data	6049	-
7050	Debris	363135	5923294	A2	8.4	2	1	Debris identified in the sidescan sonar data	6050	-
7051	Debris	351930	5926578	A2	3.2	1.9	0.4	Possible debris identified in the sidescan sonar data	6051	-
7052	Debris	349192	5927959	A2	4.4	1.8	0.6	One of at least 4 bright reflectors in a patch of seafloor disturbance identified in the sidescan sonar data	6052	-
7053	Debris	347835	5931833	A2	5.6	2.7	0.5	Debris identified in the sidescan sonar data	6053	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7054	Debris	355190	5931651	A2	38	21	0.9	Patch of debris identified in the sidescan sonar data	6054	-
7055	Debris	356846	5931071	A2	7.4	5.2	1.2	Isolated object of unknown origin but with large scour/sediment trail identified in the sidescan sonar data.	6055	-
7056	Debris	361648	5921315	A2	-	-	-	Group of three objects were identified in the sidescan sonar data. Two are approximately 4m apart and the third lies 18m NE. The largest object measures 3.2m x 1.1m x 0.5m	6056	-
7057	Debris	356440	5931500	A2	11.3	2	0.6	Isolated piece of debris.	6057	-
7058	Debris	358224	5930639	A2	7.8	1.1	0.5	Piece of debris identified in the sidescan sonar data.	6058	-
7059	Debris	359116	5923029	A2	8.2	4.8	0.4	Possible wreck debris identified in the sidescan sonar data.	6059	-
7060	Debris	359960	5921503	A2	8.3	3.6	0.4	Isolated object identified in the sidescan sonar data.	6060	-
7061	Debris	358857	5922604	A2	3.6	1.2	0.2	Near two other pieces of debris identified in the sidescan sonar data.	6061	-
7062	Debris	360233	5921705	A2	7.9	5.2	0.4	Isolated object identified in the sidescan sonar data.	6062	-
7063	Debris	358897	5922450	A2	5.1	1.9	0.4	Isolated anomaly identified in the sidescan sonar data.	6063	-
7064	Debris	358741	5922550	A2	6.3	5	0.8	One of three objects identified in the sidescan sonar data.	6064	-
7065	Magnetic	359794	5928903	A2	--	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 58.41nT	6065	-
7066	Magnetic	363866	5922575	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 25.4nT	6066	-
7067	Magnetic	361127	5926765	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 21.29nT	6067	-
7068	Magnetic	362866	5921255	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 18.15nT	6068	-
7069	Magnetic	363626	5922710	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of	6069	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
								16.32nT		
7070	Magnetic	362931	5921555	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 15.04nT	6070	-
7071	Magnetic	361712	5921735	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 14.16nT	6071	-
7072	Magnetic	361471	5926313	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 9.94nT	6072	-
7073	Magnetic	357312	5927060	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 9.69nT	6073	-
7074	Magnetic	359587	5930768	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 9.67nT	6074	-
7075	Magnetic	362676	5921365	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 9.48nT	6075	-
7076	Magnetic	363831	5920175	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 6.47nT	6076	-
7077	Magnetic	362881	5920545	A2	-	-	-	Isolated anomaly identified in the magnetometer data measuring a total magnetic amplitude of 6.25nT	6077	-
7078	Unobserved Wreck	358760	5929143	A3	-	-	-	The wreck of the *Dromore Castle*, a British Steam Ship was sank by mine whilst on passage from London to Leigh. Built in 1919 by Harland & Wolff Ltd, Greenock with dimensions 122m x 15.9m x 8.7m and a gross tonnage of 5242 tons. It was owned at the time of loss by the Union Castle Mail SS Co Ltd. Not found since 1994 and hence considered a foul ground	2012	UKHO – 8675 Live

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7079	Unobserved Wreck	359255	5929050	A3	-	-	-	The wreck of the *Fittonia* (possibly), a British Steam trawler. Sank by mine. Built in 1891 by Cochraine, Cooper & Scofield with the following dimensions 2936mx6.2mx3.4m and a gross tonnage of 146 tons. It was owned at the time of loss by the North East Steam Fishing Co Ltd. Sonar dimensions obtained by UKHO survey: 30mx6mx1m with an orientation of 000/180 degrees.	2013	UKHO – 9101 Live
7080	*Petroswift*	348475	5928131	A3	-	-	-	The wreck of the *Petroswift,* a British Motor Launch. Sank after taking on water following striking an unknown submerged object. It was a fibre glass hulled vessel measuring 10.7m in length.	2016	UKHO – 9184 Live
7081	Unobserved Wreck	359496	5927219	A3	16	5	1.9	An unknown UKHO sonar obstruction. It is entirely possible that this is the site of an unknown wreck from the sonar dimensions however this can not be substantiated until further investigation can be done.	2017	UKHO – 9158 Live
7082	Unobserved Wreck	362386	5926121	A3	1	1	0.5	A foul ground with sonar dimensions of 1mx1mx0.5m.	2020	UKHO – 9102 Live
7083	Unknown	365799	5922476	A3	-	-	-	An unknown foul ground. No dimensions recorded. This location lies within the OSA buffer zone, outside the geophysical survey area.	2024	UKHO – 8660 Live
7084	Unobserved Wreck	353464	5932056	A3	-	-	-	An undefined feature amended to Dead	2027	UKHO – 67288 Dead
7085	*Rheno*	347342	5930765	A3	-	-	-	A wreck of the Rheno, a British Steam Trawler. Sank in collision with ST Cruz in 1908. Wreck not found on survey therefore amended to Undefined and Dead. This wreck lies within the OSA buffer zone, outside the geophysical survey area.	2028	UKHO – 8680 Dead
7100	Dark Reflector	347157	5929862	A2	5.6	1.4	0.7	Large dark reflector with shadow, possible piece of debris. In an area with numerous contacts interpreted as fishing gear so could be recent.	6006	-
7101	Dark Reflector	348715	5932777	A2	2.7	1.0	0.5	Two adjacent dark reflectors with large shadows but no associated magnetometer contact. Could be natural boulders or pieces of debris.	6011	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7102	Debris	349153	5933366	A2	9.9	4.2	0.5	Angular dark reflector with large shadow but no associated magnetometer contact. Other smaller, angular contacts in the vicinity. Could be natural in origin, but unusually shaped and could be a piece of non-metallic debris.	6013	-
7103	Dark Reflector	349270	5932730	A2	5.2	0.3	0.7	Large, elongate dark reflector with large shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6014	-
7104	Dark Reflector	349869	5932804	A2	9.5	3.9	0.4	Large dark reflector with large shadow and associated scour, but no magnetometer contact. Could be natural or a piece of non-metallic debris.	6016	-
7105	Debris	350170	5932542	A2	4.1	1.1	0.4	Probable small group of dark reflectors with shadows but no associated magnetometer contact. Close to small linear contact (7106) and possible non-metallic debris.	6017	-
7106	Debris	350196	5932547	A2	0.9	2.2	0.2	Small, linear dark reflector with shadow but no associated magnetometer contact. Close to cluster of dark reflectors (7105), and possibly a piece of linear non-metallic debris.	6018	-
7107	Debris	350505	5932673	A2	24.7	13.6	0.3	Curvilinear dark reflector with shadow but no associated magnetometer contact. Appears to curve around a point contact (7108), and could be debris relating to this or a seabed feature caused by its presence.	6019	-
7108	Debris	350503	5932662	A2	6.2	6.1	0.1	Large dark reflector with shadow but no associated magnetometer contact. Circled on one side by curvilinear anomaly (7107). Could be natural in origin or a piece of non-metallic debris.	6020	-
7109	Dark Reflector	351078	5933117	A2	13.4	0.9	0.6	Large dark reflector with large shadow and associated scour, but no magnetometer contact. Could be natural or a piece of non-metallic debris.	6021	-
7110	Debris	351790	5933594	A2	6.4	0.2	0.6	Elongate dark reflector with shadow but no associated magnetometer contact. In an area of numerous similar contacts and possibly a piece of debris.	6024	-
7111	Dark Reflector	351992	5933108	A2	3.6	0.2	0.6	Large dark reflector with large shadow and associated scour, but no magnetometer contact. Could be natural or a piece of non-metallic debris.	6026	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7112	Debris	352375	5933378	A2	2.5	0.7	0.4	Elongate dark reflector with shadow but no associated magnetometer contact. No other similar contacts in the vicinity, and possibly a piece of linear non-metallic debris.	6028	-
7113	*Shepherd Lad*	352443	5933579	A1	17.6	4.4	2.4	Wreck identified on both sidescan sonar and swathe bathymetry data and as a very small (29nT) magnetometer contact. Very broken up and not recognisable as a vessel. Comprises one large central dark reflector with a large shadow surrounded by a limited area of debris. A linear target, possibly a rope or chain, is clearly visible from one angle.	6029	UKHO - 8704, Admiralty Chart 107 Live
7114	Dark Reflector	352191	5932368	A2	1.3	2.1	0.6	Isolated dark reflector with large shadow and some scour, but no associated magnetometer contact. Could be natural in origin or a piece of debris.	6030	-
7115	Dark Reflector	352425	5932528	A2	1.4	0.3	0.8	Isolated dark reflector with large shadow and some scour, but no associated magnetometer contact. Could be natural in origin or a piece of debris.	6031	-
7116	Dark Reflector	352715	5932241	A2	3.8	0.7	0.5	Isolated dark reflector with large shadow and some scour, but no associated magnetometer contact. Could be natural in origin or a piece of debris.	6032	-
7117	Debris	352788	5932658	A2	4.7	2.9	0.6	Dark reflector with shadow at the centre of an area of disturbed seabed. Two linear contacts extend in different areas from the central contact. No associated magnetometer contact observed, but could be a possible anchor point with associated ropes or chains, a sunken buoy, or the tip of a buried structure.	6033	-
7118	Debris	353009	5933210	A2	3.3	2.7	0.8	Two adjacent dark reflectors with large shadows, associated with curvilinear contact (7119) and a 45nT magnetometer contact (not tagged). Probable area of debris.	6034	-
7119	Rope / Chain	353020	5933198	A2	21.2	0.9	0.0	Curvilinear dark reflector associated with probable debris (7118) and a 45nT magnetometer contact (not tagged). Possible length of rope or chain.	6035	-
7120	Dark Reflector	353981	5933490	A2	7.8	1.4	0.5	Large dark reflector with shadow, could be either natural in origin or a piece of debris. Any magnetometer signal will be masked by the nearby wreck 7121.	6039	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7121	*SS Flashlight*	353792	5933655	A3	-	-	-	Given position of UKHO wreck number 8706 (*SS Flashlight*), but wreck not identified by any of the geophysical equipment. The UKHO description is very similar to that of wreck 7122 (UKHO 9042), located approximately 150m to the NE, and it is possible that they represent the same structure.	-	UKHO - 8706 Live
7122	Wreck	353911	5933750	A1	72.1	13.5	4.7	UKHO wreck number 9042, identified on both sidescan sonar and swathe bathymetry data and associated with a 1281nT magnetometer contact. Wreck is upright and still showing some height and structure, but badly broken up and either buried in the centre or broken in two pieces. Associated with a small surrounding debris field. Swathe bathymetry data show it to be situated within a large area of scour, approximately 80m x 150m and 1m deep. Wreck orientated approximately NNE - SSW, and possibly the same as unobserved wreck 7121 (UKHO 8706).	6040	UKHO - 9042, Admiralty Chart 107 Live
7123	Dark Reflector	354135	5933803	A2	2.7	0.0	0.3	Elongate dark reflector with shadow, any magnetometer contact masked by that of nearby wreck 7122. Could be natural in origin or debris relating to the wreck (though is located approximately 220m ENE of the wreck).	6041	-
7124	Debris	354349	5933930	A2	9.9	1.5	0.8	Large dark reflector (or two adjacent) with large shadow and associated scour. Any magnetometer signal masked by wreck 7122. possible piece of debris.	6042	-
7125	Dark Reflector	354178	5932340	A2	1.3	1.0	0.5	Isolated dark reflector with shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6043	-
7126	Dark Reflector	354693	5933094	A2	6.8	5.7	0.2	Isolated elongate dark reflector (or two adjacent) with shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6044	-
7127	Debris	354899	5933432	A2	8.2	0.4	0.5	Small dark reflector with shadow but no associated magnetometer contact. Other smaller, similar contacts in the vicinity, but possibly a piece of debris.	6045	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7128	Debris	355268	5933800	A2	1.3	2.5	0.2	Elongate dark reflector with shadow but no associated magnetometer contact. In an area of numerous similar contacts but possibly a piece of debris.	6046	-
7129	Debris	355309	5932453	A2	1.8	1.5	0.2	Two associated elongate dark reflectors with shadows but no associated magnetometer contact. Numerous similar contacts identified in the vicinity, but possibly a piece of debris.	6047	-
7130	Dark Reflector	355740	5932595	A2	1.7	0.8	0.8	Large dark reflector with large shadow and associated scour, but no magnetometer contact. Could be natural or a piece of non-metallic debris.	6049	-
7131	Dark Reflector	355756	5932587	A2	1.3	1.5	0.4	Small, indistinct dark reflector with shadow, possibly associated with larger contact 7130. Could be natural in origin or a piece of non-metallic debris.	6050	-
7132	Dark Reflector	355890	5933855	A2	3.7	3.2	0.5	Isolated elongate dark reflector (or two adjacent) with shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris. Potentially the same contact as 7133 (though they are located 50m apart).	6052	-
7133	Dark Reflector	355932	5933892	A2	3.2	1.4	0.4	Isolated elongate dark reflector (or two adjacent) with shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris. Potentially the same contact as 7132 (though they are located 50m apart).	6053	-
7134	Dark Reflector	357066	5932041	A2	5.1	1.0	0.4	Two adjacent dark reflectors with large shadows but no associated magnetometer contact. Could be natural boulders or pieces of debris.	6057	-
7135	Debris	357589	5931721	A2	3.8	0.4	0.6	Angular dark reflector with shadow and an associated 22nT magnetometer contact. Possible piece of debris.	6058	-
7136	Dark Reflector	356667	5932451	A2	4.7	1.3	0.4	Isolated dark reflector with large shadow but no associated magnetometer contact. Could be natural in origin or a piece of debris.	6059	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7137	*SS Cavehill* (possibly)	356662	5933874	A1	81.8	23.0	4.0	UKHO wreck number 9031 (Poss. *SS Cavehill*), identified on both sidescan sonar and swathe bathymetry data and associated with a 1651nT magnetometer contact. Wreck still displays significant height and some structure, though is fairly broken up and possibly in two pieces. Unable to determine whether it is upright or inverted. Swathe bathymetry data indicate it is situated within an area of shallow scour, approx. 130m x 50m and 0.5m deep. Some possible associated debris scattered relatively far from the vessel. orientated approximately NW - SE.	6060	UKHO - 9031 Live
7138	Debris	356673	5933796	A2	6.2	0.3	0.7	Two adjacent dark reflectors with shadows, any magnetometer signal masked by wreck 7137. Possible debris relating to the wreck.	6061	-
7139	Debris	356762	5933990	A2	10.5	0.4	0.3	Elongate dark reflector with shadow, any magnetometer signal masked by wreck 7137. possible debris from the wreck.	6062	-
7140	Debris	356808	5933974	A2	5.2	2.6	0.3	Dark reflector with shadow, any magnetometer signal masked by wreck 7137. possible debris from the wreck.	6063	-
7141	Dark Reflector	356412	5934006	A2	7.1	1.3	0.3	Isolated elongate dark reflector with shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6064	-
7142	Dark Reflector	357005	5933574	A2	2.5	0.8	1.2	Large dark reflector with large shadow but no magnetometer contact. Could be natural or a piece of non-metallic debris. Possibly related to similar contact 7143.	6066	-
7143	Dark Reflector	357090	5933601	A2	2.3	1.0	0.7	Dark reflector with shadow but no magnetometer contact. Could be natural or a piece of non-metallic debris. Possibly related to similar contact 7142.	6067	-
7144	Dark Reflector	357417	5934033	A2	3.6	2.7	0.6	Large dark reflector with large shadow but no magnetometer contact. Could be natural or a piece of non-metallic debris.	6069	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7145	Dark Reflector	358832	5933787	A2	0.8	0.6	0.5	Large dark reflector (or two adjacent) with large shadow and associated scour but no associated magnetometer contact. In an area with other smaller contacts so probably natural in origin, but much larger and stronger than surrounding contacts so could be non-metallic debris. On the edge of the survey area.	6074	-
7146	Dark Reflector	359155	5933085	A2	1.6	0.2	0.7	Elongate dark reflector with shadow but without associated magnetometer contact. Much more defined than other instances in the area, and possibly a piece of non-metallic debris.	6076	-
7147	Dark Reflector	359342	5932919	A2	5.0	1.4	0.9	Large, isolated dark reflector with large shadow and some scour but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6077	-
7148	Dark Reflector	357962	5932503	A2	4.9	0.3	0.9	Angular dark reflector with large shadow but no associated magnetometer contact. Other smaller, angular contacts in the vicinity. Could be natural in origin or could be a piece of non-metallic debris.	6079	-
7149	Dark Reflector	359200	5932323	A2	6.3	4.4	0.6	Angular dark reflector with shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6081	-
7150	Dark Reflector	359672	5932073	A2	5.3	3.2	0.9	Elongate dark reflector (or two adjacent) with shadow but without associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6083	-
7151	Debris	358174	5931386	A2	7.1	3.1	1.3	Linear dark reflector with shadow, possibly associated with very small, tentative 8nT magnetometer contact. Possible piece of debris.	6085	-
7152	Debris	359149	5931611	A2	2.0	1.1	0.4	Dark reflector with shadow and some scour but without an associated magnetometer contact. Other similar, smaller, reflectors in the vicinity but possibly a piece of debris.	6086	-
7153	Debris	359750	5931547	A2	6.1	0.5	1.0	Dark reflector with shadow and some scour but without an associated magnetometer contact. Other similar, smaller, reflectors in the vicinity but possibly a piece of debris.	6087	-

WA_ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Notes	Internal References	External References
7154	Seafloor Disturbance	358669	5931125	A2	10.2	9.3	0.0	Cluster of small, angular dark reflectors with shadows but no associated magnetometer contact. Could be natural or a patch of non-metallic debris. Possibly associated with nearby large contact 7155.	6088	-
7155	Dark Reflector	358700	5931117	A2	2.4	1.1	1.2	Large dark reflector with large shadow but no associated magnetometer contact. Possibly associated with nearby seafloor disturbance (7154). Could be natural in origin or a piece of non-metallic debris.	6089	-
7156	Debris	354189	5924510	A2	4.3	1.9	0.7	Large dark reflector with large shadow but no associated magnetometer contact. Possible piece of non-metallic debris, and probably related to nearby group of similar features (7157).	6198	-
7157	Debris	354286	5924488	A2	55.1	45.0	0.0	Large area of approximately 10 scattered dark reflectors with large shadows arranged in a rough rectilinear shape, along with possible short linear scars and dark reflectors. Largest dark reflector approximately 6.5m x 5.3m x 0.6m. No associated magnetometer contact, but could be a scatter of non-metallic debris or partially buried structure. Probably associated with contact 7156. No known wreck or structure from UKHO or Admiralty chart present in the vicinity.	6199	-
7167	Dark Reflector	357546	5922292	A2	1.8	0.4	0.4	Isolated dark reflector with large shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6218	-
7168	Debris	357587	5922095	A2	1.2	0.9	0.7	Isolated angular dark reflector with an unusual shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6219	-
7169	Dark Reflector	357761	5921927	A2	1.9	0.6	0.5	Isolated dark reflector with large shadow but no associated magnetometer contact. Could be natural in origin or a piece of non-metallic debris.	6220	-

APPENDIX III: MARINE GEOPHYSICAL SURVEY TECHNICAL SPECIFICATIONS AND PROCESSING METHODOLOGY

OSIRIS PROJECTS 2008

The Osiris Projects survey was carried out between July and October 2008 on board MV *Freja* and MV *Barinthus*. The geophysical datasets consist of sidescan sonar, sub-bottom profiler (boomer), swathe bathymetry and magnetometer data.

The datasets were digitally recorded by Osiris Projects in datum WGS 1984, UTM Zone 31°N.

All levels are expressed relative to Chart Datum (CD) at Spurn Head.

Technical Specifications

Sidescan Sonar Data

The data were acquired at high frequency (410kHz), 100m range and at a 150m line spacing using a GeoAccoustics 159D sidescan sonar system, a SS941 dual frequency sidescan sonar transceiver and recorded with a CODA DA2000 acquisition system.

The sidescan sonar survey produced a total seafloor overlap of 50% and coverage of 150%. Seafloor coverage below 200% is considered insufficient for archaeological purposes as the area below the towfish is not always ensonified. 200% seafloor coverage enhances the probability for the detection of objects and sites lying directly underneath the towfish, and allows for more accurate positioning of those features. The survey was undertaken to cover the wind farm areas in full, but this did not include the 1km buffer designed by WA to encompass sites of archaeological interest lying on the edge of the development.

Magnetometer Data

The magnetometer data were acquired using a Geometrics G882 magnetometer. This system provides absolute readings of total magnetic field with a working resolution of 0.01nT.

The magnetometer survey was undertaken simultaneously with the sidescan sonar instrument at 150m line spacing. Although a narrower line spacing would have been desirable for maximising the identification of buried material, the data were of good quality.

Multibeam Bathymetry Data

The multibeam bathymetry data were acquired using a GeoAccoustics ‘GeoSwath’ swath bathymetry system. The dataset was acquired at 75m line spacing for the main lines and 1500m line spacing for the cross lines, covering the study area in full.

Sub-bottom Profiler Data

The sub-bottom profiler data were acquired using an Applied Acoustics ‘Boomer’ sub-bottom profiling system with a pulse frequency in the range of 400 Hz to 14 kHz and with the majority of the energy being directed vertically downwards at a

maximum output of 300 joules per pulse. The boomer was fired at a rate of 4 times per second, using 100 joules per pulse and recorded with a Coda DA2000 acquisition system.

Processing

Sidescan Sonar

The sidescan sonar data were processed by WA using Coda Geosurvey software. This allowed the data to be replayed with various gain settings in order to optimise the quality of the imagery. The data were initially scanned to give an understanding of the geological nature of the area and were then interpreted for any visible objects of possible anthropogenic origin: the position and dimensions of any such objects were recorded into a gazetteer (**Appendix II**). A mosaic was also created in order to assess the quality of the navigation information in the files and general geomorphological trends and sedimentological variations across the survey area.

Magnetometer Data

The magnetometer data were recorded in text format in an x,y,z file, comprising grid co-ordinates (x,y) and total magnetic field strength (z). The data were processed by WA using Magpick software which allows the removal of the regional magnetic field and any large diurnal variations, which may mask small magnetic anomalies of interest to this assessment. The data were then gridded to produce a contour map of the survey area and plotted with the magnetic field strength values represented by graded colour bands to show changes in the magnetic field strength.

The magnetic anomalies were then assessed and the position and magnitude of all anomalies with an amplitude of 5nT or more were recorded and integrated into the gazetteer (**Appendix II**).

Multibeam Bathymetry Data

The data were tide corrected by Osiris Projects and exported to text format to give an x,y,z file comprising grid co-ordinates (x,y) and water depth below Chart Datum (z). The data were processed by WA using IVS Fledermaus software. This allowed the data to be gridded and made into a surface. The bathymetry data provided a vertical datum for the other geophysical datasets. However, as the data had been gridded with a 5m cell size, it was of insufficient resolution for the identification of isolated anomalies and the detailed study of sites of archaeological interest.

Sub-bottom Profiler Data

The data were processed by WA using Coda Geosurvey software. This software allows the data to be replayed with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting a sedimentary boundary that might be of archaeological interest.

The shallow seismic data were interpreted with two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth the velocity of the seismic waves was estimated to be 1,600m/s. This is a standard estimate for shallow, unconsolidated sediments.

For the purpose of this project, every fourth line of data (25%) was assessed. Where palaeo-features or other sedimentary boundaries of archaeological interest were identified, the adjacent lines were assessed in order to trace such features across the survey area.

GARDLINE GEOSURVEYS LTD 2009

The geophysical data assessed for this report consisted of sidescan sonar, sub-bottom profiler, magnetometer and swathe bathymetry data acquired by Gardline between the 17th June and 4th August 2009 utilising the survey vessel MV *Confidante*.

Primary positioning for the survey was provided by the Fugro Starfix DGPS system, with secondary positioning provided by the R110 Hemisphere system using EGNOS corrections.

For this survey all positions were recorded and expressed in WGS 1984, UTM Zone 31°N.

Technical Specifications

Sidescan Sonar Data

Gardline used an Edgetech 4200 dual frequency sidescan sonar towfish operating at both 410kHz and 120kHz and 100m range per channel. The sidescan sonar data were digitally recorded as *.xtf* files using the accompanying Edgetech Discover recorder, and output as hard copy data rolls using an Ultra 120 thermal printer.

Magnetometer Data

The magnetometer data were acquired using a towed Geometrics G-882 caesium vapour magnetometer. The data were recorded digitally as *.csv* files.

Multibeam Bathymetry Data

The swathe bathymetry data were collected using a hull-mounted Kongsberg EM3002 Dual Head system, operated at 300kHz with a ping rate of 10Hz. The data were digitally recorded using the Kongsberg SIS software and provided to Wessex Archaeology as *.xyz* files.

Sub-bottom Profiler Data

The sub-bottom profile data were acquired using an Applied Acoustics surface-towed boomer, operated at a power of 300J and firing rate of 300ms, with a towed 20 -12 hydrophone receiver. The sub-bottom profiler data were recorded digitally as *.sgy* files using a CodaOctopus 760 recording system, and as hard-copy data rolls using a Dowty 3710 thermal printer.

Processing

Sidescan Sonar

The sidescan sonar data were processed by WA using Coda Geosurvey software. This allowed the data to be replayed with various gain settings in order to optimise the quality of the images. The data were initially scanned to give an understanding of the geological nature of the area and were then interpreted for any objects of

possible anthropogenic origin: the position and dimensions of any such objects were recorded into a gazetteer and an image of each anomaly acquired.

Magnetometer Data

The magnetometer data were processed by WA using Geometrics MagPick software in order to identify any discrete magnetic contacts which could represent buried metallic debris or structures such as wrecks.

The software enables both visualisation of individual lines of data and gridding of data to produce a magnetic anomaly map. Smoothed averages of the data were first calculated, and then subtracted from the raw data values in order to reduce the effect of natural variations in the magnetic field such as changes in geology and water depth.

Multibeam Bathymetry Data

The swathe bathymetry data were used to provide a vertical reference for the sub-bottom profiler data, and fully analysed to identify any unusual seabed structures that could be shipwrecks or other anthropogenic debris. The data were gridded and analysed using Fledermaus software, which enables 3-D visualisation of the acquired data.

Sub-bottom Profiler Data

The shallow seismic data were processed by WA using Coda Geosurvey software. This software allows the data to be replayed with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting a sedimentary boundary that might be of archaeological interest.

The shallow seismic data were interpreted with two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth the velocity of the seismic waves was estimated to be 1,600 m/s. This is a standard estimate for shallow, unconsolidated sediments.

APPENDIX IV: DOCUMENTED LOSSES

Shipwrecks

NMR ID	Name	Year of Loss	Description	Easting	Northing
1347896	*Brothers and Sisters*	1821	An English sloop foundered on the Lincolnshire coast off Ingoldmells.	323407	5896891
942803	*Betsey and Mary*	1822	English vessel stranded on the Lincolnshire coast the crew were saved.	323407	5896891
1351130	*Neath Castle*	1823	English vessel stranded on the Lincolnshire coast	323407	5896891
1316022	*Unknown*	1830	A Dutch cargo vessel was stranded between Ingoldmells and Skegness coast.	323407	5896891
942744	*Mary*	1749	British cargo vessel stranded on the Lincolnshire coast.	324002	5897802
942746	*Owners Goodwill*	1752	British cargo vessel lost on the Lincolnshire coast.	324002	5897802
1301852	*Greyhound*	1762	British cargo vessel stranded on the Lincolnshire coast.	324002	5897802
942755	*St Nicholas*	1765	Vessel stranded on the Lincolnshire coast	324002	5897802
1301871	*Elenora*	1768	Vessel grounded and bilged on the Lincolnshire coast which was later recovered.	324002	5897802
1301873	*Gouldsbury*	1768	Cargo vessel grounded on the Lincolnshire coast which was later recovered.	324002	5897802
942757	*John and Sally*	1770	English cargo vessel stranded on the Lincolnshire coast.	324002	5897802
942759	*George and Jane*	1772	British craft grounded on the Lincolnshire coast which was later recovered.	324002	5897802
942761	*Windsor*	1777	British craft stranded on the Lincolnshire coast.	324002	5897802
1301944	*Kent*	1781	British craft stranded on the Lincolnshire coast.	324002	5897802
1301945	*Baltik Merchant*	1784	British cargo vessel grounded on the Lincolnshire coast which was later recovered.	324002	5897802
1301947	*Mary*	1785	British cargo vessel grounded on the Lincolnshire coast which was later recovered.	324002	5897802
1336682	*And Esther*	1795	English vessel stranded on the Lincolnshire coast all crew were lost.	324002	5897802
942763	*Industry*	1796	British vessel stranded on the Lincolnshire coast.	324002	5897802
942766	*Chance*	1797	British vessel stranded on the Lincolnshire coast.	324002	5897802
942770	*America*	1799	British vessel stranded on the Lincolnshire coast all crew were saved.	324002	5897802
942772	*Persis*	1800	British cargo vessel stranded on the Lincolnshire coast.	324002	5897802
942777	*Betsey*	1801	English vessel grounded on the Lincolnshire coast which was later recovered.	324002	5897802
1338869	*William*	1802	British vessel stranded on the Lincolnshire coast all crew were last save one the master.	324002	5897802
1338899	*George*	1802	British vessel stranded on the Lincolnshire coast.	324002	5897802
1339400	*Union*	1803	Vessel stranded on the Lincolnshire coast	324002	5897802
1339438	*Hornsby*	1803	British vessel grounded on the Lincolnshire coast but was rescued a few days later and put into dock.	324002	5897802
1340569	*Union*	1807	Vessel stranded on the Lincolnshire coast the crew were saved.	324002	5897802
1341872	*Margaret*	1810	English vessel stranded on the Lincolnshire coast all crew were lost.	324002	5897802
1341918	*Hoy*	1810	The cargo vessel Hoy was wrecked on the Lincolnshire coast all crew were saved.	324002	5897802
1342862	*Gute Mutter*	1813	German cargo vessel wrecked on the Lincolnshire coast the cargo and crew were saved.	324002	5897802
1342985	*Armen*	1815	British cargo vessel stranded on the Lincolnshire coast.	324002	5897802
1344658	*Good Hope*	1816	An English cargo vessel lost on the Lincolnshire coast.	324002	5897802
1346563	*Patent*	1819	British cargo vessel wrecked on the Lincolnshire coast the cargo was discharged.	324002	5897802
1347879	*Gothenberg*	1821	Swedish cargo vessel wrecked on the Lincolnshire coast the cargo was saved.	324002	5897802

NMR ID	Name	Year of Loss	Description	Easting	Northing
1348655	*Unknown*	1821	An English cargo sloop was stranded on the Lincolnshire coast.	324002	5897802
1348707	*Adventure*	1821	Vessel was lost on the Lincolnshire coast.	324002	5897802
1349030	*Ferdinand*	1821	Prussian cargo vessel stranded on the Lincolnshire coast the cargo was saved.	324002	5897802
1351144	*John*	1823	English vessel stranded on the Lincolnshire coast	324002	5897802
1351147	*Darby*	1823	English vessel stranded on the Lincolnshire coast.	324002	5897802
1351149	*Jason*	1823	English vessel stranded on the Lincolnshire coast	324002	5897802
1351781	*Vrow Gesina*	1824	Cargo vessel lost on the Lincolnshire coast, part of the cargo was saved.	324002	5897802
942805	*Fortunatus*	1824	Vessel lost on the Lincolnshire coast.	324002	5897802
1352063	*Cotanza*	1917	Italian cargo steam ship torpedoed by a German submarine	333839	5908580
1389921	*Mary*	1784	English cargo vessel which stranded on the Dowsings on her passage with coal; a wooden sailing vessel.	337049	5904757
971706	*Expedition*	1805	British cargo vessel which foundered after grounding on the Inner Dowsing, on her passage from Shields to London with coal; a wooden sailing vessel.	337049	5904757
1342677	*Hannah*	1812	English cargo vessel which stranded on the Inner Dowsing en route from London to Gothenburg with goods; a wooden sailing vessel.	337049	5904757
1407872	*Good Intent*	1826	English collier which foundered about 10 miles S of the Humber following a collision. On her passage from London in ballast, she was a wooden sailing vessel.	337049	5904757
1316026	*Susannah*	1827	British craft which struck upon the Inner Dowsings and filled with water. The master and crew landed at Grimsby.	337049	5904757
942817	*Pollock*	1841	English Brig which struck Sheringham Shoals while on route from Shields to London and sunk off the Inner Dowsing	337049	5904757
1306205	*Robert*	1841	English schooner which foundered off the Inner Dowsing following collision with the *Hunter* which also foundered. Bound from Goole to London with coal, she was a wooden sailing vessel.	337049	5904757
1306215	*Hunter*	1841	English schooner which foundered off the Inner Dowsing following a collision with the *Robert* which also foundered. Bound from London to Sunderland in ballast, she was a wooden sailing vessel.	337049	5904757
1363714	*Wentworth*	1873	English cargo vessel which foundered 23 miles SE of Spurn Head after springing a leak en route from Shields to London with coal. Constructed of iron in 1865 or 1866, she was a steam-driven vessel.	337049	5904757
1321617	*Unknown*	1878	Full rigged ship lost while under tow in ballast from Yarmouth to the Tyne during a gale with the loss of all crew.	337049	5904757
943086	*Fidelity*	1890	English Ketch foundered and lost following collision with the dandy *Esmeralda.*	337049	5904757
943002	*Shoaynyo*	1894	English Ketch foundered in wind conditions NW force 11.	337049	5904757
943009	*Tiger*	1896	English Ketch foundered in wind conditions W force 10.	337049	5904757
943014	*Moonlight*	1897	English steam ship foundered and lost after striking floating wreckage in wind conditions E force 1, the vessel sinking some time later.	337049	5904757
943095	*Express*	1899	English smack foundered 2.5 miles SW of Inner Dowsing Buoy.	337049	5904757
1351949	*River Thames*	1904	English towed barge which sank in wind conditions ESE force 4 when it broke from its tug	337049	5904757
1302227	*Stockton*	1909	English steam ship which foundered 7 mile ENE of Skegness Pier	337049	5904757
943113	*Reindeer*	1911	English Ketch which foundered 1 mile W of the Inner Dowsing	337049	5904757

NMR ID	Name	Year of Loss	Description	Easting	Northing
1302298	*Achilles*	1914	English Ketch which foundered 6 miles SE of Inner Dowsing Light Vessel	337049	5904757
1374729	*Fittonia*	1914	English trawler which foundered 27 miles SE of Spurn Head light vessel after being mined. This iron steam vessel, built 1891, departed from Grimsby on a fishing and return trip.	337049	5904757
943135	*Fane*	1917	Norwegian cargo vessel which foundered 2.5 miles E of the Inner Dowsing Light Vessel after being mined en route from Rouen for Sunderland in ballast. Constructed in 1901 of steel, she was a steam-driven vessel.	337049	5904757
1302364	*Onesta*	1917	Italian steamship and cargo vessel torpedoed by a German submarine and lost in the North Sea.	337049	5904757
1352099	*Capitiane Edmond Laborie*	1939	French steamship and cargo vessel which foundered after being mined or torpedoed .	337049	5904757
942833	*Temple*	1875	English Barge sprang a leak in heavy sea and wind conditions WNW force 4 and foundered.	337843	5911788
1351119	*Ranger*	1879	English Dandy foundered and lost in wind conditions SE force 2 after supposedly striking a sunken wreck.	337843	5911788
1372313	*Emma*	1895	English ketch which foundered 30 miles SE of Spurn Head in a gale. This wooden sailing vessel, built 1863, was en route from Ipswich for Newcastle upon Tyne with timber.	337843	5911788
1302306	*Lord Stanhope*	1914	English steamship and trawler lost near the Inner Dowsing Light Vessel.	337843	5911788
1302345	*Unknown*	1917	1917 or earlier wreck of sailing vessel which foundered approximately 0.75 miles NNE of the Inner Dowsing Light Vessel, as given in a contemporary report. May have been lost to a mine, possibly one of four fishing vessels captured by submarine in the North Sea during April 1917.	337843	5911788
1302371	*Vernon*	1917	English steamship and cargo vessel torpedoed and sunk by a German submarine, only the master lost his life in the explosion.	337843	5911788
1459750	*Argo*	1917	Norwegian cargo vessel which foundered with the loss of 9 lives after being mined near the Inner Dowsing Light Vessel, while en route from Kingston-upon-Hull for Rouen with coal. Constructed of iron in 1883, she was a steam-driven vessel.	337843	5911788
1459768	*Heimland I*	1917	Norwegian cargo vessel which foundered 2 miles ESE of the Inner Dowsing Light Vessel after being striking a contact mine en route from the River Tyne for St. Nazaire with coal. Constructed of steel in 1913, she was a steam-driven vessel. TF 77 NE 1 is now the	337843	5911788
1371004	*Ipswich*	1763	English cargo vessel which foundered in the North Sea on passage between Stockholm and London with a cargo of 390 tons of iron and deals.	355610	5911584
1350022	*Olive*	1865	English Smack foundered and lost following collision.	355610	5911584
1350987	*Leonie*	1871	French cargo vessel foundered and lost in wind conditions SW force 5 following collision.	355610	5911584
1350993	*Ann*	1873	English Brigantine foundered and lost in wind conditions WSW force 8 with a cargo of 212 tons. The vessel became very leaky and unmanageable due to the heavy seas, she was hove to and the crew left her in the boats, few minutes after which she went down head foremost.	355610	5911584
1351097	*Don Colino*	1877	Channel Island Schooner foundered and lost in wind conditions force 3 following collision with the Italian registered barge *Destino*.	355610	5911584
1351111	*Kron Prinz Ernst August*	1878	German schooner foundered and lost offshore in wind conditions NE force 11.	355610	5911584
1351150	*Dora*	1880	English Smack foundered and lost in wind conditions SW force 8 following collision with the smack *Tiger*.	355610	5911584
943080	*Rescue*	1883	Channel Island Brigantine foundered and lost in wind conditions W force 10.	355610	5911584

NMR ID	Name	Year of Loss	Description	Easting	Northing
1351202	*Wonderful*	1883	English Ketch stranded and lost in wind conditions N force 5.	355610	5911584
1370547	*William and Susannah*	1889	An English dandy which collided with another vessel and foundered 14 miles E of New Sand light vessel in 1889. Wind conditions were ENE force 2. She departed from Grimsby on a fishing and return trip. The wooden sailing vessel was built in	355610	5911584
1370570	*H Smethurst*	1890	An English dandy which burnt and foundered 22 miles E of Spurn Head. The wind conditions were NNE force 5. She departed from Grimsby on a fishing and return trip. The wooden sailing vessel was built in 1865.	355610	5911584
1370602	*Sarah*	1891	An English schooner which foundered 18 miles SE of Spurn Head in 1891; wind conditions were WNW force 10. She departed from King's Lynn for Stockton on Tees with a cargo of wheat. The wooden sailing vessel was built in 1861.	355610	5911584
1371421	*Savills*	1894	English ketch which foundered 20 miles ESE of Spurn Head in a gale. This wooden sailing vessel, built 1860, was en route from Wisbech to Middlesbrough with wheat.	355610	5911584
1372306	*Twiggs*	1895	English schooner which foundered 20 miles E of Spurn Head in a gale. This wooden sailing vessel, built 1860, was en route from Middlesbrough to Grimsby with salt.	355610	5911584
943021	*Edwin*	1899	English steamship and cargo vessel foundered and lost following collision with the *SS Chipchase* in wind conditions ENE force 1.	355610	5911584
1372611	*Presto No 1*	1901	English dandy which foundered 25 miles SES of Spurn Head. This wooden sailing vessel departed from Grimsby on a fishing and return trip.	355610	5911584
1302213	*Seagull*	1904	British Lugger foundered and lost following collision with the *Fisher Lass* in wind conditions WNW force 4.	355610	5911584
943102	*Cramlington*	1908	English merchant steamer foundered and lost following collision with the *SS Cadby*. The wreck was dispersed by explosives level with the seabed	355610	5911584
1374683	*Umbe*	1913	Spanish cargo vessel which foundered 20 miles E of Spurn Head light vessel following collision. This steel steam vessel, built 1907, was en route from Bilbao to Middlesbrough with iron ore.	355610	5911584
1302304	*Torquay*	1914	Norwegian steamship and cargo vessel foundered and lost following collision with the steam trawler *Carrington*.	355610	5911584
1374766	*Khartoum*	1914	English cargo vessel which foundered 20 miles ESE of Spurn Head having been mined. This steel steam vessel, built 1893, was en route from the River Tyne to Oran with coal.	355610	5911584
1374851	*Schieland*	1915	Dutch cargo vessel which foundered 20 miles ESE of Spurn light vessel after detonating a mine. This steel steam vessel was en route from Goole to Rotterdam with coal.	355610	5911584
1375335	*Hanna Larsen*	1917	English cargo vessel which foundered 20 miles E of Spurn Head after being scuttled. This steel steam vessel, built 1903, was requisitioned by the Royal Navy and was en route from London to the River Tyne in ballast in order to load coal.	355610	5911584
1381280	*Straton*	1918	British trawler which foundered 26 miles E of the River Humber light vessel after detonating a mine. This steel steam vessel was on a fishing trip.	355610	5911584
1377215	*Eros*	1918	British trawler which foundered 36 miles ENE of Spurn Head after detonating a mine. This steel steam vessel was on a fishing and return trip.	355610	5911584
1351292	*Content (Possibly)*	1923	Report of a cargo vessel *Content* which sunk c. 20miles north of Dudgeon while on route from London to Shields with a cargo of tobacco, her rudder gone and leaking having struck upon the Dousens.	355610	5911584

NMR ID	Name	Year of Loss	Description	Easting	Northing
1352096	*Polzella*	1928	British steamship and cargo vessel foundered and lost following collision.	355610	5911584
943161	*Mamari III*	1941	British steam powered liner sold to the admiralty and converted to represent the aircraft carrier HMS *Hermes*. She was on passage to Chatham after the real *Hermes* had been sunk off Ceylon in 1941. She struck the wreck of the tanker *SS Ahamo* and whilst aground was torpedoed by a German E-boat and lost.	355610	5911584
1352230	HMS *Dalemoor*	1945	English steamship and cargo vessel foundered and lost after detonating a mine whilst on passage for Immingham, due to being diverted into the Thames.	355610	5911584

Aircraft

NMR ID	Name	Year of Loss	Description	Easting	Northing
1354050	*Hampden MK I X3062*	1941	British Bomber shot down by intruder off Mablethorpe, Lincolnshire on return from Hamburg	333839	5908580
1354135	*Spitfire MK I X4353*	1942	Supermarine Spitfire Mk I standard single-seat fighter lost when it flew into the sea in haze off Mablethorpe.	337049	5904757
1323066	*Blenheim MK IV R3765*	1940	Bristol Blenheim Mk IV standard light bomber ditched near Outer Dowsing lightship when lost and low on fuel on return from Hamm.	355610	5911584
1354038	*Hampden MK I X3062*	1941	Handley Page Hampden Mk. I standard Bomber Command aircraft damaged by flak and ditched off Lincolnshire coast on return from Schipol.	355610	5911584
1354212	*Wellington MK IV Z1285*	1942	Vickers Wellington Mk IV standard heavy night bomber shot down by night fighter off Lincolnshire coast on return from Munster.	355610	5911584
1354383	*Whitley MK VII Z6960*	1942	Armstrong Whitworth Whitley Mk VII standard night bomber ditched 12 miles E of Spurn Head.	355610	5911584
1404780	*Dornier DO217M-1 (6045) U5+GK*	1943	German Dornier Do217 which was shot down and crashed off Spurn Head. It was part of Squadron 2/KG2.	355610	5911584
1404778	*Dornier DO217K-1 (4412) U5+BA*	1943	German Dornier Do217 which was shot down and crashed 15 miles E of Spurn Head. It was part of Stab/KG2.	355610	5911584

APPENDIX V: WESSEX ARCHAEOLOGY FIVE STAGE BOREHOLE ASSESSMENT METHODOLOGY

Stage 1: Archaeological Assessment of Borehole Logs

A desk based archaeological assessment of the core logs generated by Fugro (Fugro GeoConsulting 2009) preceded this phase of work. This assessment established the likely presence of horizons of archaeological interest and broadly characterised them, as a basis for deciding whether and what Stage 2 archaeological recording was required (Wessex Archaeology 2009).

Stage 2: Geoarchaeological Recording

The current Stage 2 geoarchaeological recording of selected core samples entails recording of details such as sediment type, structure, texture, colour and stoniness, with a report outlining recommendations for further work. Sampling for potential Stage 3 assessment was also undertaken as part of this stage, as the core material is held at remote locations and is also scheduled for geotechnical testing which may make archaeological sampling impossible in future.

Stage 3: Sampling and Assessment

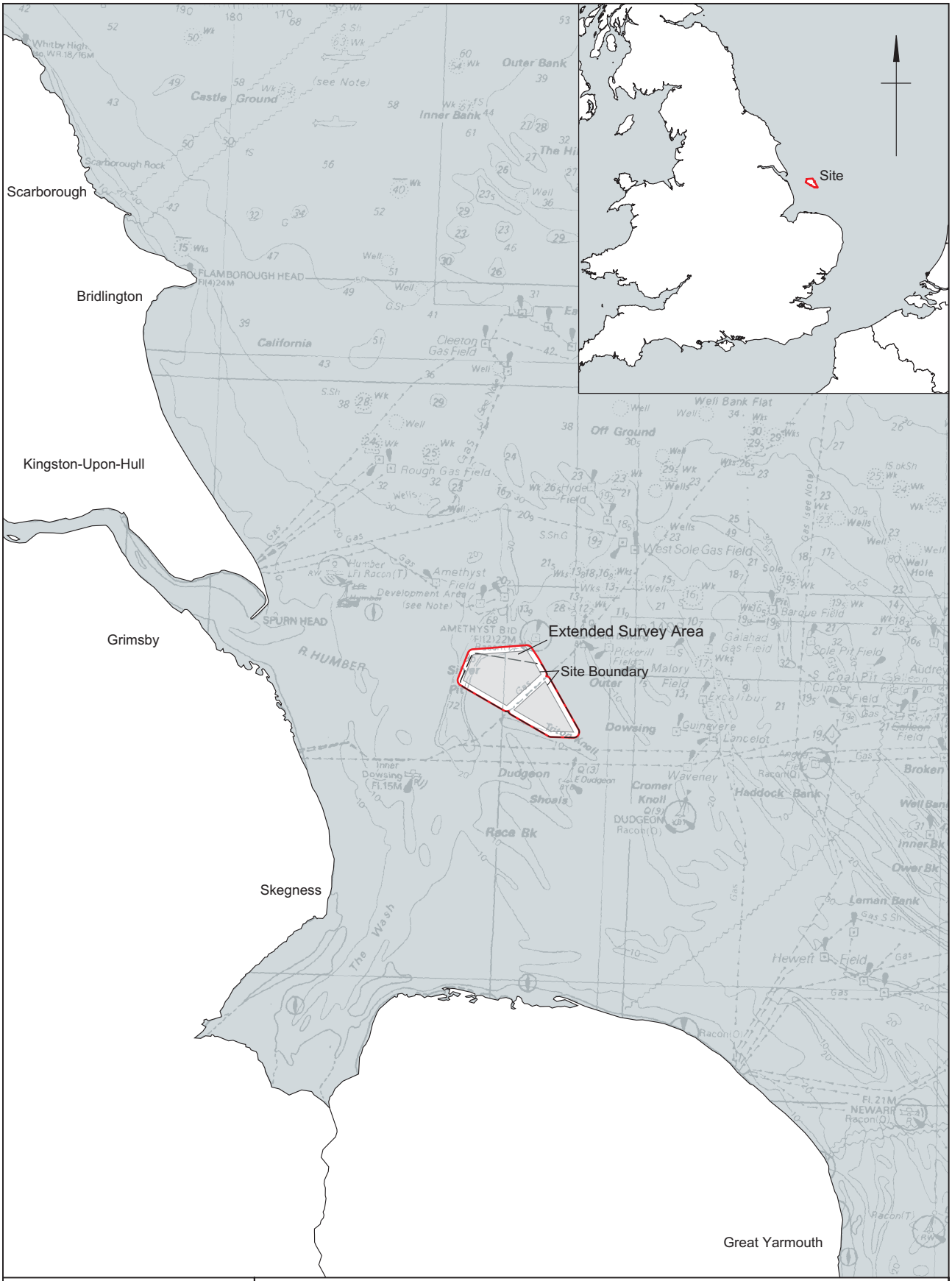
This comprises the assessment of palaeo-environmental subsamples (pollen, diatoms, ostracods and foraminifera). Subsamples taken from the core samples are sent for laboratory assessment to a level sufficient to enable the value of the palaeo-environmental material surviving within the cores to be identified. Subsamples taken are retained at this stage in case radiocarbon or scientific dating is required during Stage 4. The Stage 3 report will set out the results of each laboratory assessment together with an outline of the archaeological implications of the combined results, and will indicate whether any Stage 4 work is warranted.

Stage 4: Analysis and Dating

This entails full analysis of pollen, diatoms, ostracods and/or foraminifera assessed during Stage 3. Typically, Stage 4 will be supported by radiocarbon or scientific dating of suitable subsamples. Stage 4 will result in an account of the successive environments within the coring area, a model of environmental change over time, and an outline of the archaeological implications of the analysis.

Stage 5: Final Report

The production of a final report of the results of the previous phases of work for publication in an appropriate journal. This report will be compiled after the final phase of archaeological work, whichever phase that is.



Projection WGS84 Z31N
Admiralty Chart 2182 (dated 2000)

Offshore Wind Farm Study Area

Original Area (2009)

Wessex Archaeology

Date:	16/03/11	Revision Number:	1
Scale:	1:100,0000 @A4	Illustrator:	KMN/KJB
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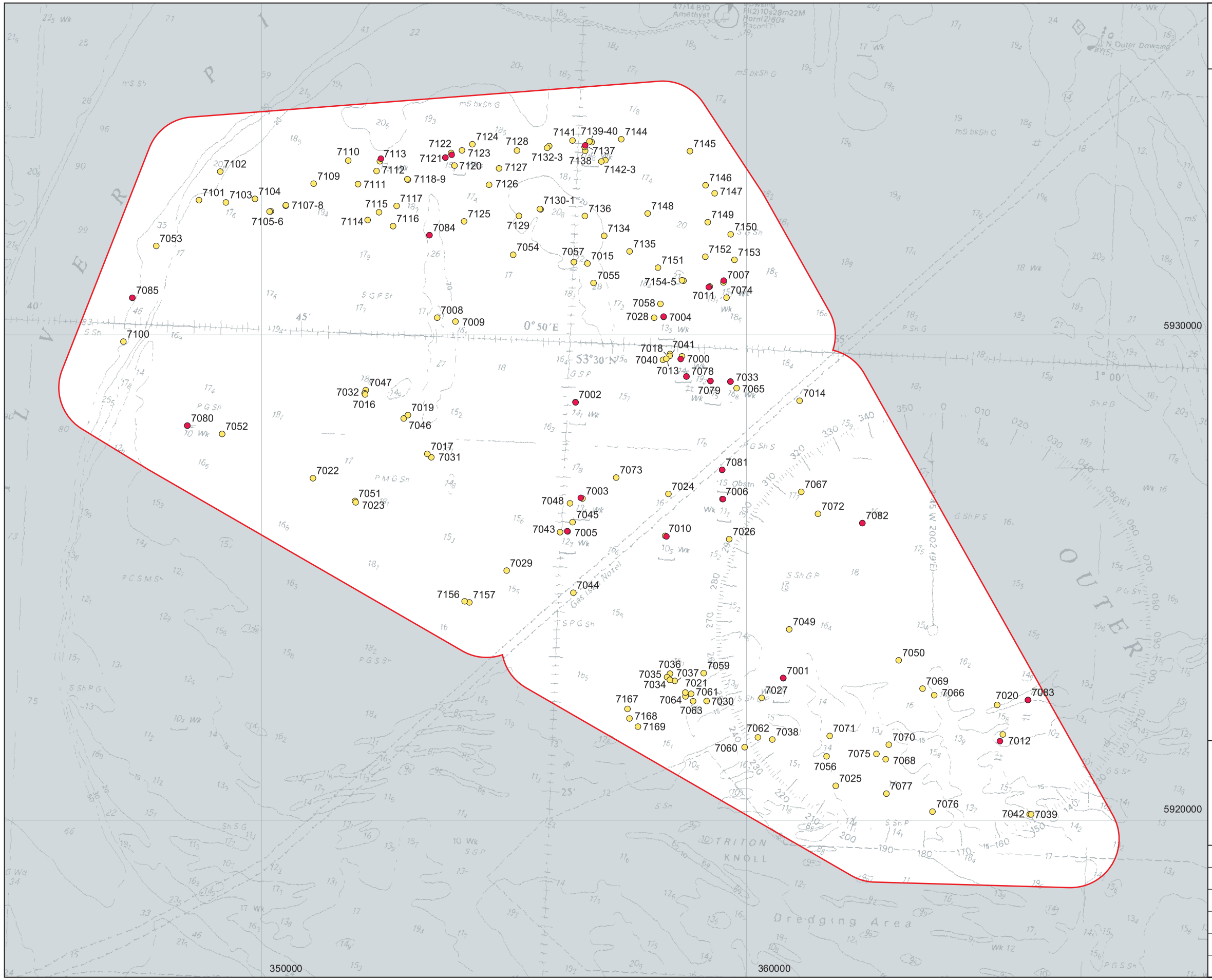
Site location and Study Area

Figure 1



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Projection WGS84 Z31N
Admiralty Chart 107 (dated 2002)

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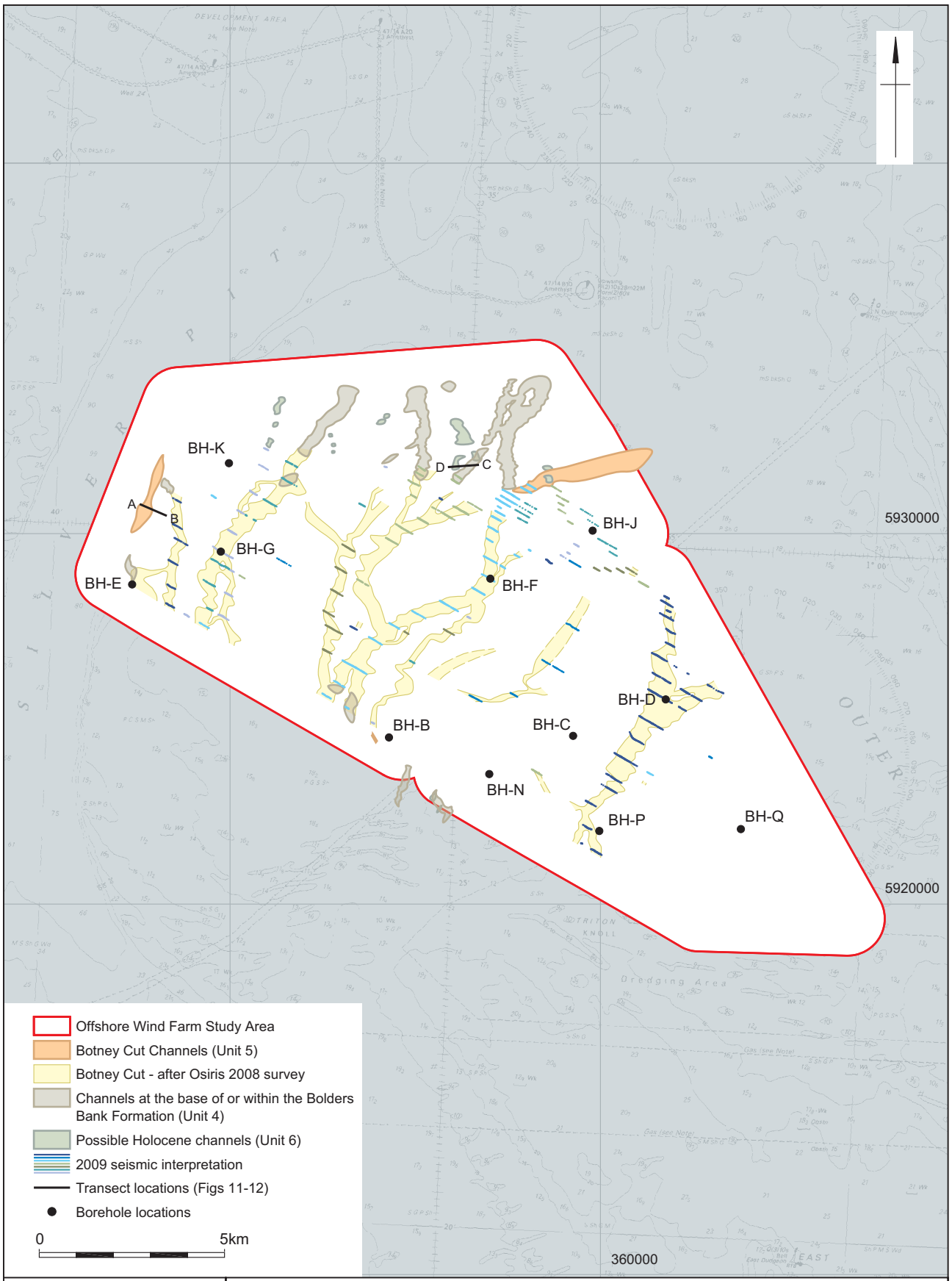
Report Figs\Triton Knoll OWF only\11-03-16	

Location of known wrecks and geophysical anomalies of known or possible archaeological potential

Figure 2



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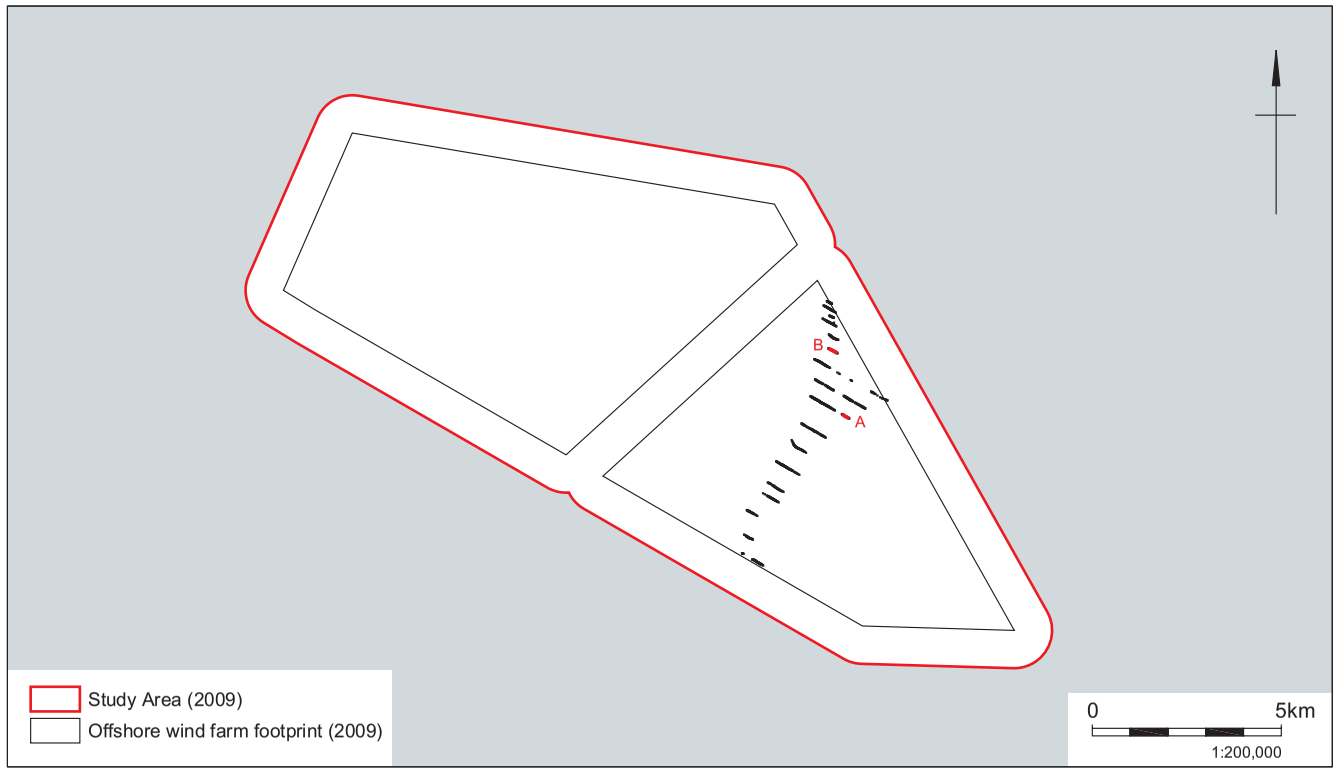
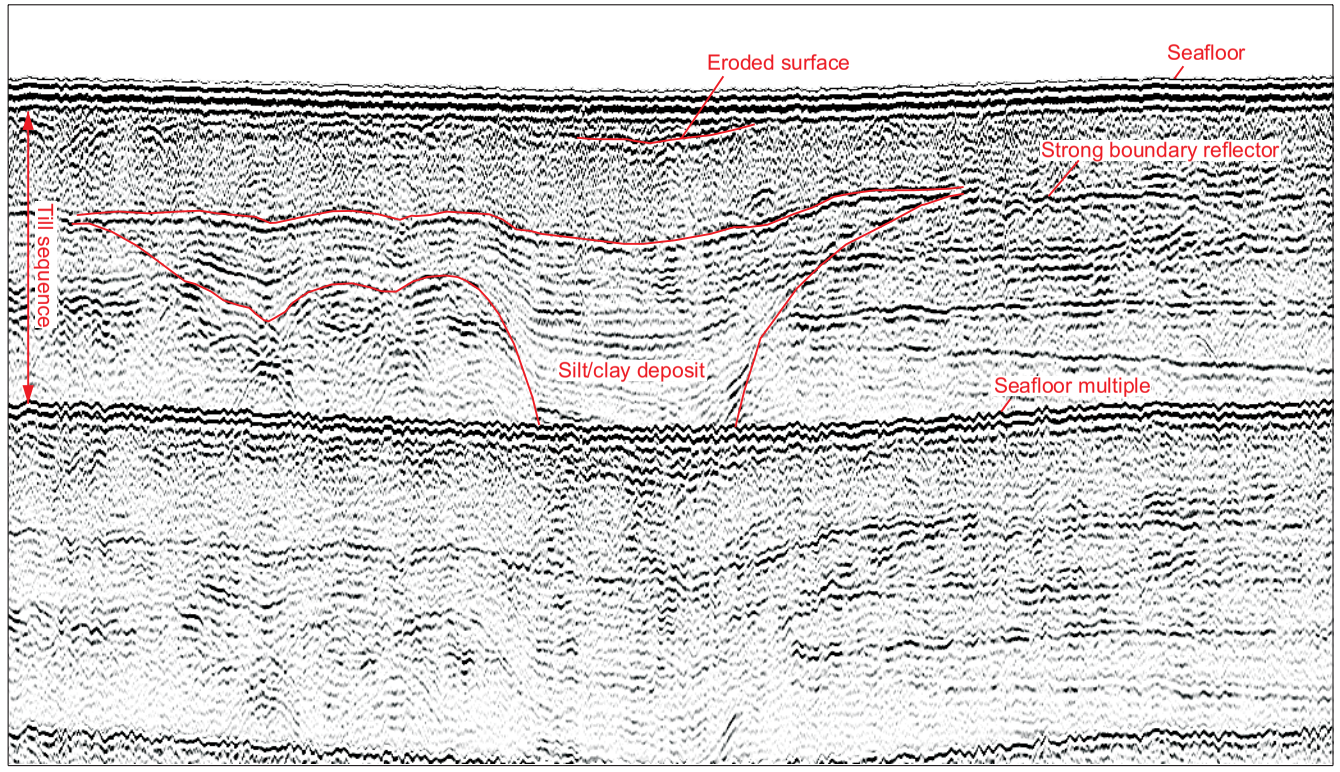
Wessex Archaeology

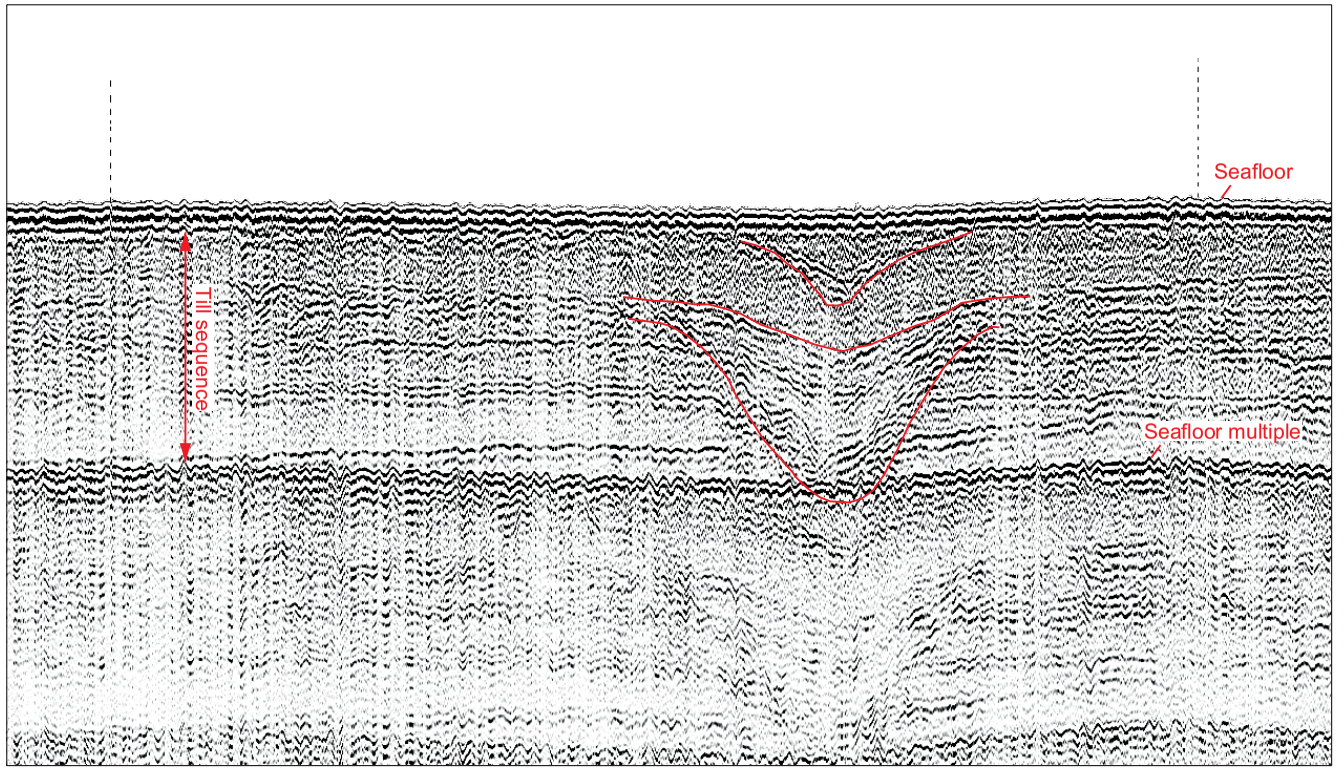
Major channel features identified from the sub-bottom profiler data, present within different levels of the stratigraphy

Figure 3





A: Channel feature (231m wide and between 7.13m and 28.2m deep)



B: Channel feature (150m and 247m wide, from 2m and 7.65m to 23.24m deep)

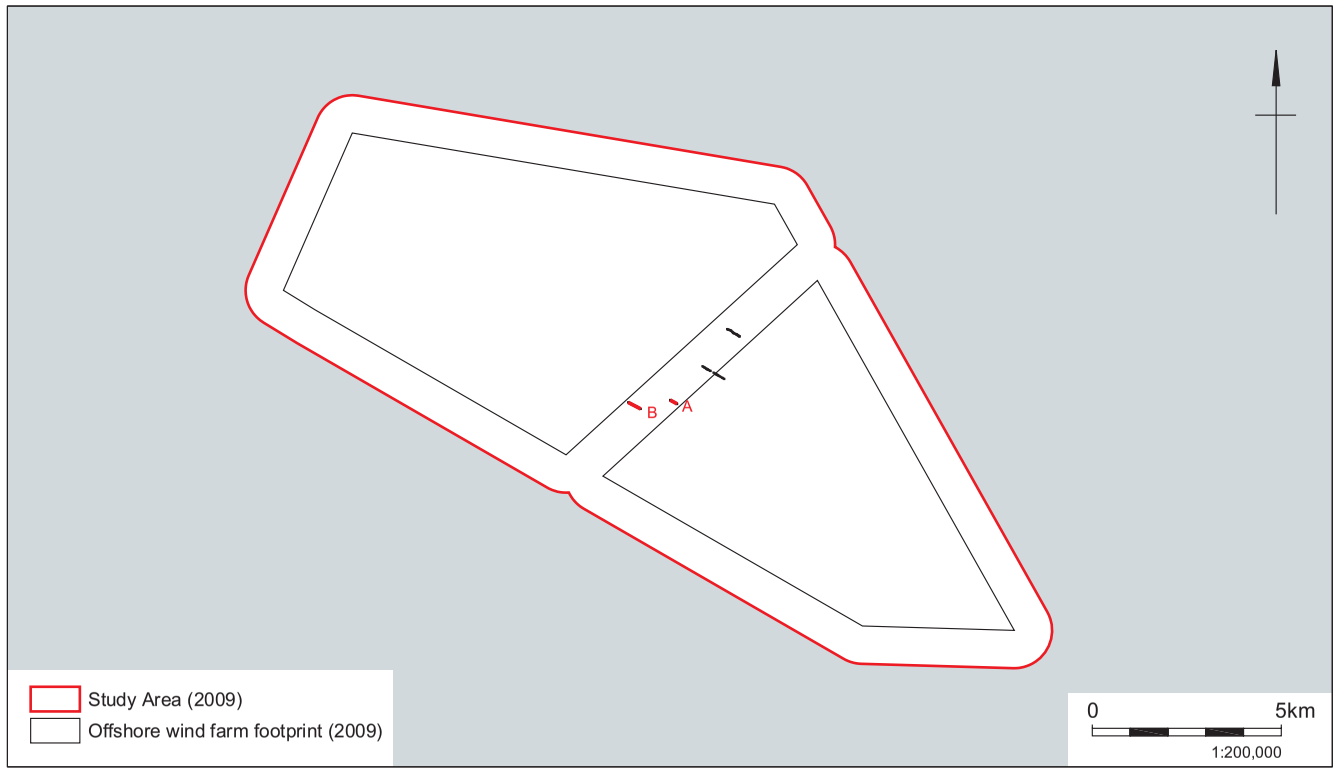
Wessex Archaeology

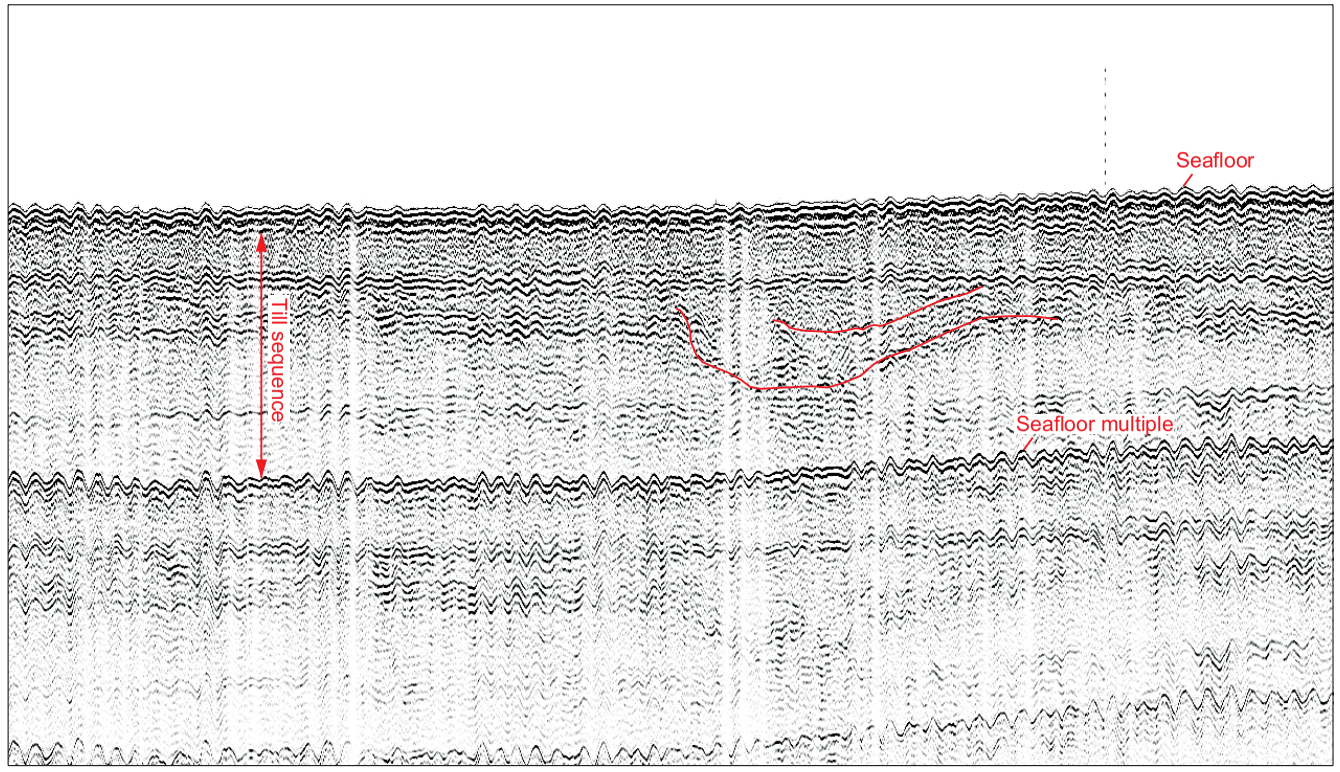
Projection WGS84 Z31N

Date:	16/03/11	Revision Number:	1
Scale:	Not to scale	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

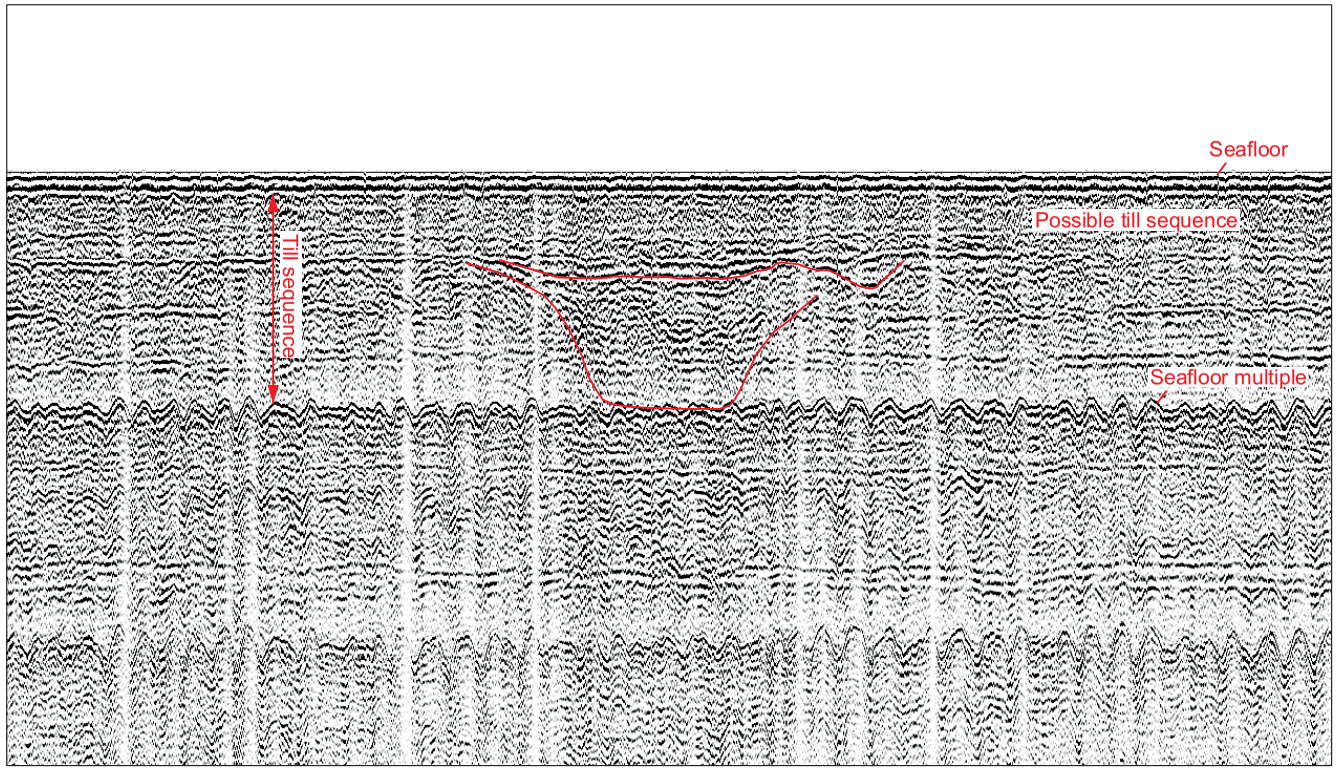
Channel feature from Osiris Projects 2008 sub-bottom profiler data

Figure 4





A: Channel like feature (213.6m wide and between 7.48m and 19.27m deep)



B: Channel like feature (375.7m wide and between 6.32m and 15m deep)

Wessex Archaeology

Projection WGS84 Z31N

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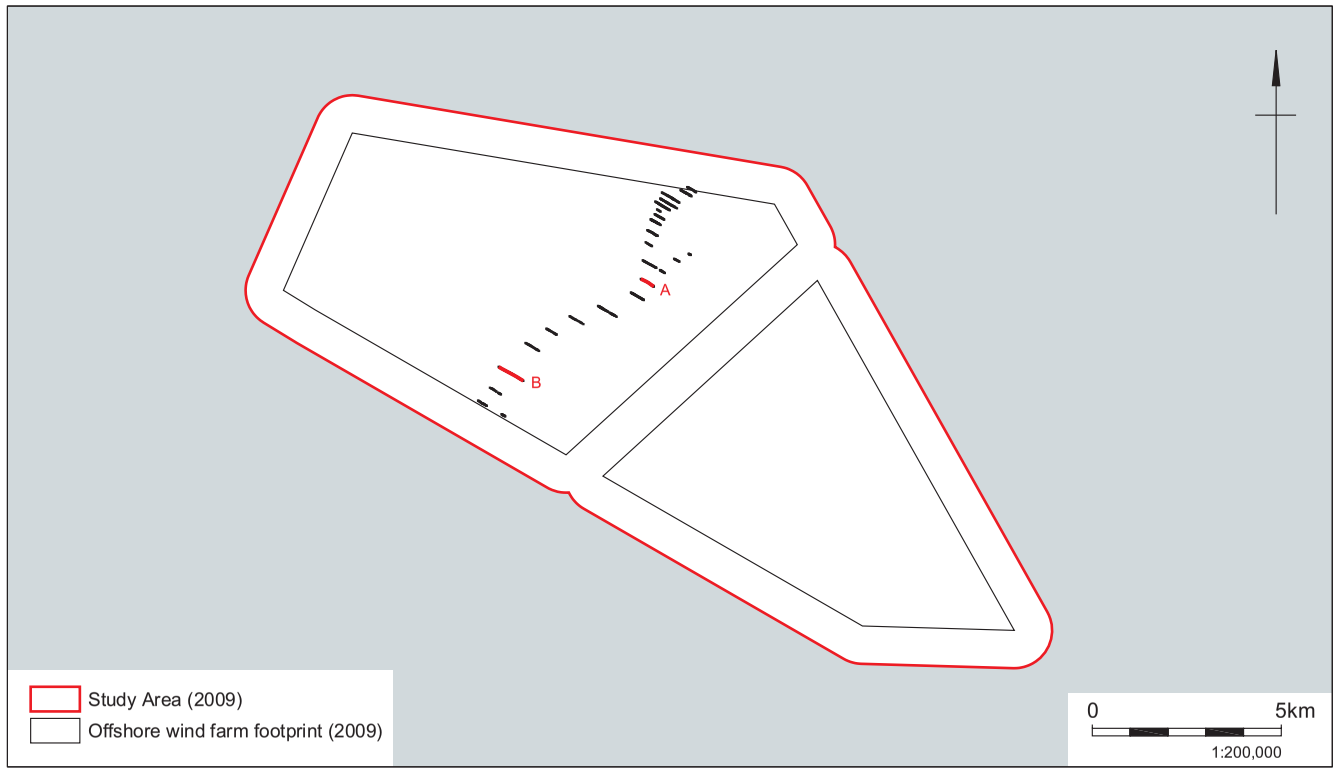
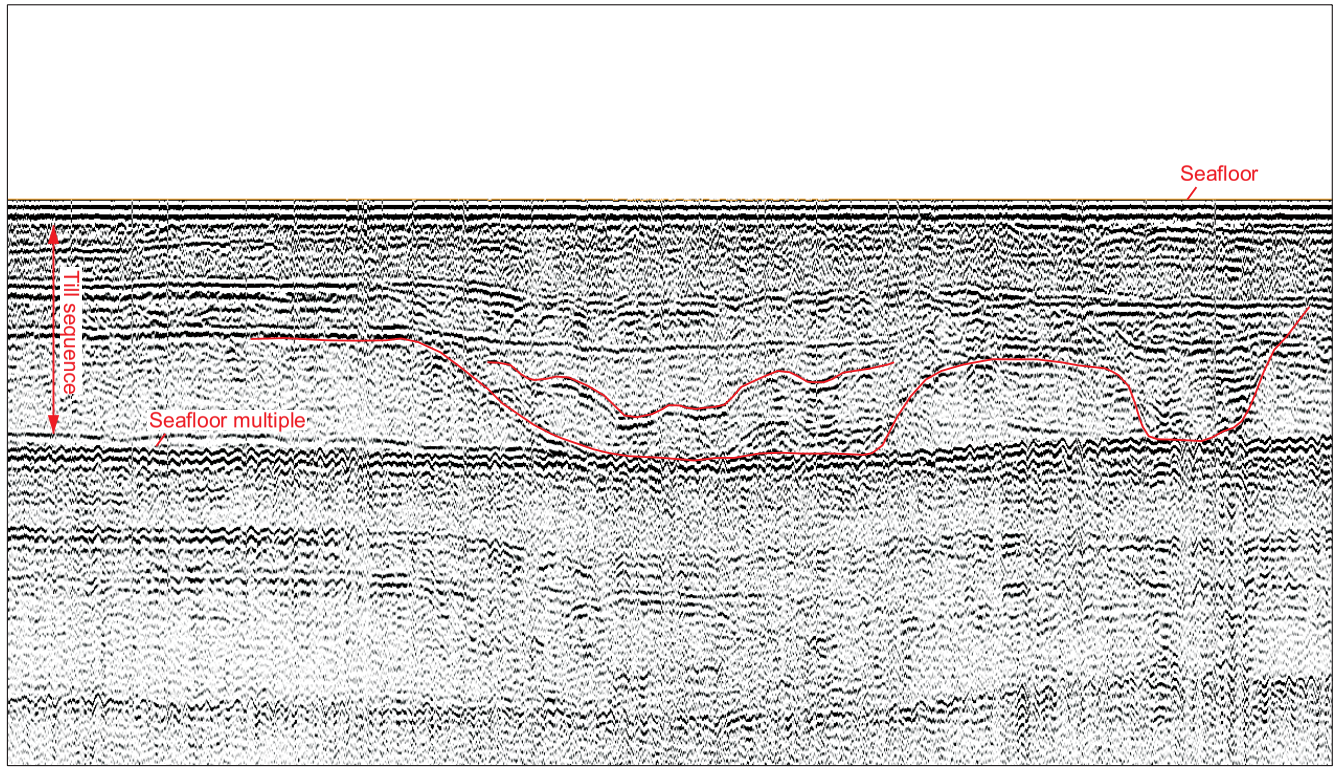
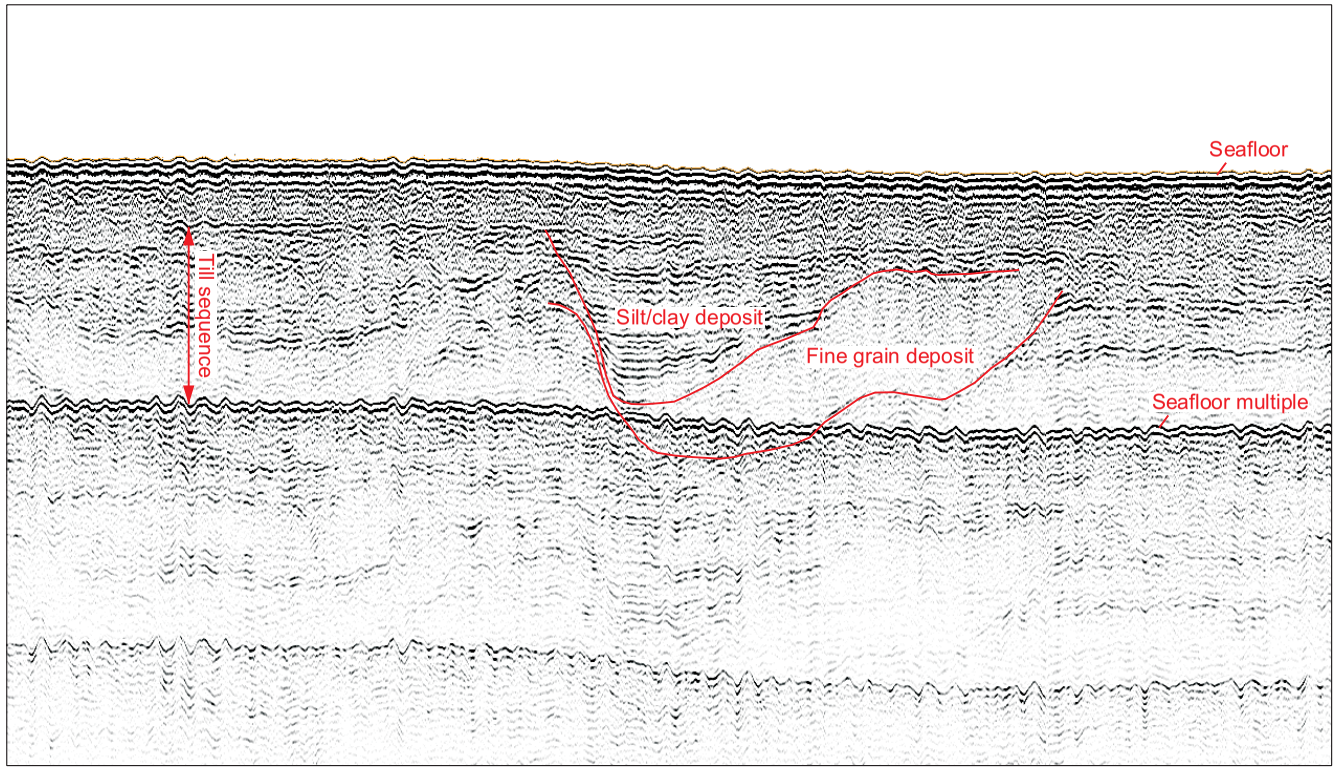
Channel feature from Osiris Projects 2008 sub-bottom profiler data

Figure 5





A: Channel like features and multiple till sequences (largest dimensions 405m wide and between 7.6m and 24.35m deep)



B: Two distinct channel sequences (384m wide and between 8.77m and 23.38m deep)

Wessex Archaeology

Projection WGS84 Z31N

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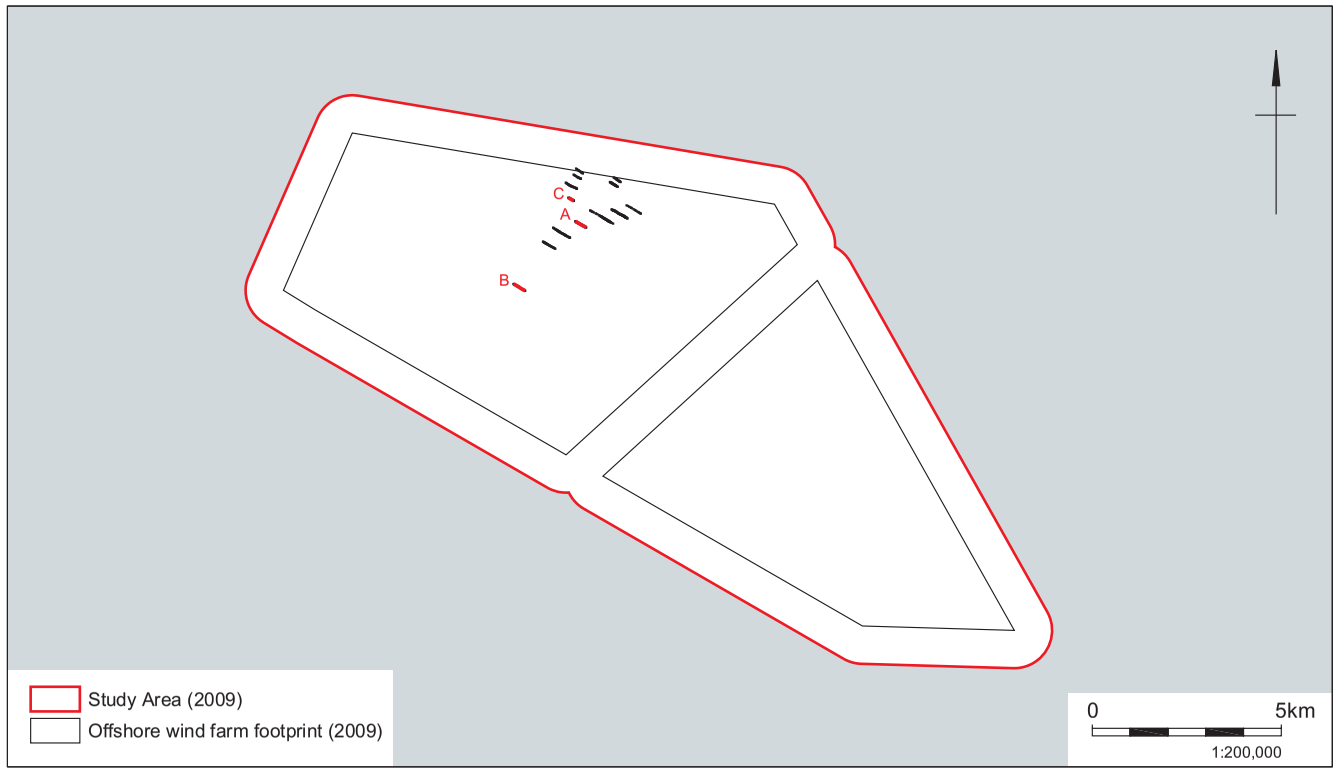
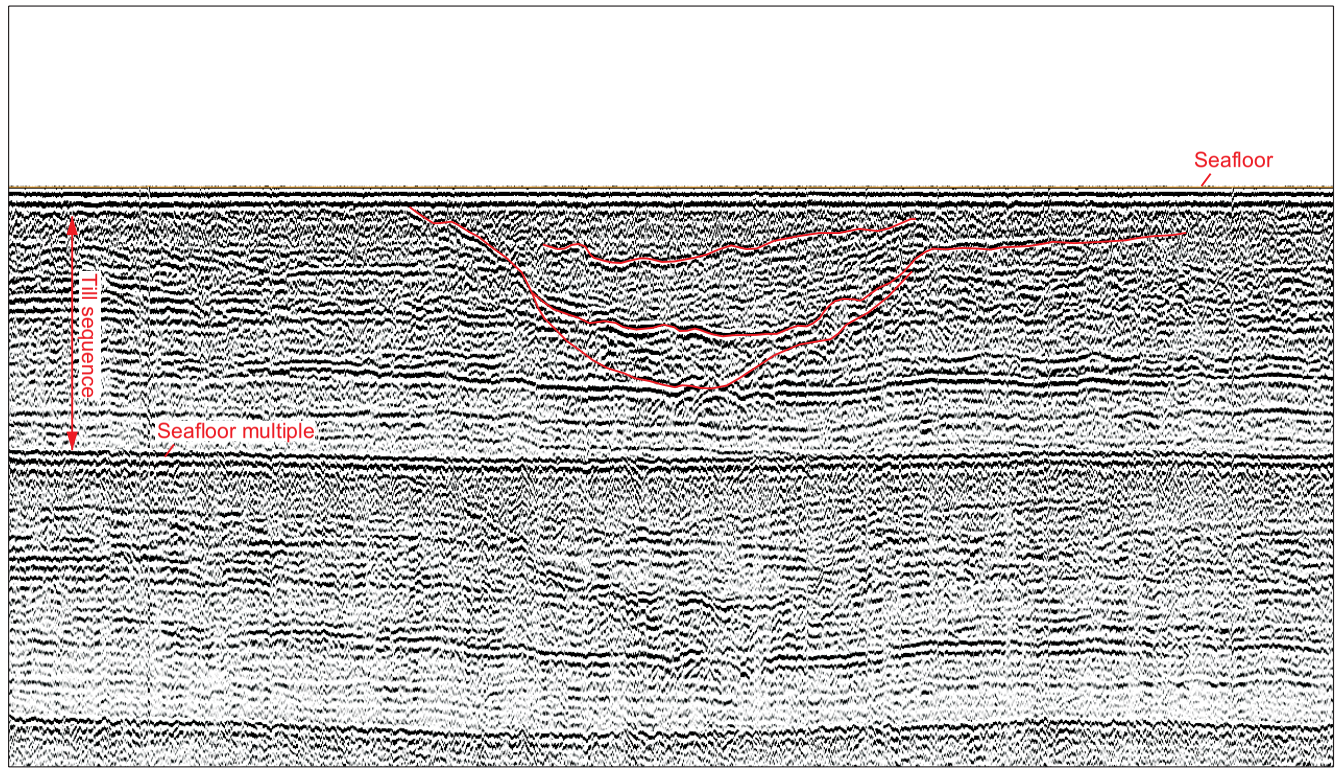
Scale:	Not to scale	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

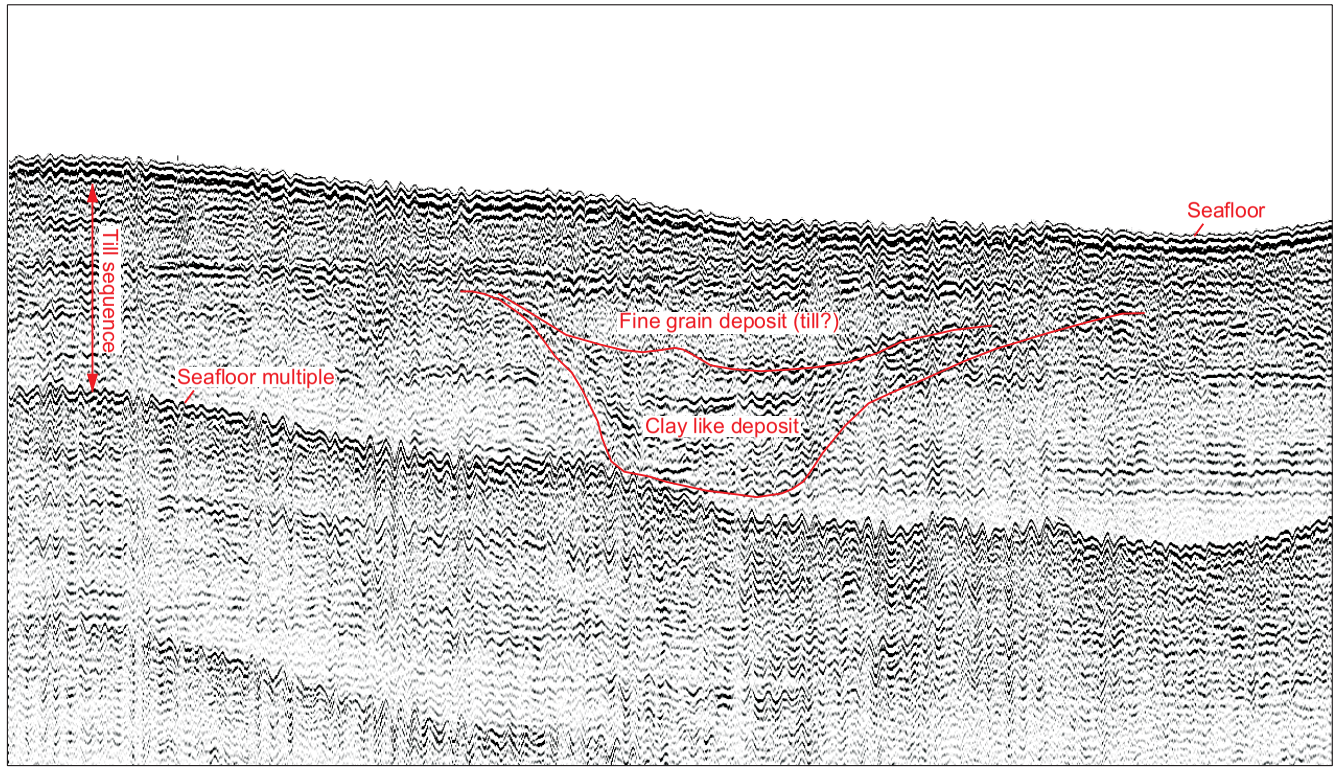
Channel feature from Osiris Projects 2008 sub-bottom profiler data

Figure 6

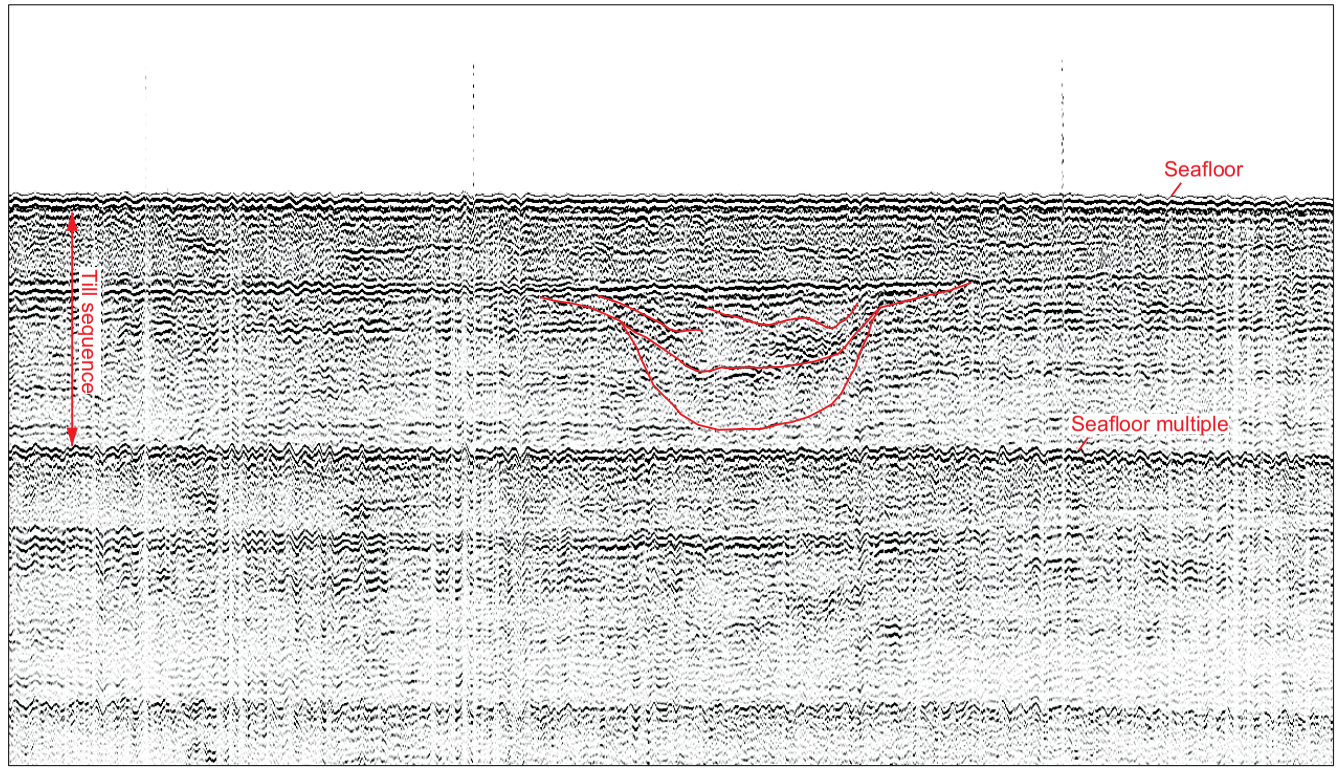




A: Channel with two distinct deposits (333m wide and between 1.79m and 13.5m deep)



B: Channel with two distinct deposits (361m wide and between 5.55m and 21.32m deep)



C: Channel like feature (375m wide and beween 6.32m and 15.04m deep)

Wessex Archaeology

Projection WGS84 Z31N

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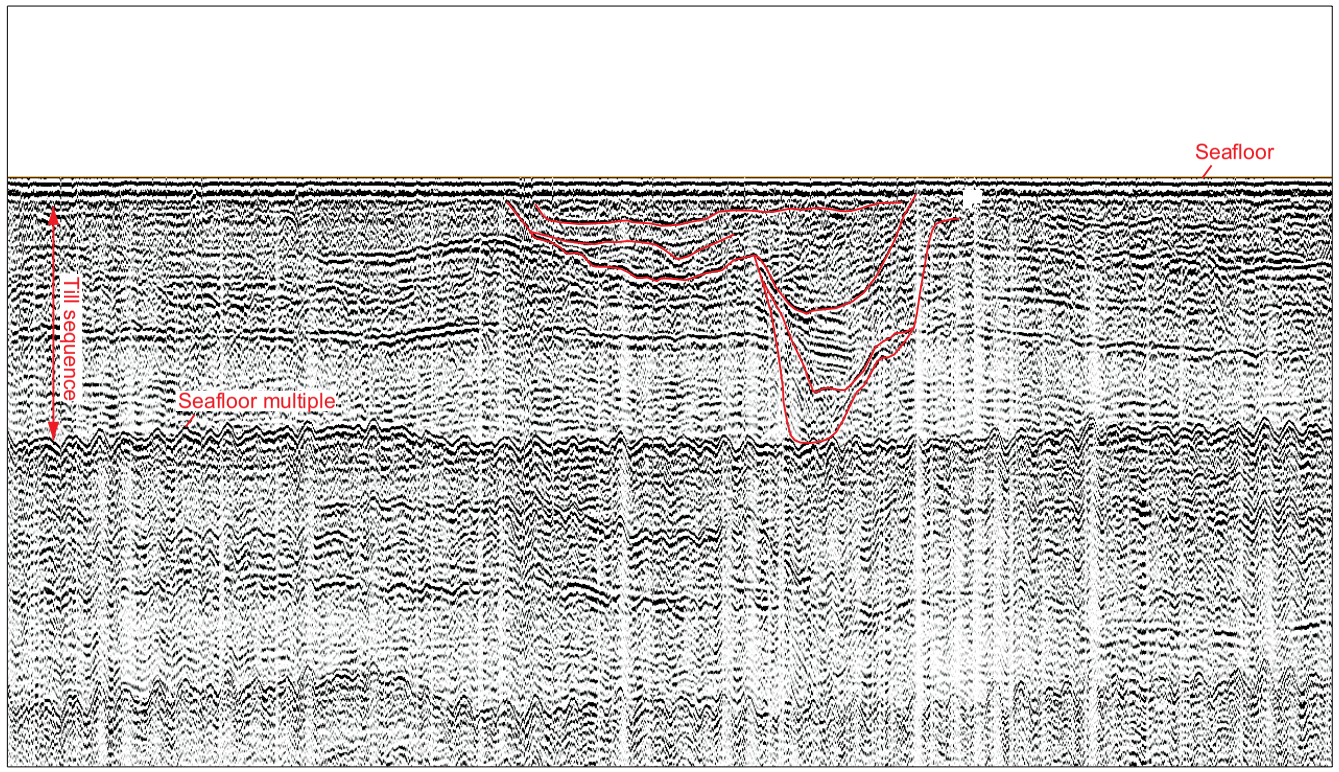
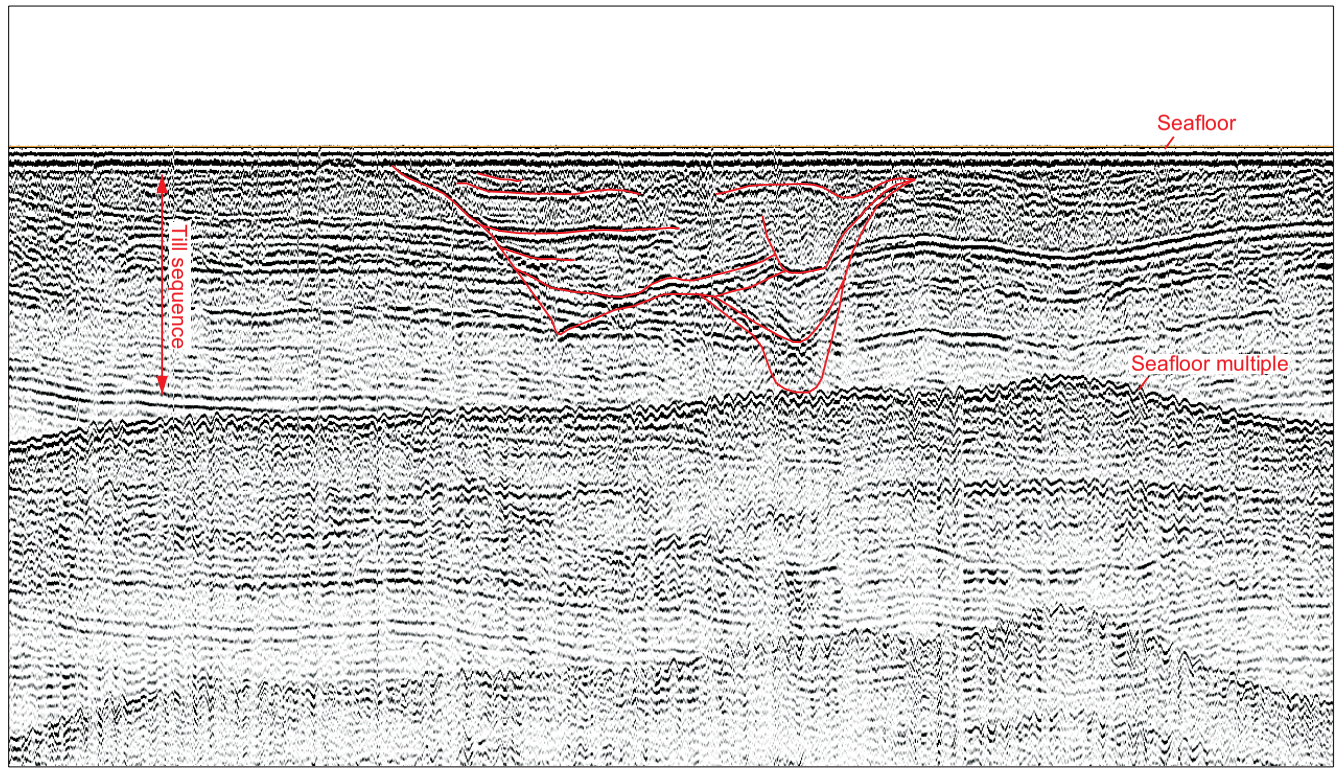
Channel feature from Osiris Projects 2008 sub-bottom profiler data

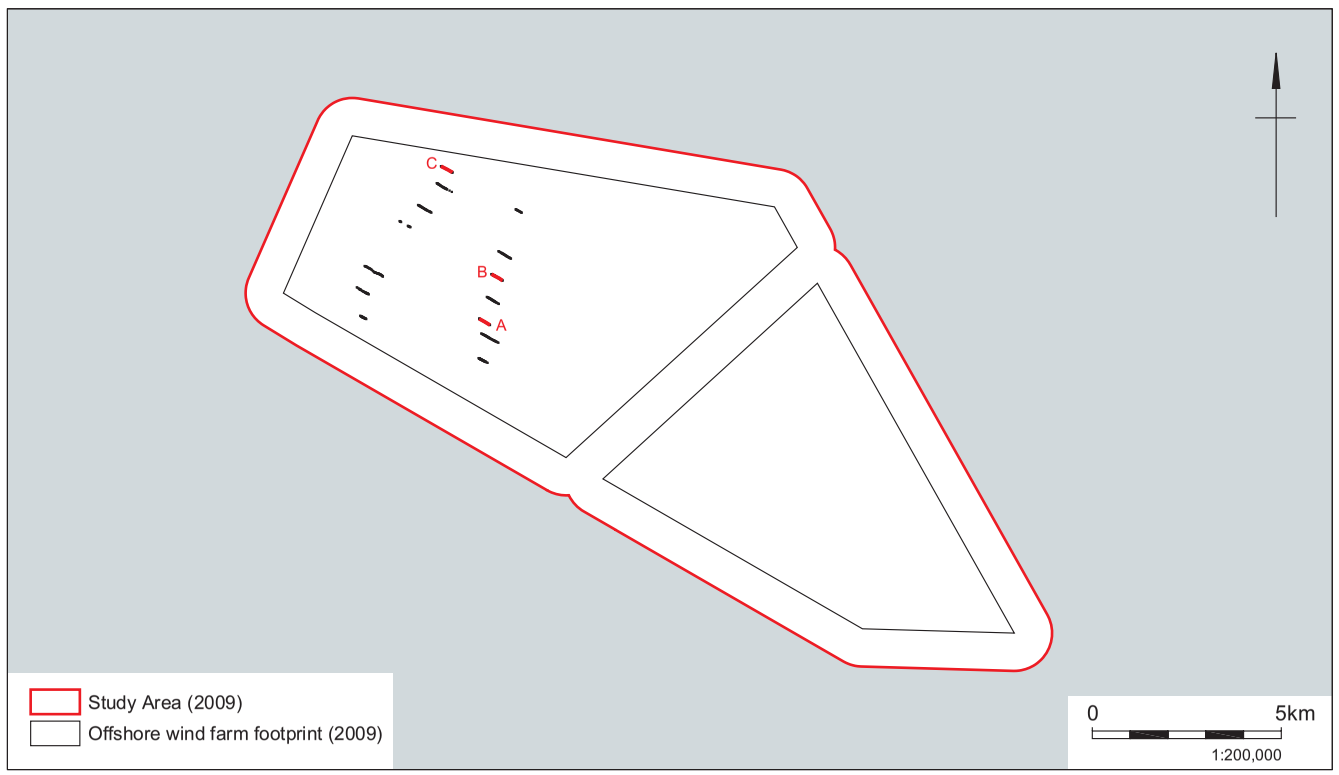
Figure 7

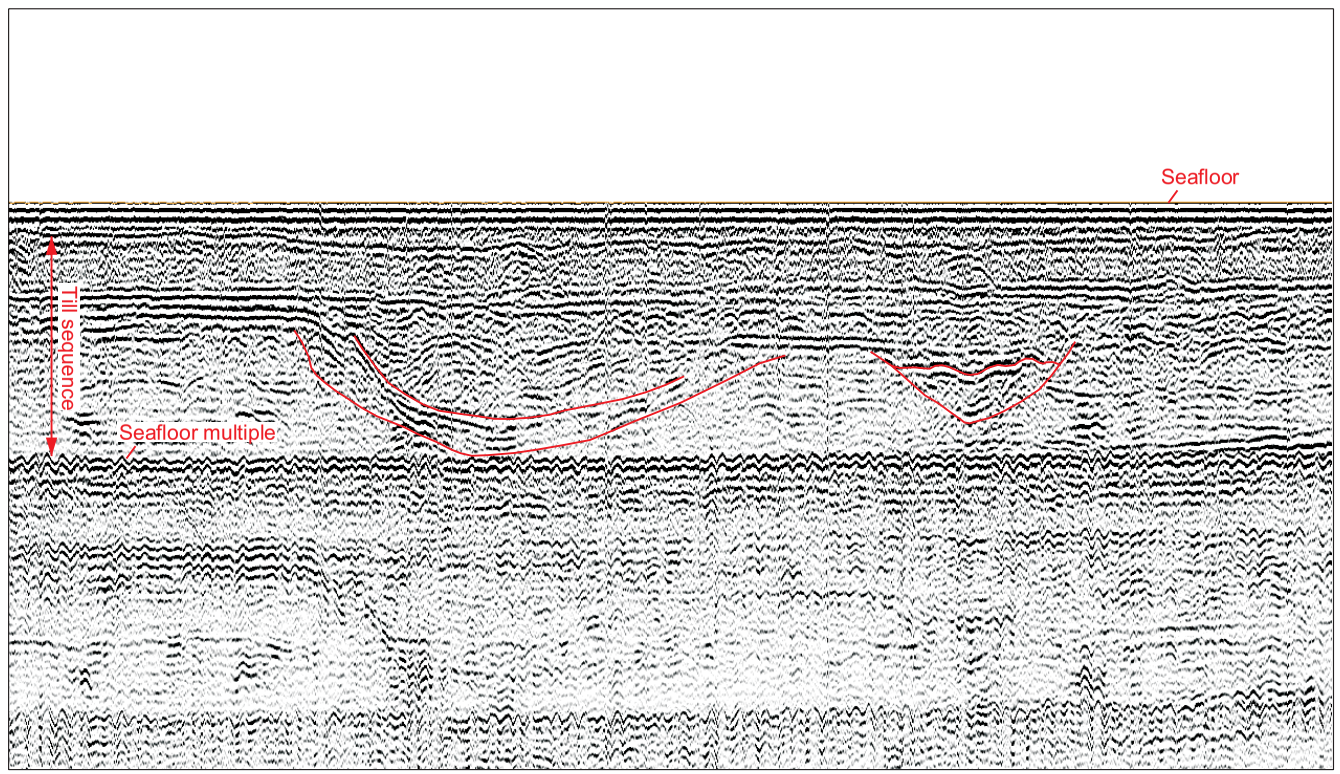


A: Channel like features with multiple cut and fill sequences (337.8m wide and between 1.37m and 22.73m deep)



B: Channel like feature with miltiple cut and fills (344.8m wide and between 1.55m and 17m deep)





C: Channel like features (209m and 87m wide and beween 10.55m and 21.62m deep)

Wessex Archaeology

Projection WGS84 Z31N

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Scale:	A-D,F 1:3000 E 1:2,500 @A3	Illustrator:	KJB
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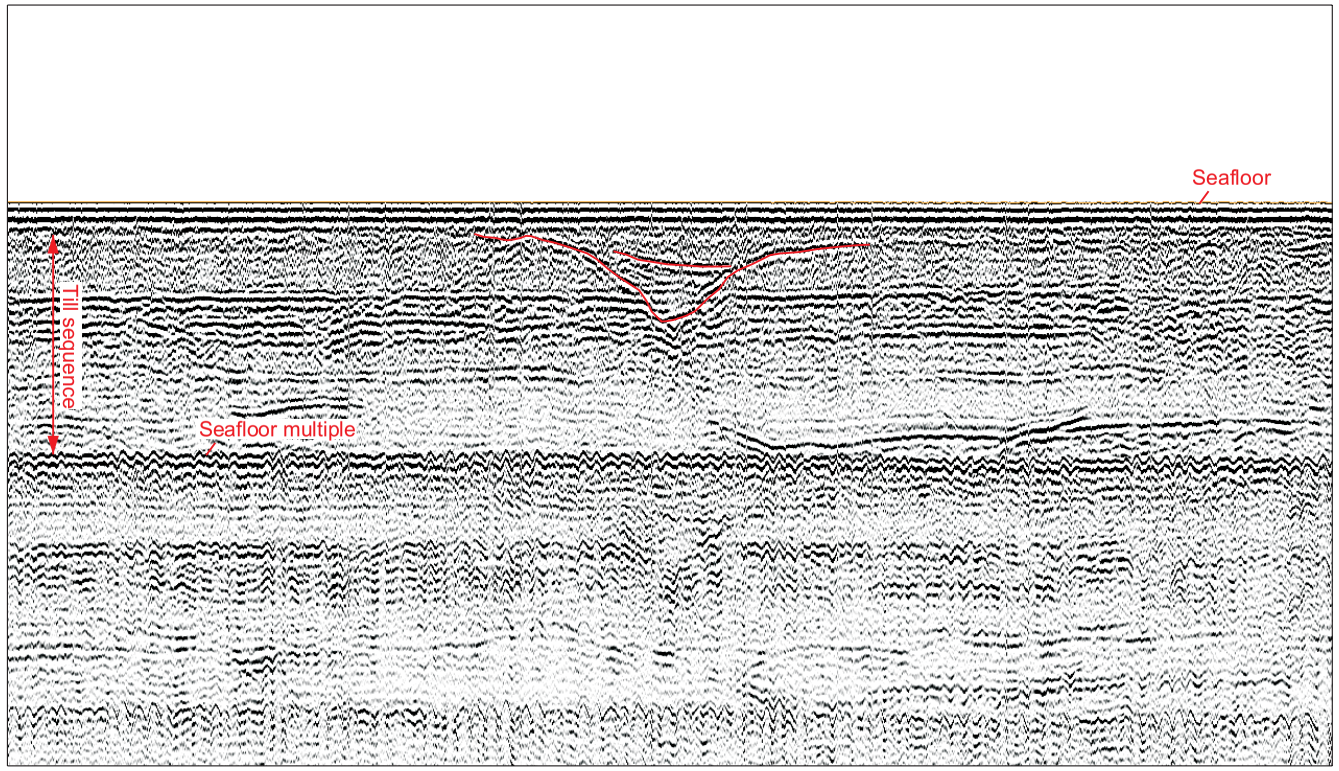
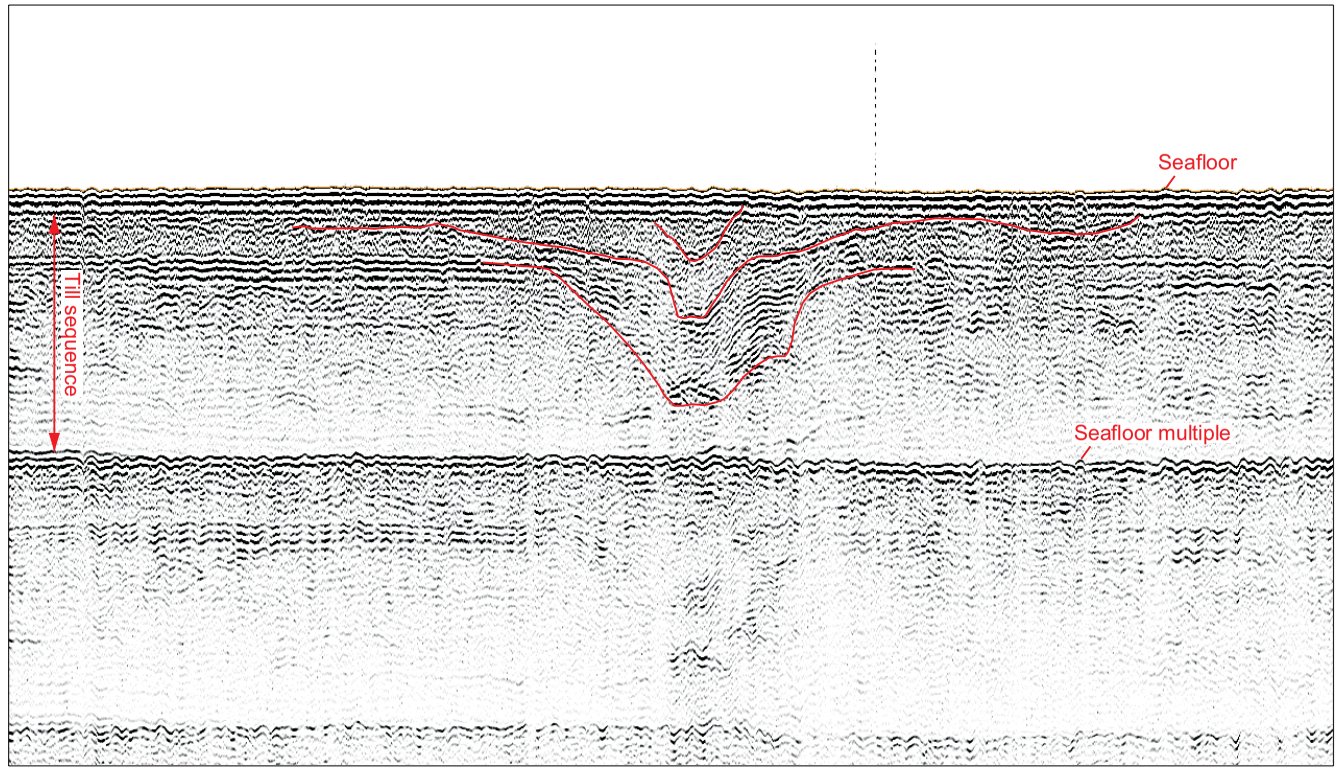
Channel feature from Osiris Projects 2008 sub-bottom profiler data

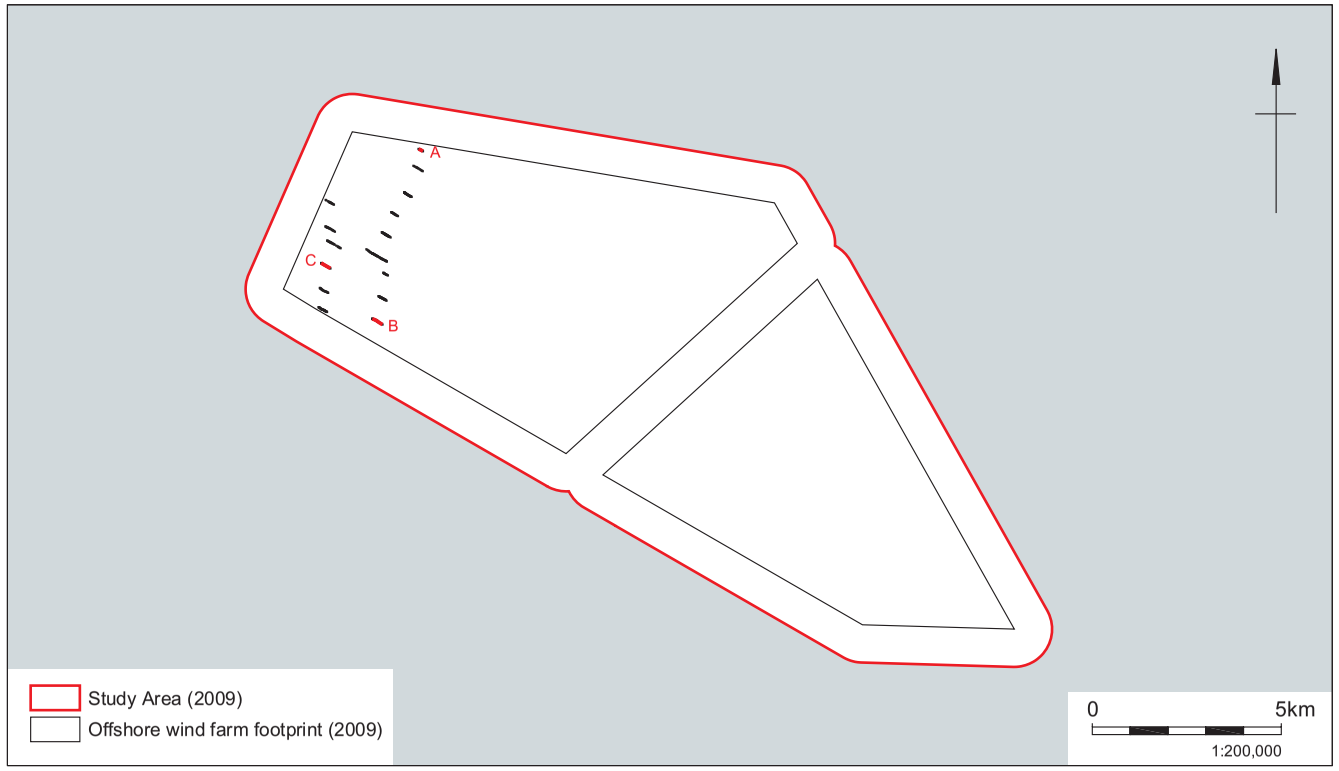
Figure 8

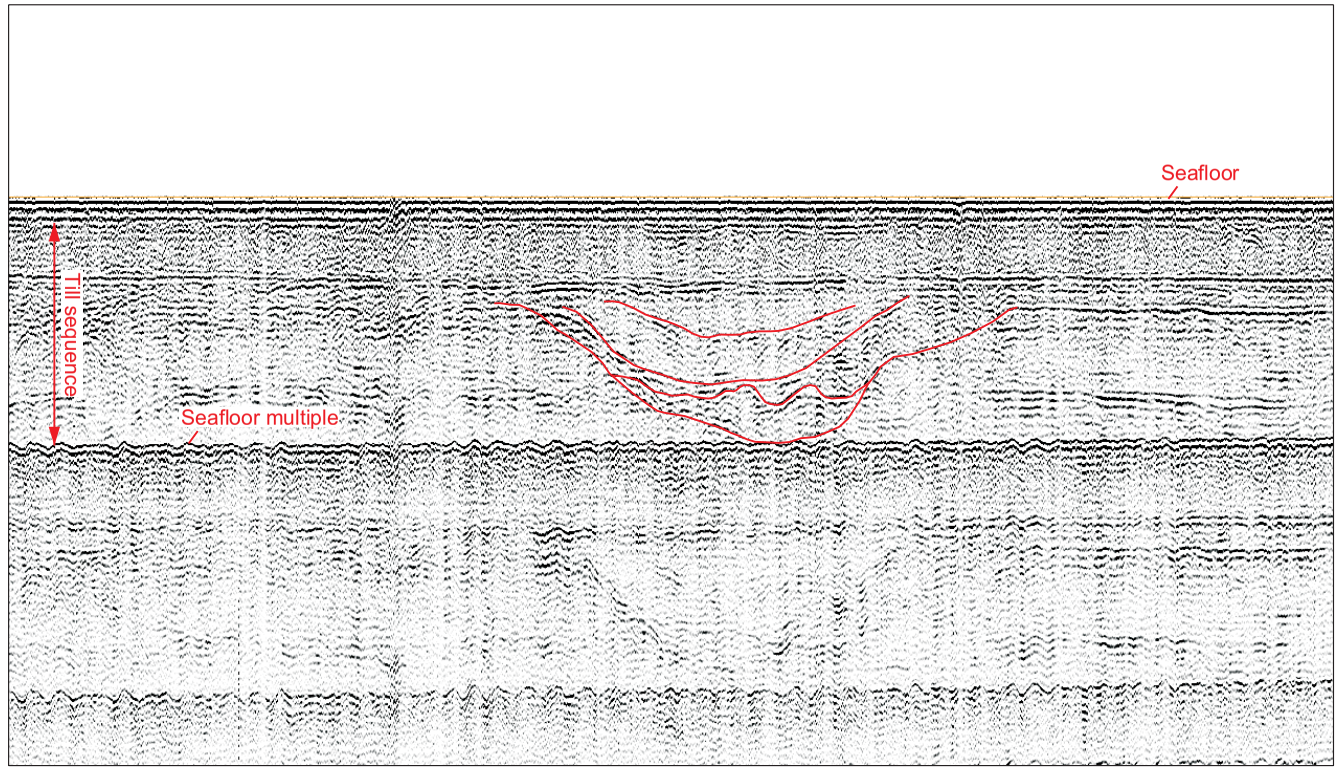


A: Channel like feature (132.9m wide and between 2.99m and 13.2m deep)



B: Channel like feature (268.8m wide and between 4.98m and 15.75m deep)





C: Channel like feature (288m wide and beween 7.55m and 17.46m deep)

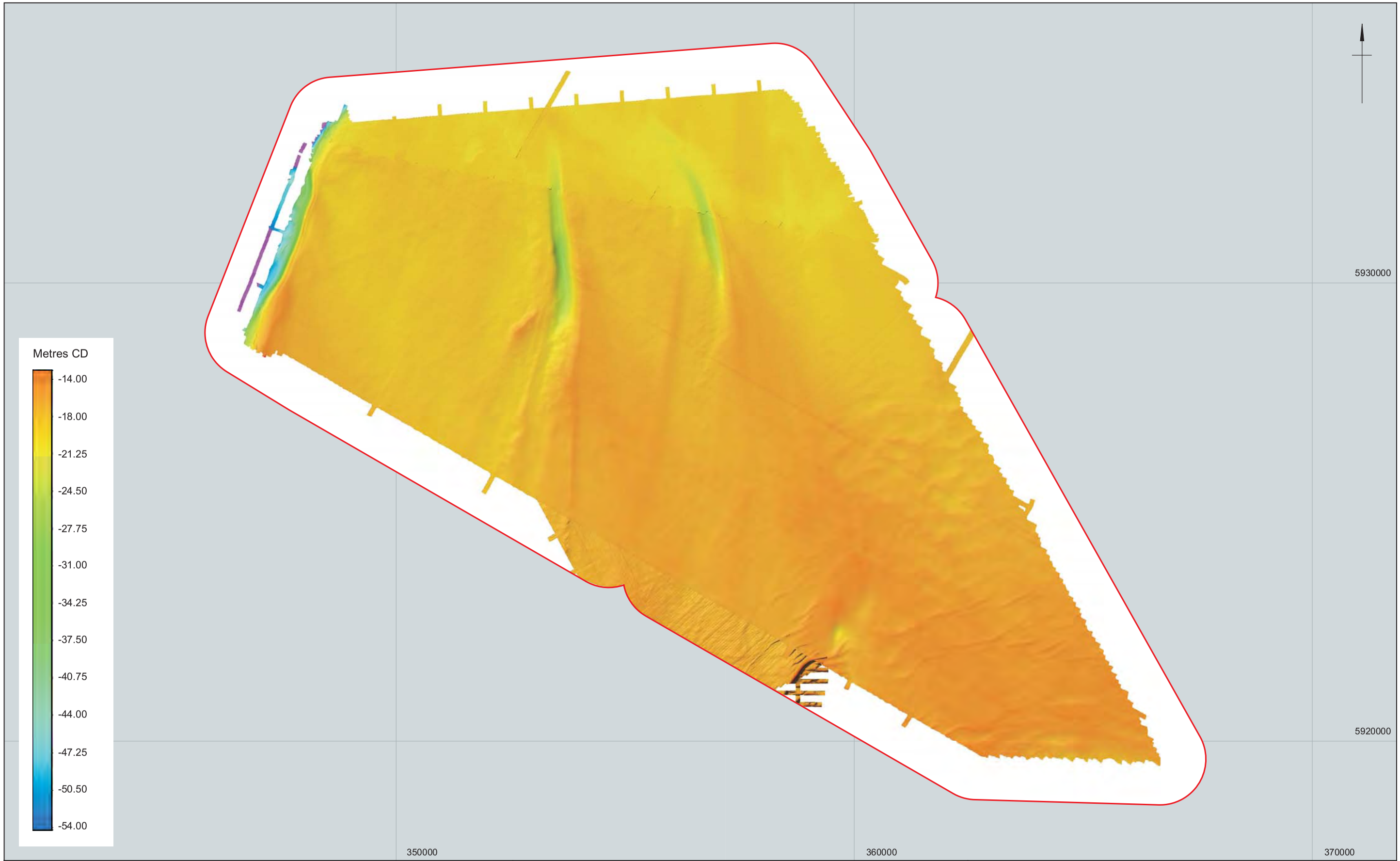
Wessex Archaeology

Projection WGS84 Z31N

Date:	16/03/11	Revision Number:	1
Scale:	A-D,F 1:3000 E 1:2,500 @A3	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

Channel feature from Osiris Projects 2008 sub-bottom profiler data

Figure 9



Projection WGS84 Z31N

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0 5km

Offshore Wind Farm Study Area

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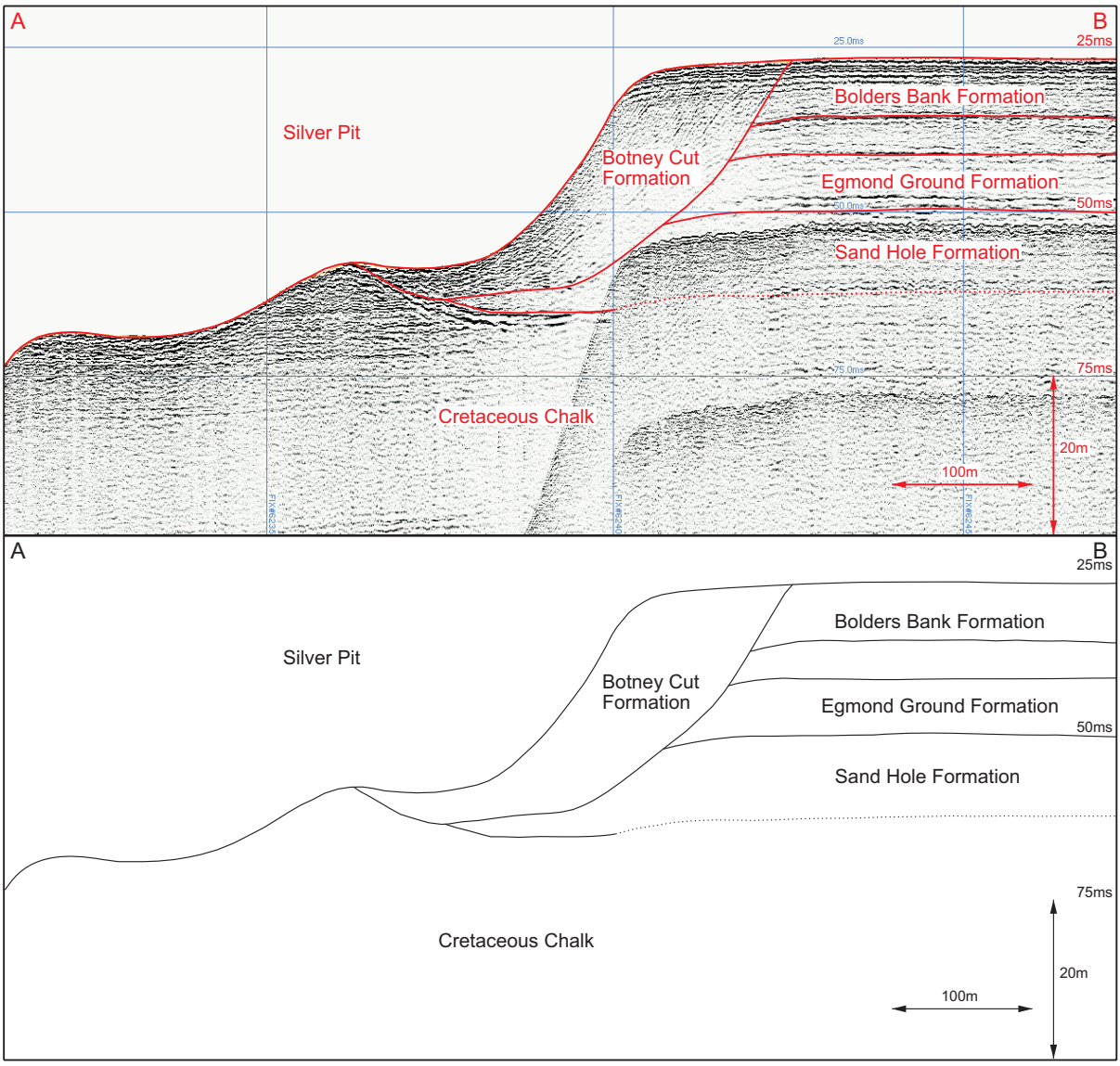
Bathymetry of main wind farm site from Osiris Projects 2008 and Gardline Geosurveys Ltd. 2009 swathe bathymetry data

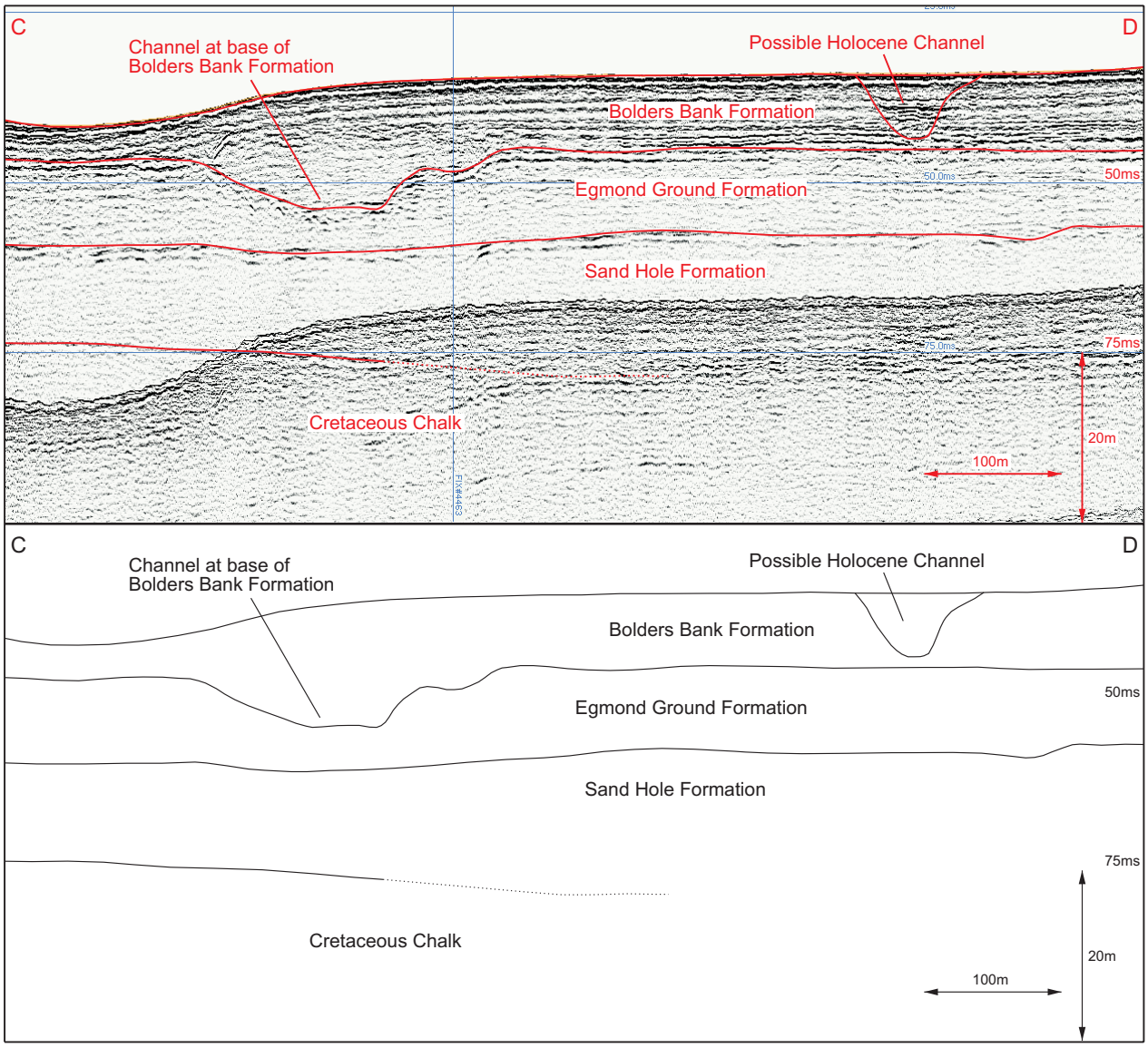
Figure 10



Drawing Projection UTM WGS84 Z31N	This material is for client report only © Wessex Archaeology. No unauthorised reproduction.		
Wessex Archaeology	Date: 16/03/11	Revision Number:	1
	Scale: 1:5000 horizontal, c. 1:85 vertical (inset 1:250,000)	Illustrator:	KJB
	Path: W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

Interpreted section of transect A - B showing the stratigraphic section and Silver Pit

Figure 11



Drawing Projection UTM WGS84 Z31N

Date:	16/03/11	Revision Number:	1
Scale:	1:5000 horizontal, c. 1:80 vertical (inset 1:250,000)	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

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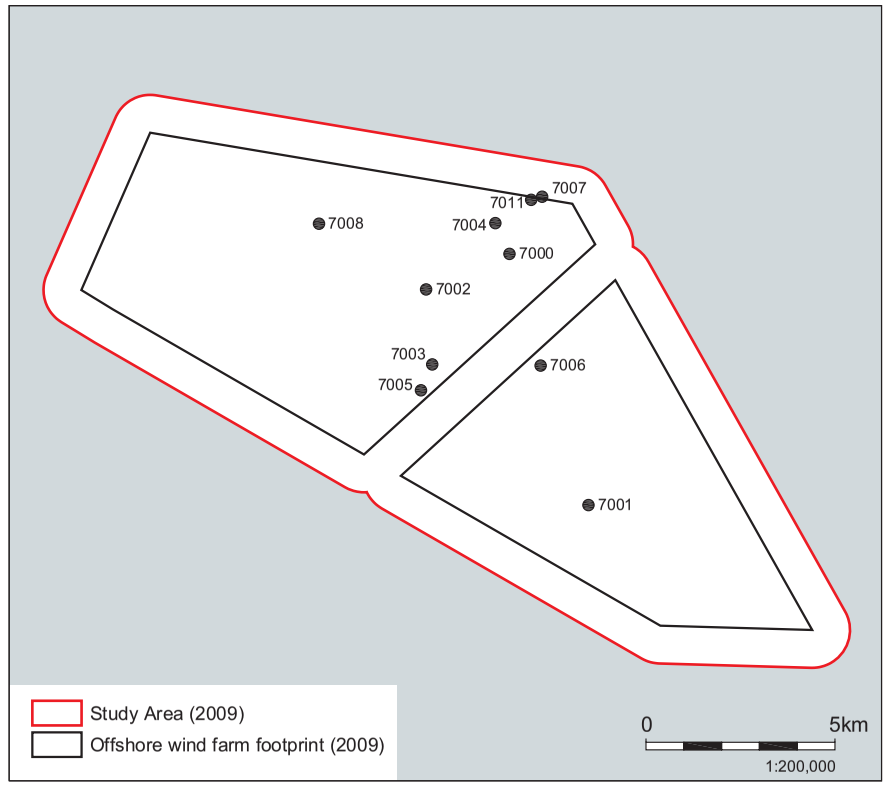
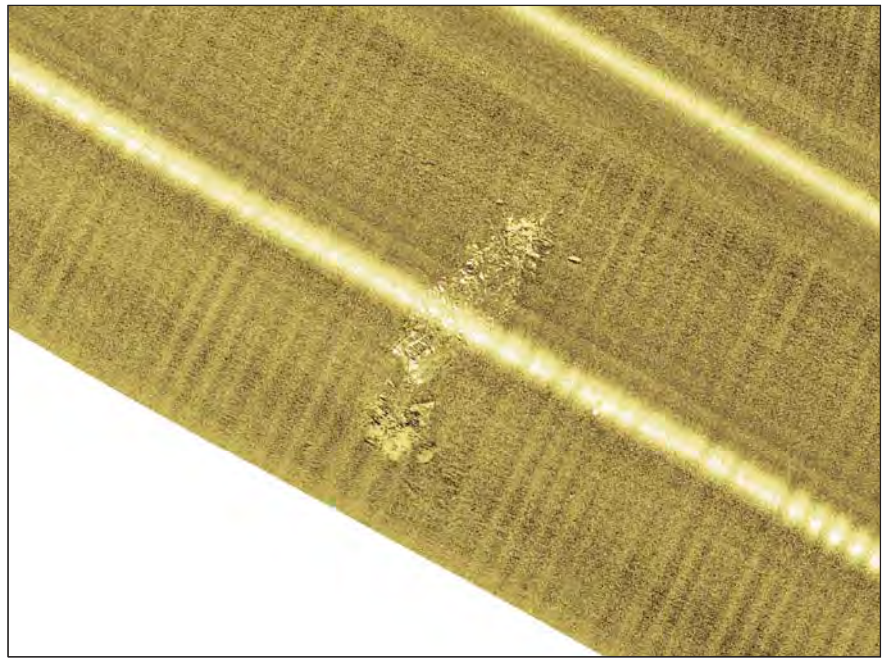
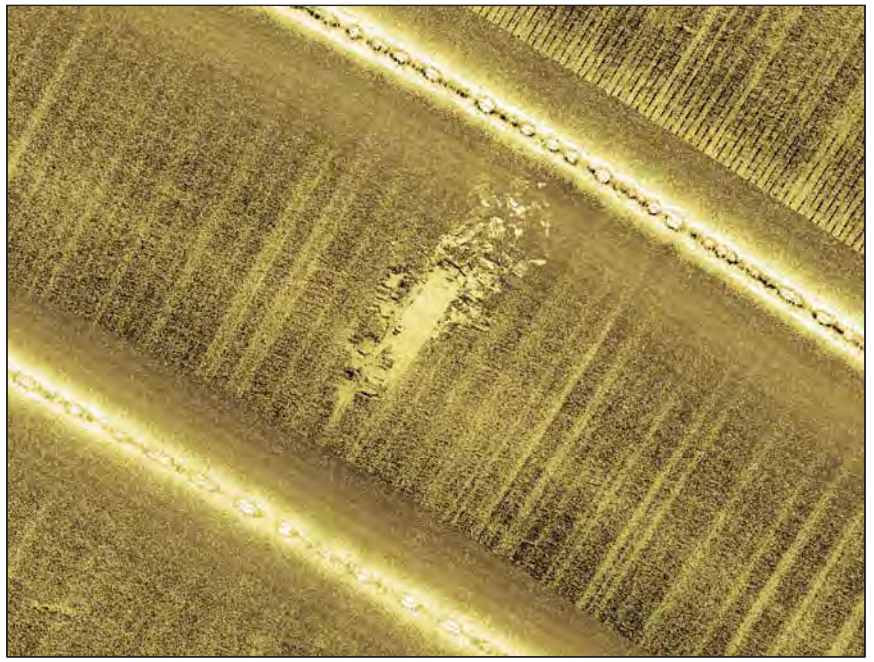
Interpreted section of transect C - D showing the stratigraphic section, a small channel at the base of the Bolders Bank Formation, and a small, possibly Holocene, channel

Figure 12



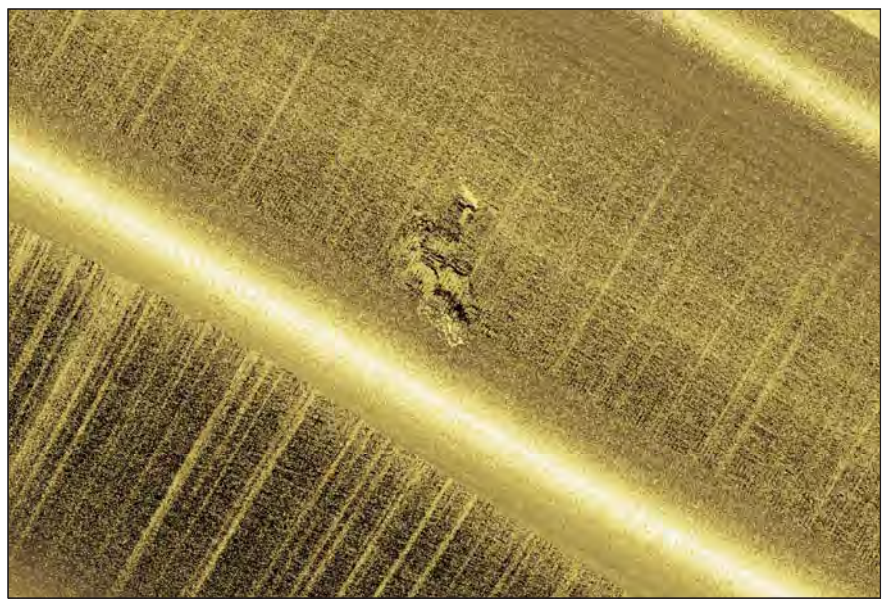


A. 7000 - Wreck and detached pieces of debris. Coincides with charted wreck of unknown identity (49m x 154m x 2.2m and a total magnetic amplitude of 8429nT).

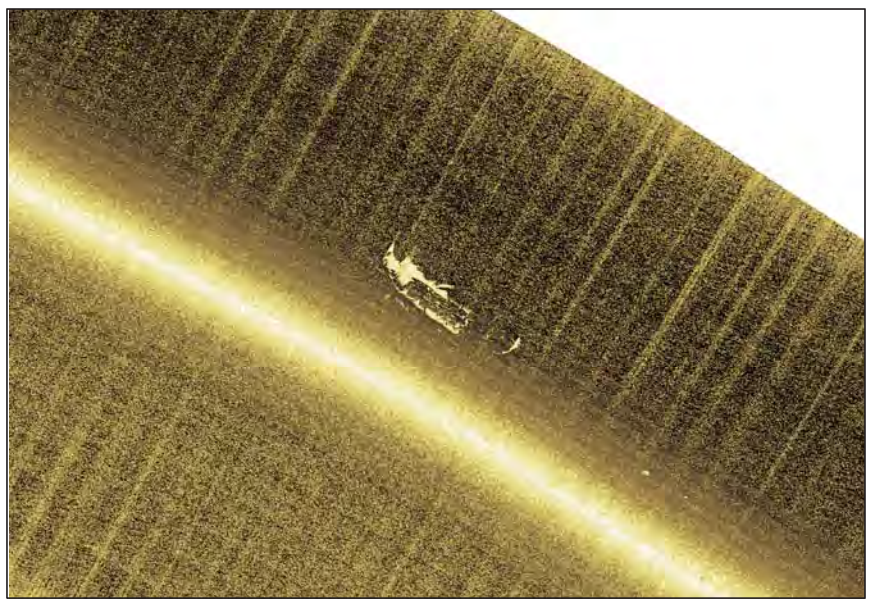


B. 7001 - Wreck and a piece of detached debris. Coincides with charted wreck of unknown identity (102m x 39.5m x 3.9m and a total magnetic amplitude of 1726nT).

C. 7001 - Wreck and a piece of detached debris. Coincides with charted wreck of unknown identity (102m x 39.5m x 3.9m and a total magnetic amplitude of 1726nT).



D. 7002 - Probably the wreck remains of HMS Cape Spartel (58m x 22m x 5.2m and a total of magnetic amplitude 679nT). Associated pieces of debris, largest measuring 9.2m x 5.2m x 0.8m.



E. 7003 - Well defined and partly buried wreck (53m x 8.6m x 2.1m and total magnetic amplitude of 602nT). Coincides with UKHO record of a wreck loss of unknown identity.

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A 0 100 200m

B-E 0 100m

Projection WGS84 Z31N

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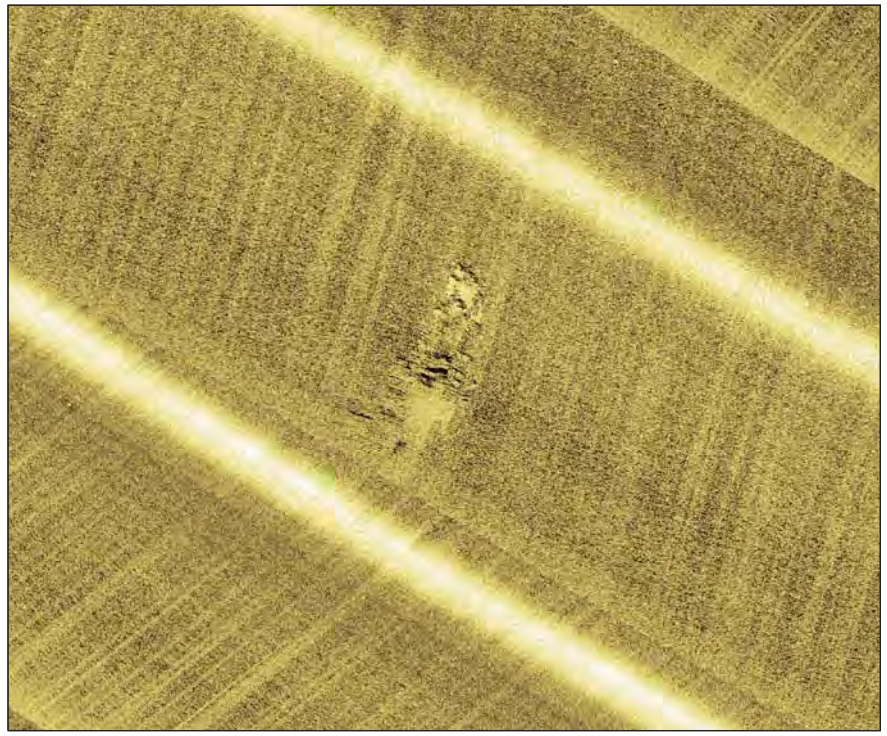
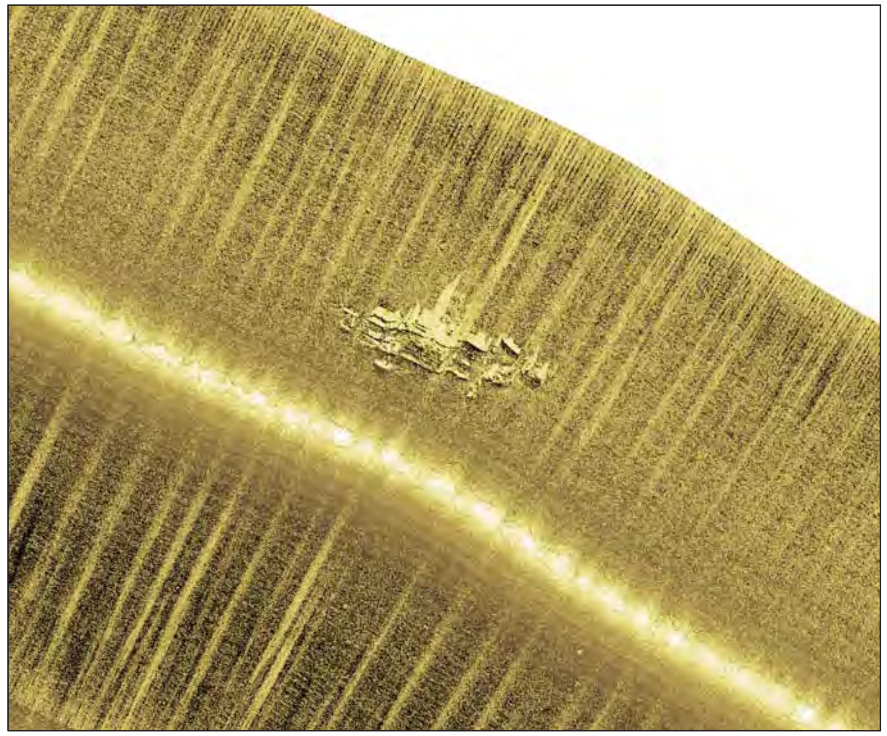
Scale:	A 1:4000, B-E 1:2500 @A3	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

Sidescan sonar anomalies WA7000-WA7003

Figure 13

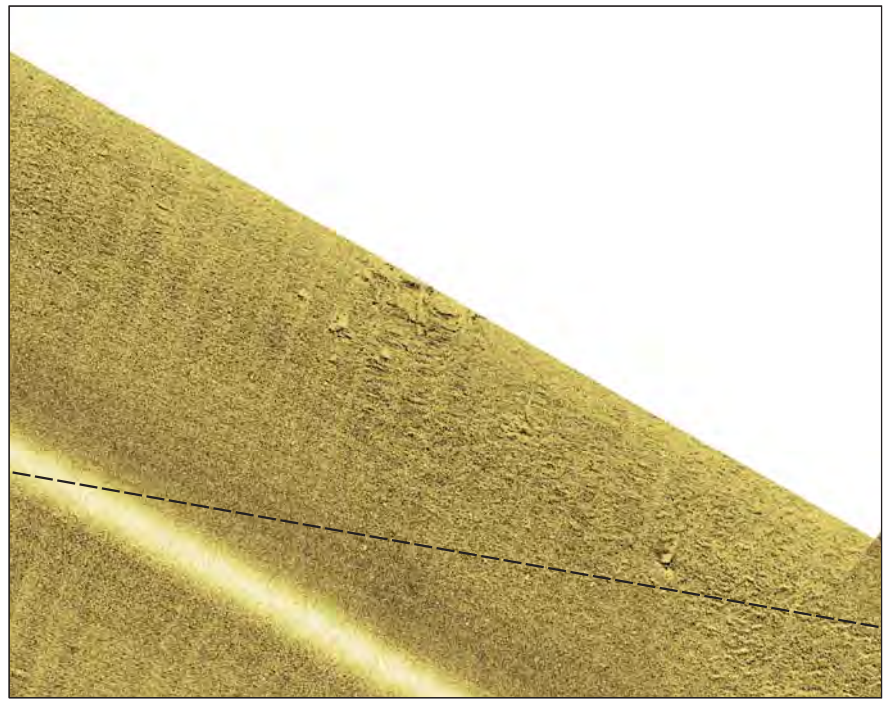


A. 7004 - Remains of a wreck of unknown identity likely to the lost steam ship recorded by the UKHO. The wreck is collapsed and the two boilers are the highest parts (70.6m x 28m x 4m and a total magnetic amplitude of 468nT).

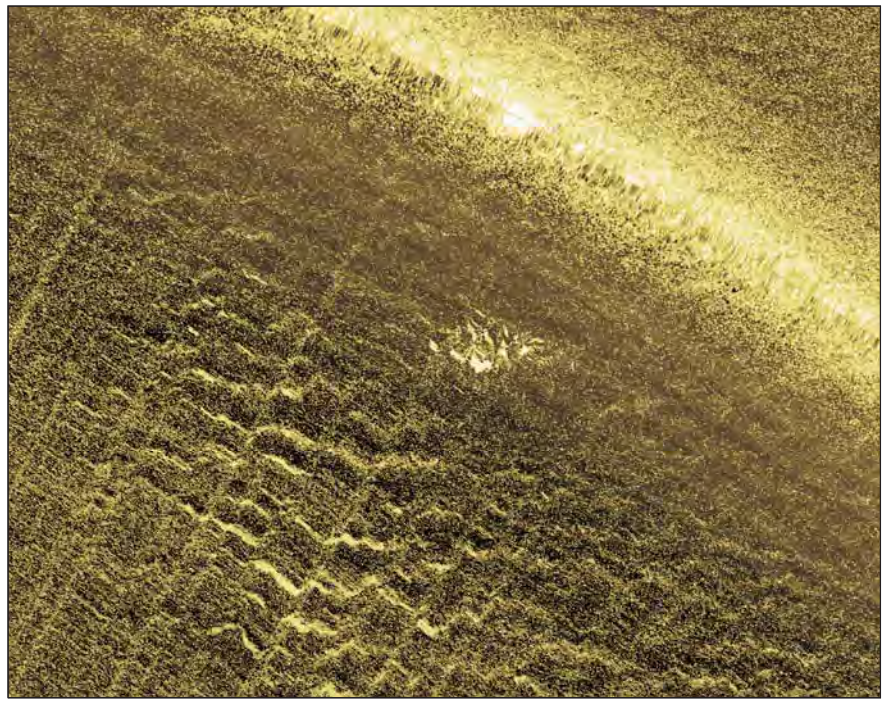


B. 7005 - Wreck of unknown identity debris (73m x 21m x 3.8m and total magnetic amplitude of 420nT) and two pieces of associated debris.

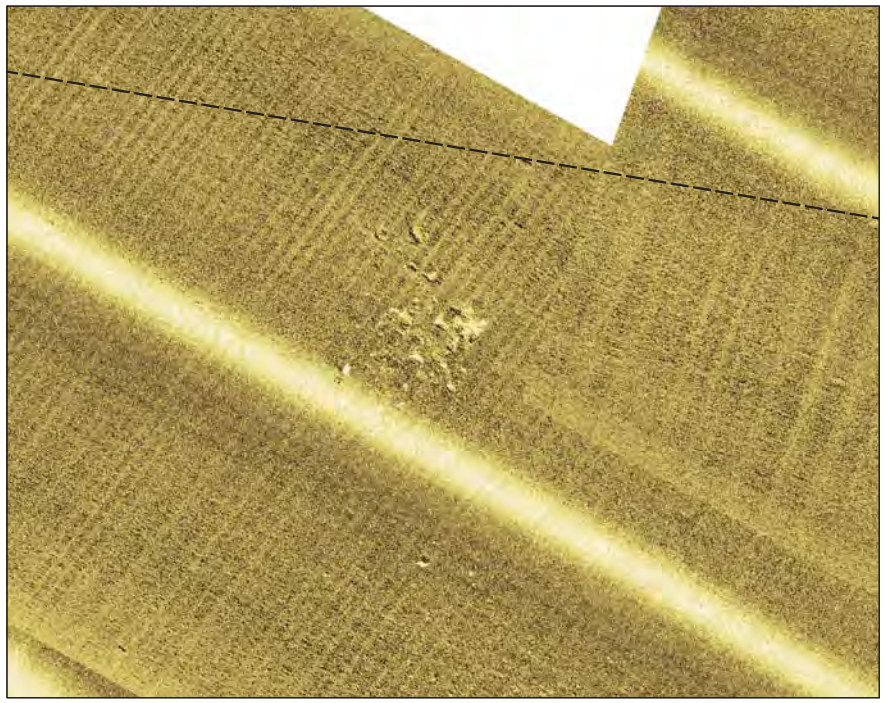
C. 7006 - Wreck of unknown identity (84m x 28.2m x 3.3m and a total magnetic amplitude of 415nT) coincides with UKHO recorded loss of a metal wreck. Site identified together with a bright reflector (3.6m x 1.7m) likely to be wreck debris.



D. 7007 - Probably the wreck remains of Royal Scott. Identified as a large area of wreckage (46.5m x 15.5m x 0.6m) and four detached pieces of debris (largest 15.1m x 10.8m x 0.9m and smallest piece 4.1m x 2.9m x 0.2m).



E. 7008 - Partially buried wreck. No hull outline, only boat shaped mound of debris/structures (28m x 10m x 0.8m)



F. 7011 - Likely remains of HMS Pintall (65.5m x 45.2m x 0.6m and a total magnetic amplitude of 492nT) with three pieces of associated debris (5m x 1.2m, 5.7m x 0.9m and 3.7m x 2m x 0.6m).

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A-D,F 0 100m

E 0 50m

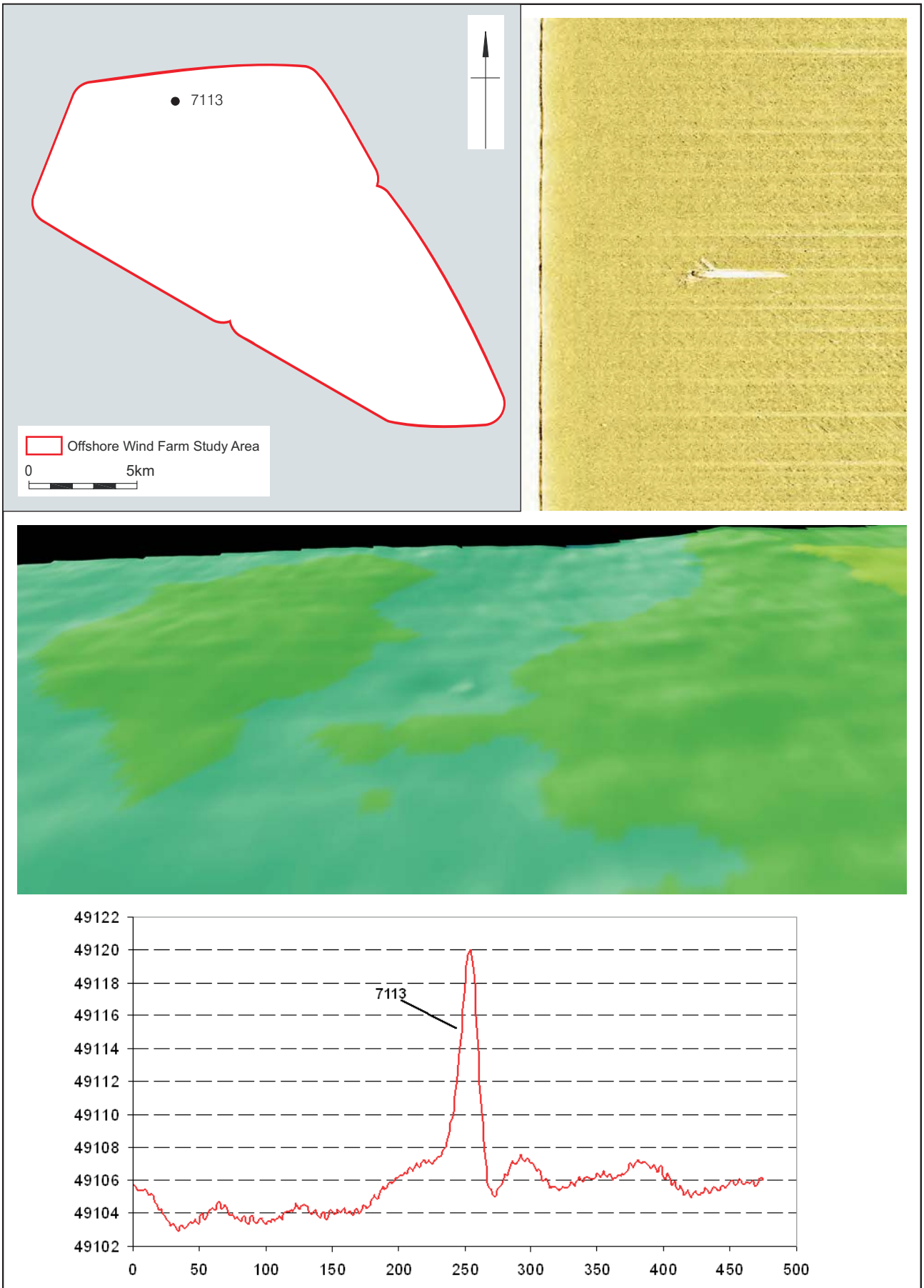
Offshore wind farm footprint (northern edge 2009)

Projection WGS84 Z31N

Date:	16/03/11	Revision Number:	1
Scale:	A-D,F 1:2500 E 1:1250 @A3	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

Sidescan sonar anomalies WA7004-WA7008 and WA7011

Figure 14



Date:	16/03/11	Revision Number:	1
Scale:	Inset 1:250,000	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

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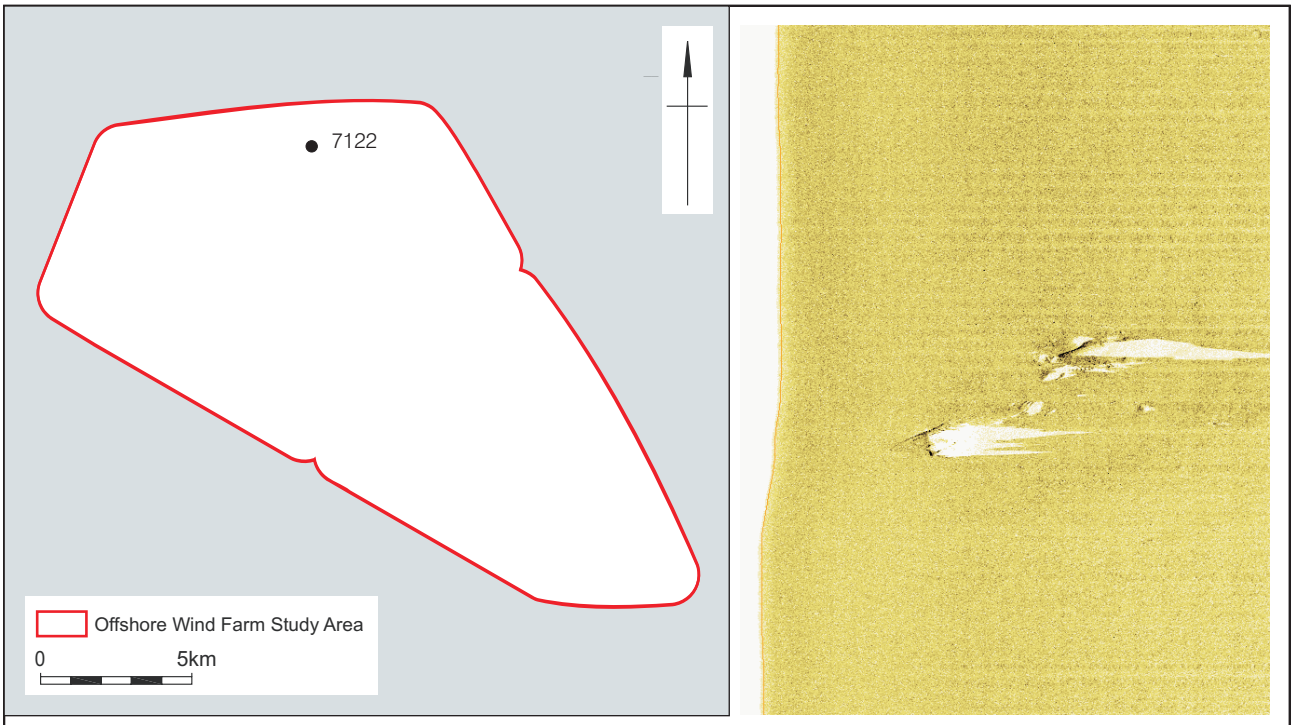
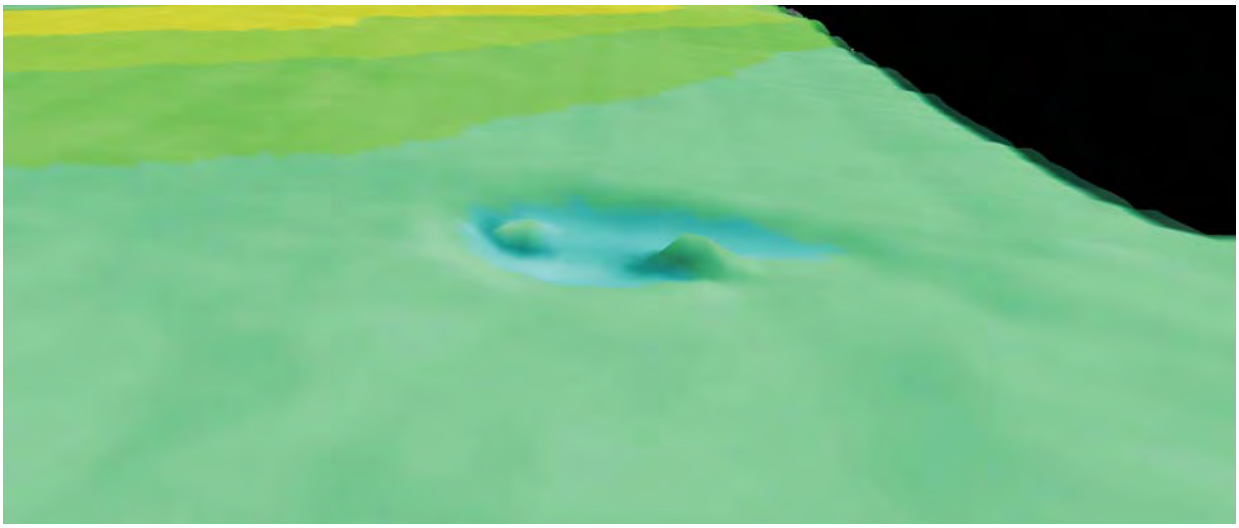
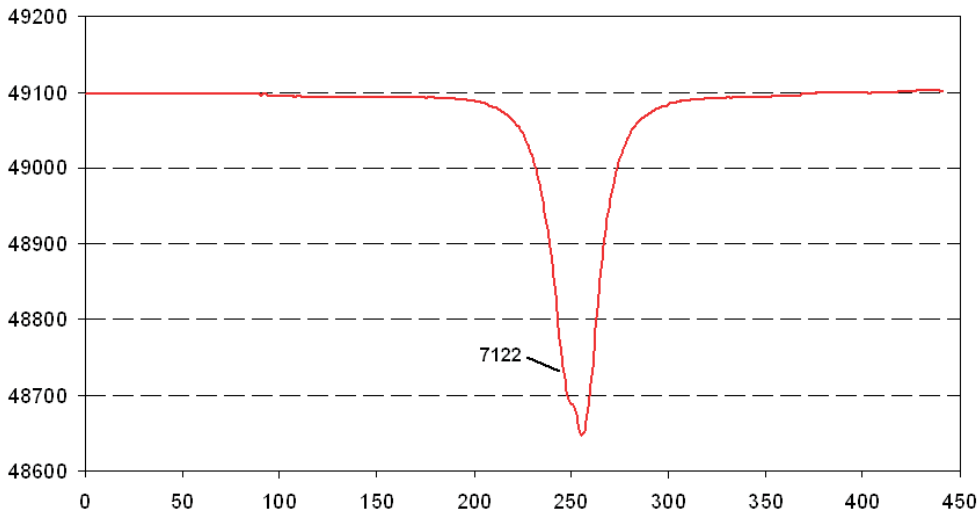
Sidescan sonar, swathe bathymetry (facing north) and magnetometer data examples of site WA7113 Figure 15







Date:	16/03/11	Revision Number:	1
Scale:	Inset 1:250,000	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-11		

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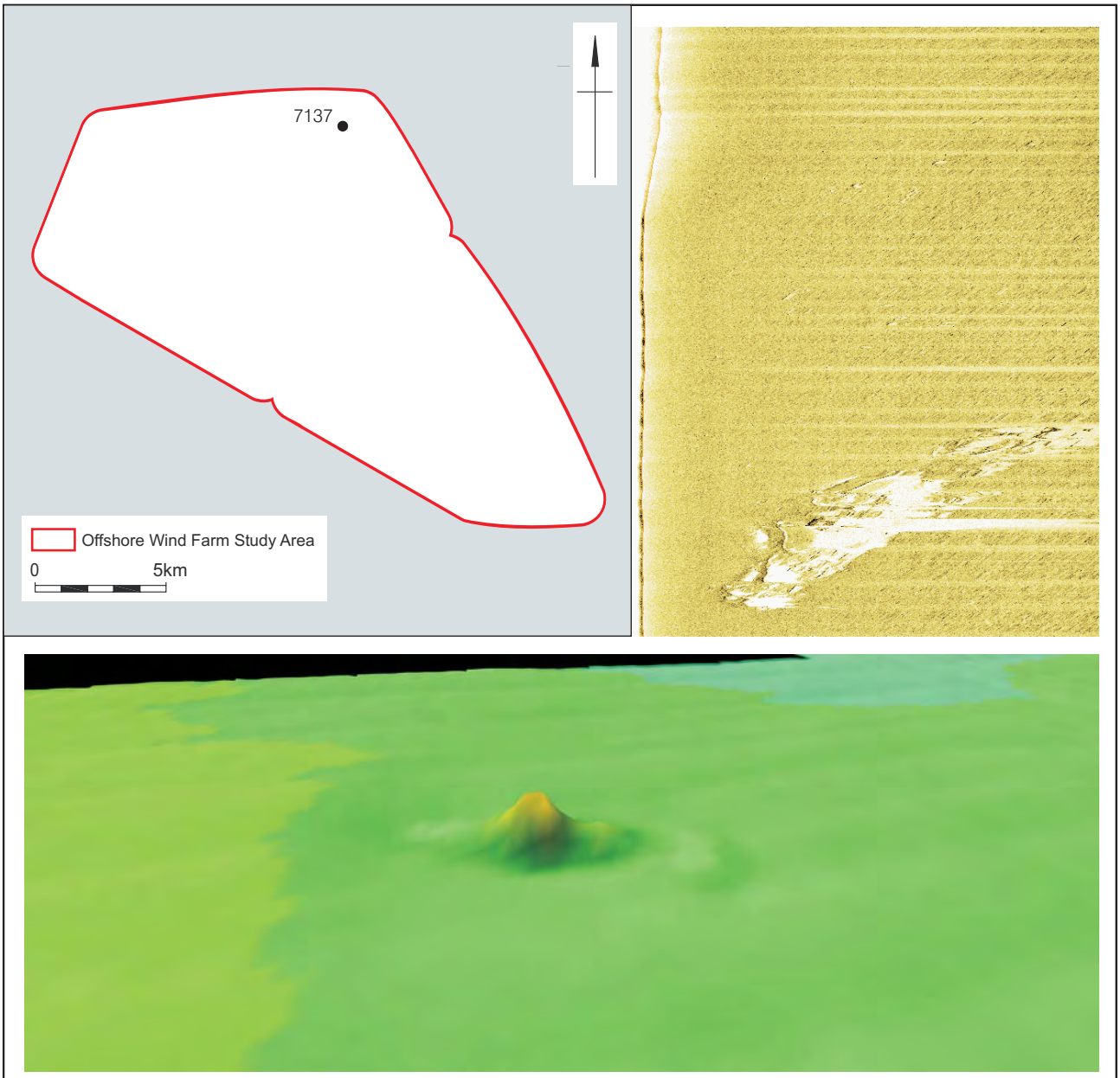
Sidescan sonar, swathe bathymetry (facing west) and magnetometer data examples of site WA7122 Figure 16

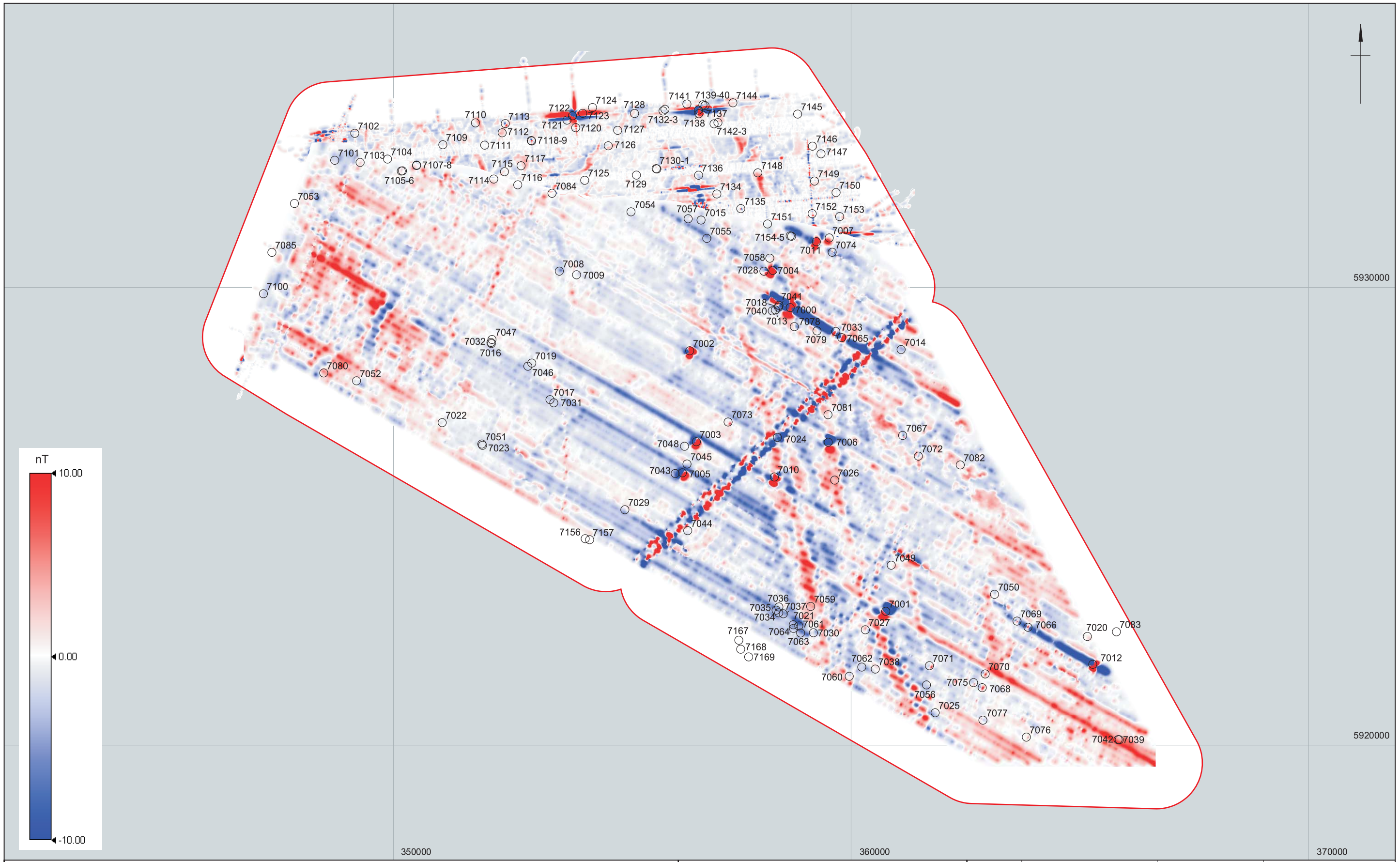


Date:	16/03/11	Revision Number:	1
Scale:	Inset 1:250,000	Illustrator:	KJB
Path:	W:\Projects\70070\Drawing Office\Report Figs\Triton Knoll OWF only\11-03-16		

Wessex Archaeology

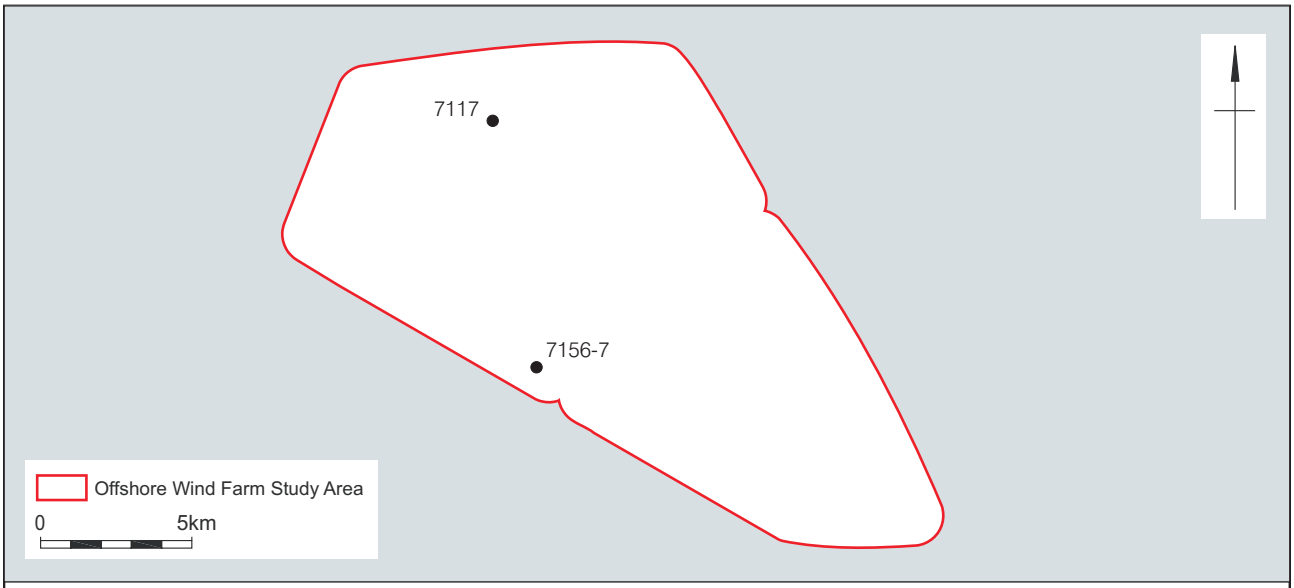
Sidescan sonar, swathe bathymetry (facing north-northeast) and magnetometer data examples of site WA7137

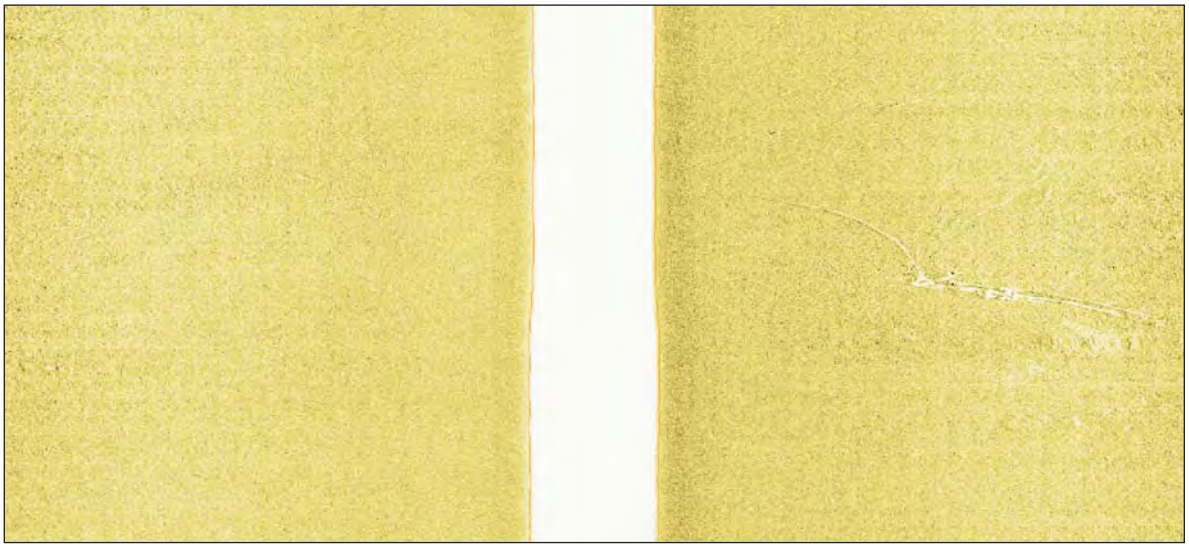
Figure 17



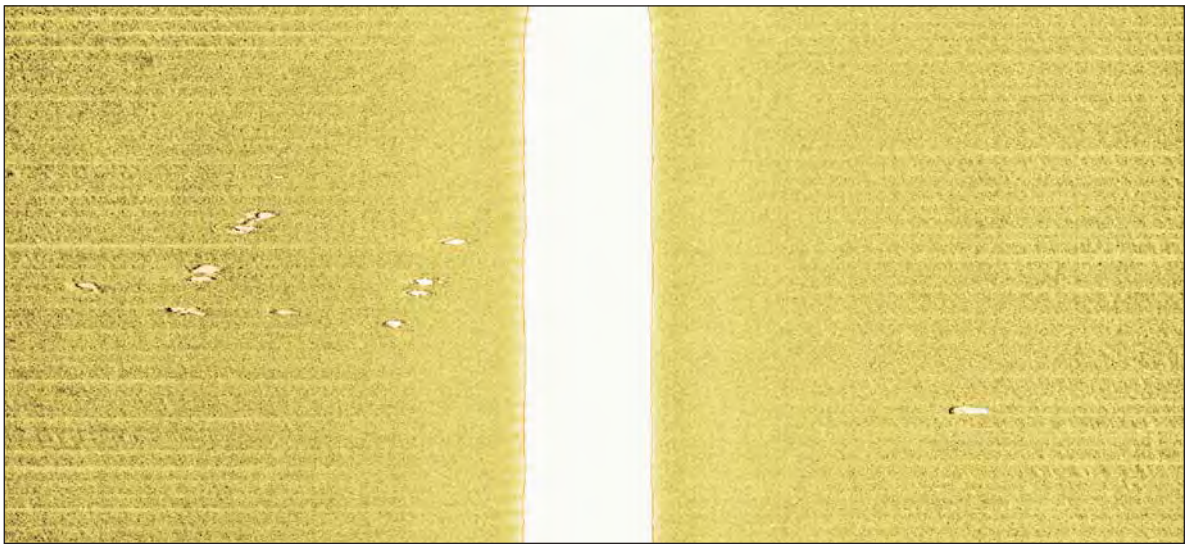
Magnetometer results within the main wind farm site from Osiris Projects 2008 data

Figure 18





A: Site 7117



B: Sites 7156 and 7157

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Scale:	Inset 1:250,000	Illustrator:	KJB
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Sidescan sonar data examples of sites WA7117 (A), WA7156 and WA7157 (B) Figure 19

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Offshore Wind Farm Study Area
Known or probable wrecks
Anomalies of archaeological interest

0 5km

Projection WGS84 Z31N
Admiralty Chart 107 (dated 2002)

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Illustrator:	KJB
Date:	16/03/11
Scale:	1:80,000 @A3
Path:	W:\Projects\70070\Drawing Office\
Report Figs\Triton Knoll OWF only\11-03-16	

Wrecks and anomalies of potential archaeological interest within the offshore wind farm

Figure 20