



Rampion Offshore Wind Farm



ES Section 13 – Marine Archaeology - Appendix 13.3

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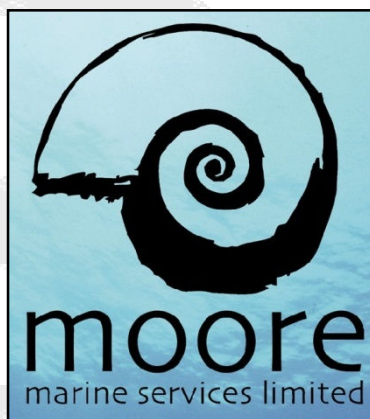
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E.ON Climate & Renewables UK Rampion Offshore Wind Limited

**MARINE ARCHAEOLOGICAL ASSESSMENT
OF
RAMPION OFFSHORE WINDFARM
FOR
RSK GROUP
ON BEHALF OF
E-ON POWER**



Moore Marine

Job Number: M12WS01

Authors: Eoghan Kieran

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ABBREVIATIONS

BC	Box core	ppm	parts per million
CAD	Computer Aided Design	psi	Pounds per square inch
CM	Central Meridian	QC	Quality Control
CPT	Cone Penetrometer Test	RTK	Real Time Kinematic
CSF	Coordinated System File	ROV	Remotely Operated Vehicle
CRP	Common Reference Point	RTCM	Radio Technical Commission for Maritime Services
DGPS	Differential Global Positioning System	S	Seconds
DP	Dynamic Positioning	SBES	Single Beam Echo Sounder
DTM	Digital Terrain Model	SBP	Sub-Bottom Profiler
EBS	Environmental Baseline Survey	SEG-Y	Seismic Data Format
ED50	European Datum 1950	SOLAS	Safety of Life at Sea
FLO	Fisheries Liaison Officer	SOW	Scope of Work
FM	Frequency Modulation	SRB	Sulphate Reducing Bacteria
GeoTIF	Geographically Referenced TIF	SSS	Side-Scan Sonar
GPS	Global Positioning System	SVP	Sound Velocity Profiler
GS	Grab Sample	TIF(F)	Tag Image File (Format)
HAT	Highest Astronomical Tide	TPU	Topside Processing Unit
HSA	Health and Safety Authority	TM	Transverse Mercator
HSE	Health and Safety Executive	UHF	Ultra-High Frequency
HV	High Voltage	UKOOA	United Kingdom Offshore Operators Association
IP	Intersection Point	USBL	Ultra Short Base Line
kHz	Kilohertz	UTC	Coordinated Universal Time
km	Kilometre	UTM	Universal Transverse Mercator
KP	Kilometre Point	UXO	Unexploded Ordnance
LAT	Lowest Astronomical Tide	VC	Vibro-Core
m	Metre	WD	Water Depth
Mag	Magnetometer	WE	Work Element
MBES	Multi-beam Echo Sounder	WGS	World Geodetic System
MM	Marine Magnetometer	XTF	Extended Triton Format
MMO	Marine Mammal Observer	XYZ	Three Primary Spatial Dimensions
MRS	Marine Route Survey		
MSL	Mean Sea Level		
m/s	Metres per second		
nT	Nano Tesla		
PGC	Piston Gravity Core		

EXECUTIVE SUMMARY

Moore Marine Services Ltd. was commissioned by RSK Group on behalf of E.On Climate & Renewables to carry out a programme of archaeological assessment and interpretation of geophysical data acquired during a site survey of the proposed Rampion Windfarm, off Shoreham, W Sussex.

The aim of the programme of archaeological assessment was to consider the archaeological and historical background of the project and to analyse the acquired data for the presence of possible archaeological features or anomalies which may be impacted by later construction works.

Geophysical survey operations took place from the 15th to 25th September 2011. The survey was undertaken using Osiris Projects dedicated survey vessel, MV Chartwell. High-resolution side scan sonar, swath multi-beam, single beam bathymetry and magnetometer data were acquired along all survey lines, in order to accurately map the seabed within the wind farm area.

The archaeological assessment comprised a combination of desktop assessment of the area followed by a review of third party acquired geophysical data. The review of the third party data reviewed the following techniques:

- Side scan sonar,
- Marine magnetometer and
- Sub bottom profiler.

There were 37 features of note on the side scan sonar survey data. 12 of these were images of known wrecks and, with one addition unidentifiable linear feature (RMP SSS 13, 16, 17, 23-32, see Appendix 3). These features are deemed to be of high archaeological significance. The remainder are deemed to be most likely of natural origin and consequently should be classed as of low archaeological significance.

The magnetometer data recorded 82 significant magnetic contacts. The position of five of the magnetic contacts corresponded with those of known wreck sites.

The sub bottom profiler data recorded that substrate thickness was larger in this area and that the palaeochannels noted in the previous sections were largely absent.

The programme of desktop assessment concluded that the proposed site was of considerable archaeological and historical significance, with evidence of continued human habitation of the region since the Palaeolithic Period. Although, given its distance from land, it is unlikely that prehistoric communities exploited this area to a large extent. Notwithstanding this there is potential that evidence of palaeolandscapes and associated cultures could be discovered in this area.

Admiralty data indicates that there are nine recorded shipwrecks in the immediate area. Only five of these wrecks were identified during the survey. The remainder may be still present in the area or may be at another position, outside the survey area. Consequently it must be considered that the likelihood of development works impacting archaeological deposits would be moderate to high.

The programme of geophysical data review noted that the data quality was generally good. It recorded the presence of 37 side scan sonar targets and 82 magnetometer targets, five of which were seen to be recorded shipwrecks.

It has been subsequently concluded that:

- Consideration should be given to the establishment of exclusion – no construction zones surrounding the identified sites, namely those of the recorded shipwrecks. The nature and extent of these exclusion zones should be developed in conjunction all relevant legislative, commercial and local parties.
- Consideration should also be give to the provision of a programme of archaeological observation of construction works in areas deemed to be of high archaeological potential such as the areas in the vicinity of the known and recorded wreck locations.

1 SCOPE OF WORKS

1.1 Introduction

Moore Marine Services Ltd. was commissioned by RSK Group on behalf of E.On Climate & Renewables to carry out a programme of archaeological assessment and interpretation of geophysical data acquired during a site survey of the proposed Rampion Windfarm, off Shoreham, W Sussex.

The aim of the programme of archaeological assessment was to consider the archaeological and historical background of the project and to analyse the acquired data for the presence of possible archaeological features or anomalies which may be impacted by later construction works.

The Osiris Projects was commissioned by E.ON Climate and Renewables UK Southern Array Ltd to undertake a detailed geophysical survey of the proposed offshore wind farm site. The object of their survey was primarily to inform turbine foundation and cable route engineering design. Equipment used included multi-beam echo sounders, side scan sonar, sub bottom profiler and marine magnetometer.

1.2 Archaeological Assessment and Data Review

The programme of archaeological assessment and real time data review was specifically designed to produce a number of results. These were:

1. To establish the archaeological and historical context to the survey area.
2. To review the acquired data for signatures which may be indicative of the presence of archaeological material and features at the survey area.
3. Where archaeological material is recorded, to inform survey strategy and resolution in order to optimise feature identification and provide sufficient data to positively identify the exact nature, extent and form of the feature.
4. To provide an indication of the potential for the project to impact archaeological materials and features.
5. To provide suggested mitigatory measures to ensure the survival of any identified archaeological features or deposits.

2 PROPOSED DEVELOPMENT

2.1 Location of the Proposed Survey Area

The proposed offshore wind farm site was located approx. 10 miles off Shoreham, W Sussex.

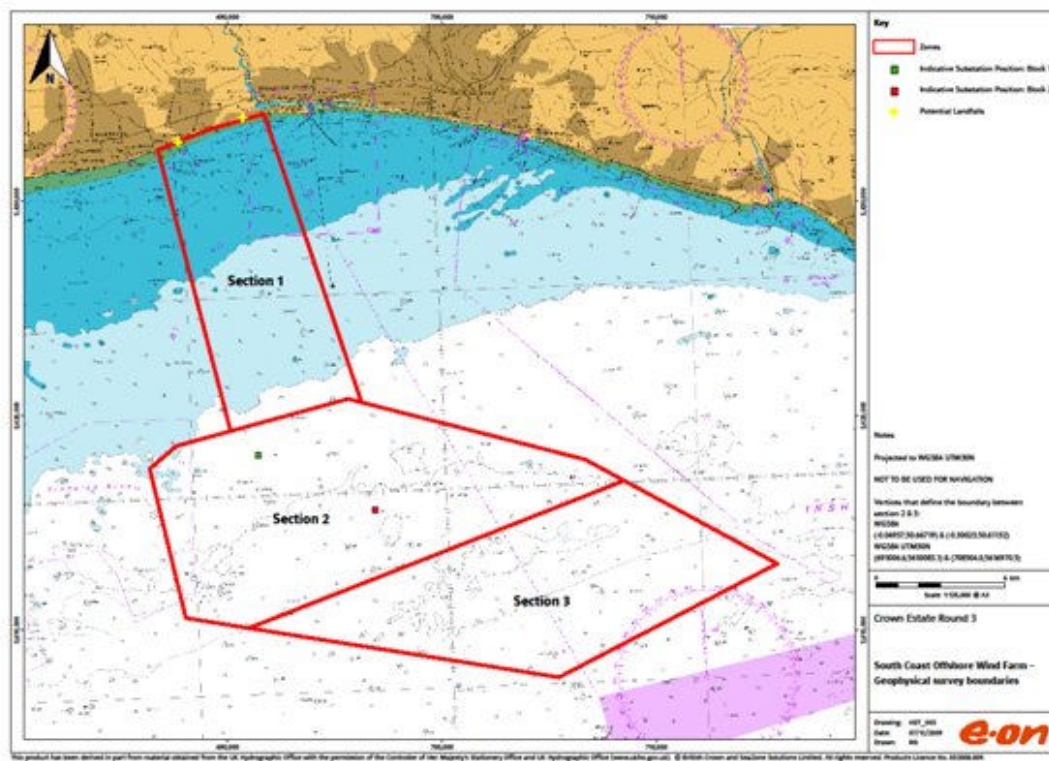


Figure 1. Section 3, survey area

3 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

3.1 UK Hydrographic Office

The UK Hydrographic Office records list over 70,000 wrecks and obstructions, of which over 20,000 are named wrecks. The Data is stored centrally and can be accessed upon request. A search of the UK Hydrographic Office recorded that there were 9 recorded wrecks or obstructions in the vicinity of the subject site (See Appendix 4). Of these, five were positively identified during the review of the geophysical data, with an additional four wrecks remaining unidentified.

4 GEOPHYSICAL SURVEY

4.1 Survey Objectives

The main objectives of the geophysical survey were as follows:

- To provide an accurate bathymetric chart of the site regions and cable routes region.
- To chart natural seabed features and any obstructions, manmade objects, debris or wrecks.
- To produce isopachyte charts to show sediment thickness of the upper, loose, and any mobile material, and of any other significant reflector levels which might impact on the engineering design to 50m below seabed.
- Locate and identify sites of near surface soft materials pertinent to jack up operations.
- To provide a detailed geological interpretation to show facies variations and structural feature changes via appropriate maps and sections.
- To produce a comprehensive factual report describing methods and events within the survey.
- To produce a comprehensive interpretative report on the survey results obtained to assist design of the offshore foundations / structures and cable burial.
- To correlate magnetic anomalies and sonar contacts to identify items that may require further physical surveys; for example UXO, wrecks, MMO, etc.
- During survey period, to identify items/areas of “Specific Areas of Interest & Archaeology” and inform the Employer as required

4.2 Survey Vessel

The mobilisation of MV Chartwell began on the 15th September 2011 in Brighton Marina. During the mobilisation phase, navigation checks, gyro, multibeam and USBL calibrations were completed. The mobilisation, calibrations and full wet test was completed by 12:00 BST on the 17th September 2011. A period of unfavourable weather immediately followed the mobilisation, with the vessel finally departing Brighton for site on the 22nd September. Survey operations were completed by the 25th September, with no further weather delays incurred.

4.3 Survey Control

4.3.1 *Horizontal Control*

Primary positioning was provided by a CNAV 2050 dGPS System. The C-NAV system is utilised across many industries, including marine construction, dredging and marine survey contractors. The C-NAV 2050 System consists of a 10 channel single constellation receiver. The system utilises correction data from either the General Lighthouse Authority (GLA) Medium Frequency (MF) radio transmission via external modem or Satellite Based Augmentation System (European Geostationary Navigation Overlay System (EGNOS)) via internal receiver

For this survey the SBAS EGNOS Differential Correction Service was utilised providing a typical positional accuracy of 1 metre at 95% confidence levels.

Secondary positioning was provided by an Applanix POS MV 320 Inertial Navigation System (INS). Primary attitude and orientation data was also derived from the system. The POS MV 320 currently provides the highest level of performance of any motion reference system, and provides positioning, orientation and attitude data to remove the effects of vessel dynamics, even during periods of poor GPS signal and total outages. The system comprises of 3 main components:

- 1) Inertial Measurement Unit (IMU) containing high quality accelerometers and gyros, installed as close as possible to the vessel's axis of rotation and gravity.
- 2) Processing Control System (PCS) containing the GPS cards and main system interface.
- 3) 2 x Dual Frequency Trimble GPS receivers, mounted perpendicular to the vessel centreline.

The system can receive any standard external Radio Technical Commission for Maritime Services (RTCM) GPS (RTCM 1, 9, 18, 19 CMR and CMR+) correction, to further improve the absolute accuracy of the system. Typical positional accuracies for dGPS are 0.5m to 2m and 0.02m to 0.10m in RTK mode. By applying a tightly coupled solution of blended GPS and Inertial Measurement Unit (IMU) data, it is possible to achieve accuracies of 0.02° to 0.01° for vessel roll and pitch (dGPS and RTK), and robust heading of 0.02° to 0.01° at 2m and 4m baselines, respectively. The real-time heave accuracy is quoted as 5cm or 5% (whichever is greatest), for a period of 20 seconds or less. Heave artefacts can be further reduced by applying the Applanix Trueheave data quoted as 2cm or 2% (whichever is greatest) during post processing.

After system installation, the sensor offsets needed by the POS MV 320 were measured using land survey techniques. The measured offsets were entered into the system and afterwards, the vessel was sailed in a series of figure of 8's with raw data being collected. The raw data was post processed using Applanix POSPac MMS and used to verify the measured offsets.

Tertiary positioning was provided by a Hemisphere Crescent VS100 GPS Compass. The VS100 system delivers sub-metre dGPS positioning accuracy, when using decoded correction data. The VS100 sensor is capable of receiving differentially corrected data from land-based General Lighthouse Authority (GLA) and also from the Space Based Augmentation System (SBAS) European GPS Navigation Overlay System (EGNOS).

For this survey, the SBAS EGNOS Differential Correction Service was utilised, providing a typical positional accuracy of 1 m at 95% confidence levels. The receiver was calibrated against an Ordnance Survey Passive Station control point coordinate, prior to survey operations, to verify the geodetic parameters and system performance.

The system also provides accurate heading data between 0.3° to 0.1° RMS, at baseline lengths between 0.5m and 2m and this data was used for tertiary vessel orientation. Secondary heading was provided by a SG Brown Gyro Compass corrected for latitude and speed.

Due to the complexity and physical characteristics of the POS MV system, it was not possible to remove the components and verify the solution against a position of known coordinate. Therefore a positional calibration was carried out with the tertiary system to confirm the project geodetic parameters. A further calibration was carried out once all receivers had been re-mobilised to the vessel, to compare the resultant computation of the same vessel offset.

Subsea towfish tracking was provided by an Ultra-Short Baseline (USBL) system. A USBL system calculates the position of a subsea target by measuring the range and bearing from a vessel mounted transceiver to a small acoustic transponder fitted to the target. For this survey, subsea positioning of the side scan sonar towfish and magnetometer towfish was provided by a Sonardyne Scout USBL system. The Scout system comprises four components – control software, a command and interface unit, an acoustic transceiver and a transponder which is attached to the towfish.

The system calculates the range and bearing from a vessel mounted transceiver to the small acoustic transponder located on the towed sensor. The Scout USBL transceiver provides a hemispherical pattern of acoustic coverage at $\pm 90^\circ$ below transceiver enabling tracking of up to 10 targets from far below through to near surface, making it ideal for shallow water surveys. The system transmits a signal at a known frequency (between 35 and 55 kHz), which is received by the subsea transponder. The transponder then waits for a predefined period before emitting a return echo. The return echo crosses the hemispherical transceiver array which enables the calculation of range and bearing to target.

The transceiver contains an integrated motion sensor to automatically compensate for the dynamic motion of the vessel. Using the internal compensation sensor, an accuracy of $\pm 2.75\%$ of slant range can be achieved; however, this accuracy can be improved to $\pm 0.50\%$, when using higher grade external gyro

and motion sensors, in this case derived from the TSS Meridian Gyro and TSS DMS (located at the swathe head). The system was calibrated prior to survey operations by undertaking a standard 'box-in' calibration routine and processed with the Sonardyne Casius calibration routine.

To improve system accuracy and towfish tracking capabilities, individual Sonardyne Wideband Supersub Mini (WSM) digital wideband transponders was fitted to the side scan sonar towfish and magnetometer towfish. The WSM is an omni-directional USBL transponder which is depth rated to 1000m and has a depth sensor fitted to aid positional accuracy.

The WSM utilises wide bandwidth digital signal processing techniques, whereas traditional beacons utilise tone burst techniques which Osiris Projects have proven are poorly suited to 'noisy' coastal environments as the signal is prone to acoustic interference.

Navigation and attitude data is interfaced to the system with all lever arms being corrected within the Scout software. The Scout is interfaced to the navigation software to enable real time tracking of subsea targets relative to the vessel frame.

A dedicated navigation computer was utilised to integrate all of the onboard sensors and to provide a single reference timeframe for all the onboard data acquisition systems taken from the incoming GPS data. In order to allow the navigation computer to display the specified project co-ordinates in real time, the incoming positional data, which is received as a WGS84 (GPS datum) Lat/Long co-ordinate, is projected into the UTM Zone 30 North coordinates.

Subsea towfish tracking was provided by an Ultra-Short Baseline (USBL) system. Subsea positioning of the side scan sonar towfish and magnetometer towfish was provided by a Sonardyne Scout USBL system. The Scout is interfaced to the navigation software to enable real time tracking of subsea targets relative to the vessel frame.

4.3.2 Vertical Control

The raw data (GPS and IMU) of the POS MV was recorded in real time. In post processing, the Primary GPS data (1Hz) was merged with either freely available UK Ordnance Survey Active Base station data (RINEX), or freely available Precise Ephemeris data, to derive the ellipsoidal antenna height accurate to 10cm (1sigma) or better. The GPS height solution was exported at 1Hz, reduced to the measured waterline level, smoothed using a non-linear filter to remove the short term effects of vessel heave and squat and then down-sampled to 10 minutes and applied as tide in post processing of the bathymetry data.

The geoid separation value between the ETRS89 (WGS84) spheroid height and Lowest Astronomical Tide was defined as 41.60 metres at the Rampion offshore wind farm. This was derived from the United Kingdom Hydrographic Office Vertical Offshore Reference Frames (UKHO VORF) project information for the Rampion Offshore Wind Farm site.

The UKHO VORF was developed between 2005 and 2008 between University College London (UCL), the Proudman Oceanographic Laboratory (POL) and the Danish National Space Centre (DNSC) to derive a definitive vertical reference model for the UK shelf seas.

The project was born out of the need to standardise using high accuracy GPS data for site specific real-time tidal reduction and to link the 700+ definitions of Chart Datum that exist around the coast of Great Britain and Ireland.

Using geodetic calculation software, the geoid separation value between WGS84 and OD(N) at each shore based gauge can be computed. By applying the published OD(N) to LAT offset (Admiralty Tide Tables Volume 1 (NP201-10)) the geoid separation between WGS84 and LAT can be established. These computed geoid separations onshore agree well with the VORF information.

4.4 Survey Operations

The survey was undertaken using Osiris Projects dedicated survey vessel, MV Chartwell from 15th to 25th September 2011.

The mobilisation of MV Chartwell began on the 15th September 2011 in Brighton Marina. During the mobilisation phase, navigation checks, gyro, multibeam and USBL calibrations were completed. The mobilisation, calibrations and full wet test was completed by 12:00 BST on the 17th September 2011. A period of unfavourable weather immediately followed the mobilisation, with the vessel finally departing Brighton for site on the 22nd September. Survey operations were completed by the 25th September, with no further weather delays incurred. The UXO investigation of location BH13 was completed successfully on the 24th September, during daylight hours.

Data acquisition comprised simultaneous recording of Reson 7101 multibeam echo sounder, Klein 3000 high resolution side scan sonar data, with piggy backed marine magnetometer and 'Boomer' sub bottom profiler. The line spacing for the extension survey was set at 150m for main lines (26 total), with cross lines at 1500m. The total line kilometres for this phase of the works was approximately 290 km. Main line orientation was set as per project C10011 at 71°/251° to coincide with predominant tidal current flow. A total of 7 cross lines were acquired perpendicular to the main line orientation at 1500m spacing. This ensured that the cross line data could be tied into the original survey results where cross lines were acquired at 750m line spacing.

The UXO investigation comprised a 200m box area, with 41 main lines spaced at 5m and orientated at 71°/251°, and 3 cross lines orientated perpendicular to the main lines. The objective of the survey was to locate any potential obstructions (natural or anthropogenic). The same equipment spread was utilised, with changes made to the settings of the boomer and multibeam to increase data resolution. The magnetometer was flown as close to the bed as possible, with flying height controlled generally between 0m and 2m above seabed.

A Fisheries Industry Representative (FIR) was assigned to the project for the duration of the survey to ease any conflict between active fisheries parties and Osiris Projects.

The project was carried out under CDM Regulations 2007, with Osiris Projects appointed Principal Contractor and Designer. The Client was appointed Client and CDM Co-ordinator.

4.5 Survey Equipment

The following equipment was used during the survey:

<i>Item #</i>	<i>Equipment Utilised</i>	<i>MV Chartwell</i>
1	AAE Multi Element Hydrophone	✓
2	APPLANIX POS MV 320 v4 RTK	✓
3	APPLIED ACOUSTICS AA200 Boomer Sub-Bottom Profiling System	✓
4	APPLIED ACOUSTICS CSP1000 and CSP 1200 Seismic Power Source	✓
5	C NAV 2050 dGPS	✓
6	CODA TECHNOLOGIES DA2000 Digital Data Acquisition System	✓
7	GEOMETRICS G882 Caesium Vapour Magnetometer	✓
8	HEMISPHERE Crescent VS100 dGPS Compass	✓
9	KLEIN 3000 Digital Dual Frequency Side Scan Sonar System	✓
10	QPS QINSy Navigation Software	✓
11	RESON SEABAT 7101 Single Head Multi-Beam Echo Sounder	✓
12	RESON Sound Velocity Profiler (SVP) 15	✓
13	RESON Sound Velocity Probe SV70	✓
14	T COUNT Cable Counter	✓
15	SG BROWN Gyro Compass	✓

Table 1. Table of equipment used

The three systems most relevant to the archaeological assessment were the sub bottom profiler, side scan sonar and marine magnetometer.

4.5.1 Sub Bottom profiler

The Applied Acoustics 'Boomer' sub-bottom profiling system comprised of an AA200 boomer plate, a CAT200 catamaran, a CSP1000 portable seismic energy source and an AAE 20/8 element hydrophone streamer.

Short duration, high-power electrical pulses, generated by the shipboard CSP1000 power supply, are discharged to the electrical coil. The resultant magnetic field explosively repels the metal plate, generating a broadband acoustic pressure pulse in the water column. The frequency of this pulse is in the range 10 kHz to 500Hz, with the majority of the energy being directed vertically downwards at a maximum output of 300 joules per pulse.

Data was acquired and processed through the Coda DA2000 digital data acquisition system, for later post-processing and archiving.

The accuracy of any sub-bottom profiling survey depends upon the correct choice of acoustic velocity for the travel path of the seismic wave. After an initial appraisal of the collected data, velocity assignments are made which, from experience and published information¹ are thought to be typical for the interpreted sediments present. Using these velocities, comparisons between depths to reflectors and any known depths to geological interfaces are made. The average seismic velocity of the travel paths may then be altered, to ensure good correlation between seismic reflectors and geological events.

The Boomer Sub-Profiling System that was used during this survey comprised of a CSP (300/500/1000/1200D) Portable Seismic Energy Source, an Applied Acoustics AA200 Boomer Plate, a CAT200 Catamaran and Applied Acoustics AAE 8 Element Hydrophone Streamer.

Data was acquired and processed through the Coda DA2000 Digital Data Acquisition System, for later post-processing and archiving.

An average velocity of 1700 ms^{-1} was used for all sub-bottom interpretation.

Boomer Settings Summary:

System Power	100 and 200 Joules
Sweep Time	200 ms
Hydrophone	AAE 8-element (365mm element spacing)
Trigger Rate	350 Hz
Layback from Towpoint	20 m
Recording Media	CODA DA2000 (COD Format)

Table 2. Table of Boomer Settings

4.5.2 Side Scan Sonar

A digital Klein 3000 simultaneous dual frequency (100 kHz and 455 kHz) side scan sonar system was utilised for this aspect of the works. The Klein 3000 system is based on new transducer designs, along with specifically developed, high-resolution circuitry and multi-beam focused sonar technologies, which provide outstanding imaging and high-range performance.

The system comprises a transceiver processor unit (TPU), a workstation running Klein 'SonarPro' software and a towfish. The towfish is fully instrumented with depth, heading, roll and pitch sensors and

can be fully integrated with magnetometer and USBL beacons. The 'SonarPro' software is a custom developed modular package combining ease of use with advanced sonar features.

Short, high frequency, high intensity sound bursts are beamed (perpendicular to the direction of travel) from transducers, which are mounted either side of the fish. This results in echoes, returned from points on the seabed up to 600 metres abeam of each transducer at 125 kHz, or 150 metres at 445 kHz. Once detected by sensors within the transducers these echoes are relayed to the transceiver unit, via the tow cable, and the signals are processed, line by line, to produce a sonar image. Harder or denser materials reflect more energy than softer seabed types, resulting in images of differing reflectivity or contrast. This enables post processed classification of differing seabed sediment types, including rock outcrops and isolated contacts/targets.

The system was operated in high frequency and at a maximum range scale of 150m per channel throughout the survey area.

Prior to survey operations the system was 'rub tested' to ensure correct transducer installation

The side scan fish cable is fed through a T-Count system, which is marketed as a reliable and accurate system for measuring the length of cable passing over a sheave block. A radio link is then used to display the count on a computer or hand held receiver.

The data was logged in Klein's 'SonarPro' software for 'real time' visualisation and target picking/measuring. The system accepts digital data from the side scan over a network connection, together with data from the navigation computer, providing real time geo-referencing of the records. The software also allows for detailed target tagging, management and investigation in real time, using image capture functions and accurate measurement and identification tools.

4.5.3 *Marine Magnetometer*

A Geometrics G882 Caesium Vapour Marine Magnetometer was utilised to obtain magnetic data throughout the survey. The system incorporates a towed 'fish', which houses a total magnetic field sensor and CM221 Larmor counter. The unit provides absolute readings of total magnetic field, with a resolution of 0.004nT/Hz RMS.

The fish was towed at a known distance 50-120m (depending on water depth) from the survey vessel, and buoyed off at as necessary in the shallow water to prevent the towfish grounding on the seabed. The position of the towfish was by USBL. All data acquired was logged to the navigation computer via an RS232 link and combined with positional data for later retrieval and post-processing.

4.5.4 *Echo Sounder/Multibeam Echo Sounder*

A Geometrics G882 Caesium Vapour Marine Magnetometer was utilised to obtain magnetic data throughout the survey. The system incorporates a towed 'fish', which houses a total magnetic field sensor and CM221 Larmor counter. The unit provides absolute readings of total magnetic field, with a resolution of 0.004nT/Hz RMS.

The magnetometer is used to detect variations in the total magnetic field of the underlying seafloor and sub-seabed geology on the basis of anomalies in the Earth's magnetic field. Increased magnetisation is caused by the presence of ferrous iron on, or below, the seafloor. Materials high in ferrous or ferric compounds may include wreck debris, pipelines, unexploded ordnance, sites of archaeological interest or volcanic rocks. For the purposes of this survey, the magnetometer was utilised to identify ferrous items that may require further physical investigation.

The fish was towed 'piggy backed' to the Klein 3000 tow fish at a fixed layback of 10m. The position of the tow fish was by USBL. All data acquired was logged to the navigation computer via an RS232 link and combined with positional data for later retrieval and post-processing.

The data was processed using Geosoft Oasis Montaj UX-Detect software. During processing, the data is initially de-spiked to remove erroneous values. The long wavelength signal caused by diurnal variations and geological conditions is removed using a non-linear filter (typical sample width 100 samples, with an amplitude tolerance of 0.0001nT). Subtracting the non-linear filter approximation from the original signal results in a normalised data set, highlighting any short wavelength anomalies. The data was gridded using a minimum curvature technique to create the magnetic anomaly image. Individual anomalies were picked manually from each individual profile based on amplitude and dipole characteristic and compared against the gridded image to ensure that multiple picks and any picks associated with geological channel features were removed. The typical tolerance for anomaly picking was set at 2nT; however anomalies over 0.5nT were picked where they displayed a clear dipolar morphology.

For the UXO survey, all anomalies over 0.5nT in amplitude were picked, where they displayed a clear dipolar or monopolar morphology.

5 ARCHAEOLOGICAL ASSESSMENT OF GEOPHYSICAL DATA

The first stage of the archaeological review of the geophysical data is analysis of the previously acquired geophysical data, namely; side scan sonar, magnetometer and sub bottom profiler data. Moore Marine Services has developed a methodology for post acquisition analysis of geophysical data which involves review of individual raw geophysical data through a number of processes. The data is reviewed in its own individual context and also in reference to the results of other techniques. The resulting information relating to the individual techniques can be cross referenced and displayed both in text and in graphic form.

- For side scan sonar data, all data is reviewed using both SonarWiz Map 5 and Coda software.
- For sub bottom profiler data, all data is also reviewed using both SonarWiz Map 5 and Coda software.
- For magnetometer data, all data is reviewed using Hypack 2012 and Surfer 8 software

5.1 Side Scan Sonar

Review of the side scan sonar data concluded that the seabed within the survey area appeared to be characterised by granular sediments. These deposits are interpreted as ranging from fine to coarse grained gravelly sands to coarser grained sandy gravels, with occasional cobbles and boulders.

The seabed across the extreme northerly part of Section 3 comprises mainly gravelly sands, which exhibit low amplitude sand/gravel waves and associated megaripple bed forms. These features are asymmetrical in profile and are orientated between N – S and NNW - SSE, with heights between 2.5m and 5.5m and average wavelengths between 250m and 350m.

The seabed across the central part of the Section 3 area within the broad trough feature mentioned above comprises mainly sandy gravels, with occasional boulders. This part of the site is characterised by a large number of trawl scars, which traverse the area, mainly from E – W.

To the S of the broad expanse of sandy gravels, the seabed sediments become less coarse grained across the long SSW-NNE orientated ridge feature mentioned above. The ridge feature also exhibits large sand/gravel waves, which are orientated from approximately NW-SE to NE-SW, with their respective orientations often changing along the length of the sand/gravel wave itself. They are asymmetrical in profile, with the steeper sides (up to 14°) facing the NE or ENE. In addition to the low amplitude sand/gravel waves, the whole of the Section 3 area is characterised by the presence of megaripple bed forms. These are orientated between N-S and NNW-SSE and present a variety of wavelengths across the site, ranging from approximately 4m to over 40m.

According to the Admiralty wreck listings, 9 wrecks are believed to be present within the Section 3 area. However, only 5 of these wrecks were identified. Four (19995, 20162, 20172 and 20173) were positively identified on the side scan sonar record and additional one (58306) was recorded by the magnetometer. Whilst the side scan sonar did not record the confirmed presence of Wreck 58306. It did record the presence of apparent trawl marks adjacent to the wreck site. Confirmation as to whether the sonar image represented actual trawl marks or possible wreckage was not possible. Consequently, it must be considered that these marks may also represent vessel remains.

No physical debris or localised magnetic anomalies were identified at any of the other wreck locations (Admiralty Nos. 19978, 19983, 20017 and 20021).

A total of only 37 sonar targets, including the above wrecks, were recorded within the Section 3 area. Several of these were boulders with a minimum dimension of 1.0m (or greater). A large number of boulder were also present in this area

Eastings	Northings	Comment	Associated Sonar	Associated Magnetic
702088	5611160	'Porthkenny' – Wreck no 19978		
702064	5611777	'Tycho' – Wreck no 19983		
709576	5612585	Unknown – wreck no 19995	RMP SSS 24	RMP MAG 47
702242	5614289	Unknown trawler – wreck no 20017		
708674	5614759	'Leaches Romance' – wreck no 20021		
709874	5614250	Unknown – wreck no 20162	RMP SSS 25 – 32	RMP MAG 51
706952	5612063	Unknown – wreck no 20172	RMP SSS 16/17	RMP MAG 27
706277	5612715	HMS Keryado – wreck no 20173	RMP SSS 13	RMP MAG 23
704337	5614031	Fishermans Fastener – wreck no W58306		RMP MAG 82

Table 3. Table of Known Wrecks and Side Scan Sonar Contacts

5.1.1 Wreck No. 20162

Admiralty Wreck no. 20162, a former World War 2 pontoon can be clearly seen on the sonar record. The pontoon is approximately 5.0m wide and is broken into a number of pieces, which exhibit little relief above the surrounding seabed. No development should be undertaken in the vicinity of this feature.

5.1.2 Wreck No. 20172

Admiralty wreck no 20172 can be clearly seen on the sonar record. It measures approximately 18.1m long and 7.1m in width. It stands 4.9m above the surrounding rippled sandy seabed. No development should be undertaken in the vicinity of this feature.

5.1.3 Wreck No. 20173

Admiralty wreck no 20173 can be also clearly seen on the sonar record. This wreck measures approximately 39.6m long and 8.1m wide and stands 2.6m above the surrounding sandy rippled seafloor. No development should be undertaken in the vicinity of this feature.

5.1.4 Wreck No. 1995

The remains of Admiralty wreck 19995 were noted approximately 265m to the S of the southern boundary of the Section 3 area. There does however appear however, sonar target S24 appears to be an area of debris (see figure 7, below), with an associated magnetic anomaly (M47). These features are located approximately 520m S of the as-given position of wreck 19995.

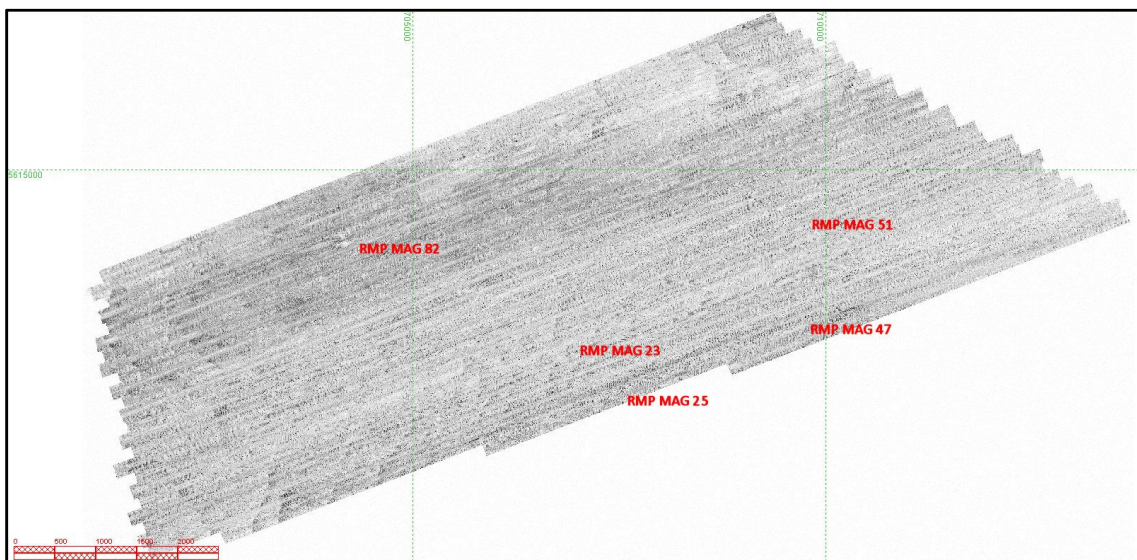


Figure 2. Side Scan Sonar mosaic with anomaly identifications

5.2 Marine Magnetometer

The marine magnetometer recorded 82 isolated ferrous contacts. These isolated contacts generally represented non archaeological materials. Five recorded shipwrecks were noted during the survey these were Admiralty Wreck No. 58306, 20173, 20172, 20162 and 19995. No development should be undertaken in the vicinity of these features

A table detailing the results of the marine magnetometer survey is contained in Appendix 2. The prefix RMP MAG applies to all Rampion Windfarm Magnetometer (Section 3) contacts. It details the magnetic signature, its location and cross reference to the side scan sonar survey.

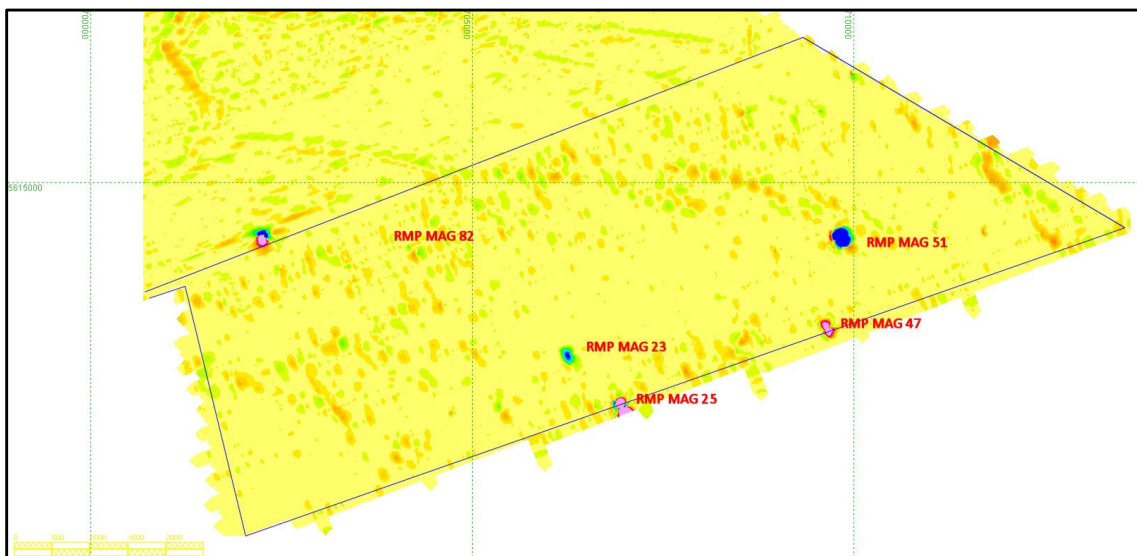


Figure 3. Rampion Section 3, Magnetometer Contacts

5.3 Sub Bottom Profiler

Review of the Sub Bottom Profiler data concluded that sediment thicknesses in Section 3 ranged from approximately 4.0m, in the NE, to over 30.0m in the southern part of Section 3. The deep palaeo-channel features noted in Sections 1 and 2 are not evident in Section 3. Much of the variation in sediment thicknesses is due to the shapes of the large banks of coarse sediments. There was no apparent submerged archaeological heritage noted in this area.

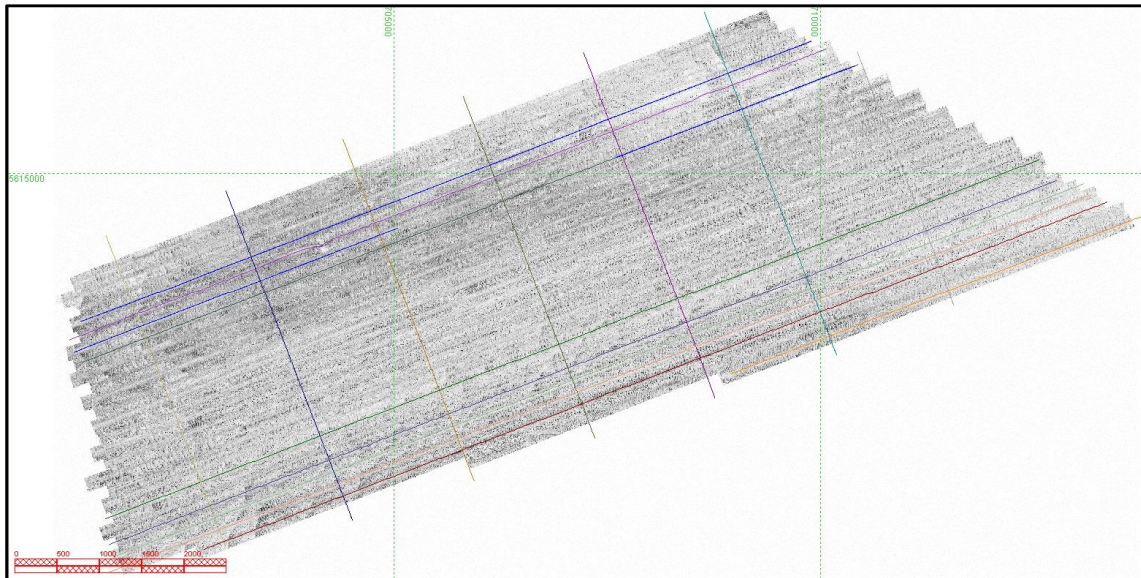


Figure 4. Sub Bottom Profiler lines overlaid on Side Scan Sonar Mosaic

6 SUMMARY AND CONCLUSION

6.1 Summary

The desktop historical and archaeological assessment of the subject site indicated that there has been the site of continued human habitation since the Palaeolithic Period, with 123 Palaeolithic find spots in West Sussex alone. Most of these finds comprise mainly of hand axes and flakes. During the Neolithic period, around 4000BC, those communities that settled along the southern coast of Britain enjoyed access to large amounts of flint due to the large number of flint mines in Hampshire and West Sussex. The archaeological record around these mines testifies to a large number of flint tools being manufactured and from about 4300 BC to about 3400 BC the mining of flint for use locally and also for wider trade was a major activity in Neolithic Sussex. The discovery in 2009 of a Bronze Age vessel off the coast of Devon gave an insight into contemporary maritime activities. It was carrying an extremely valuable cargo of tin and hundreds of copper ingots from the Continent when it sank around the year 900BC. These craft and exotic artefacts found in Bronze Age burials testify to the increase in overseas trade across the English Channel. The arrival of the Iron Age saw increased trading and exchange contacts, between Britain and mainland Europe. The later Roman route into England was made easier because of these existing trade routes.

After an apparent sharp decline in maritime trade during the early post-Roman period, commercial trading activity with continental Europe was stimulated again from the late 6th century. The 8th and 9th centuries saw the greatest resurgence of European trade since the fall of the Roman Empire. Most of this trade relied on water transport and as a consequence urban settlements were revitalised along rivers and near to the coast, changing the character of the landscape/seascape. Between the 8th and 11th centuries, the distinctly maritime orientated Scandinavian influence spread widely across Europe and beyond, disrupting earlier trade patterns and patrons but creating new ones. The Norman conquest of 1066 reorientated England towards continental Western Europe and away from Scandinavian influence. It opened up important new trading areas for England, including the wine growing region of Gascony.

Throughout the medieval period, the location of shipbuilding sites seems to have been rather haphazard in England's landscape. The sites themselves were rudimentary, although ships were being built in simple docks from at least the 1330s. The 16th Century saw the Thames and surrounding region grow to become the shipbuilding capital of the country. In 1559 there were 520 shipwrights employed in the royal yard in the Thames and at Portsmouth. In later years, the English shipping industry underwent a particularly rapid development following the Seven Years War against France (1756-63), and the rate of English naval construction rapidly increased. During the mid 19th century, technological and economic

progress gained momentum with England as a world leader in the development of steam-powered ships and railways, and later the internal combustion engine and electrical power generation. England became one of the leading industrial powers of the 19th century, due in no small part to the strength of its shipping industry.

The geophysical survey of the site in question was undertaken using Osiris Projects dedicated survey vessel MV Chartwell, from 15th to 25th September 2011.

High-resolution side scan sonar, swath multi-beam, single beam bathymetry and magnetometer data were acquired along all survey lines, in order to accurately map the seabed within the wind farm area. Main survey lines were run at 50m centres, with cross lines at 750m centres. A total of 4,860 design line kilometres were acquired.

The archaeological assessment reviewed the following techniques: Side scan sonar, marine magnetometer and sub bottom profiler. It concluded that:

- There were 37 features of note on the side scan sonar survey data. 12 of these were images of 4 known wrecks, with one additional unidentifiable linear feature (RMP SSS 13, 16, 17, 23-32, see Appendix 3). These features are deemed to be of high archaeological significance. The remainder are deemed to be most likely of natural origin and consequently should be classed as of low archaeological significance.
- There were 82 recorded magnetometer contacts. The position of five of the magnetic contacts correspond with those of known wreck sites.
- The sub bottom profiler data recorded that substrate thickness was larger in this area and that the palaeochannels noted in the previous sections were largely absent.

6.2 Conclusion

The programme of desktop assessment concluded that the proposed site was of considerable archaeological and historical significance. Although it is unlikely that evidence of palaeolandscapes and associated cultures would be found in this area, Admiralty Data indicates that there are nine recorded shipwrecks in the immediate area. Only five of these wrecks were identified during the survey. The remainder may be still present in the area or may be at another position, outside the survey area. Consequently it must be considered that the likelihood of development works impacting archaeology is moderate to high.

The programme of geophysical data review noted that the data quality was generally good. It recorded the presence of 37 side scan sonar targets and 82 magnetometer targets, five of which were seen to be recorded shipwrecks.

Consideration should be given to the establishment of exclusion – no construction zones surrounding the identified sites, namely those of the recorded shipwrecks. The nature and extent of these exclusion zones should be developed in conjunction all relevant legislative, commercial and local parties. Consideration should also be give to the provision of a programme of archaeological observation of construction works in areas deemed to be of high archaeological potential such as the areas in the vicinity of the known and recorded wreck locations.

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APPENDIX 2 MAGNETOMETER ANOMALY LIST

Contact Number	Easting	Northing	Width	Amplitude	Type	SSS Reference
RMP MAG 01	701700.1	5613727.4	27.4	2.9	Positive Monopole	
RMP MAG 02	702128.1	5610996.9	35.8	2.0	Positive Monopole	
RMP MAG 03	702486.2	5613865.0	27.6	9.7	Positive Monopole	
RMP MAG 04	702601.7	5611707.4	52.3	4.0	Positive Monopole	
RMP MAG 05	702973.3	5610673.3	20.3	2.5	Dipole	
RMP MAG 06	703367.8	5612594.1	29.7	1.9	Positive Monopole	
RMP MAG 07	703399.7	5612607.0	33.1	1.8	Dipole	
RMP MAG 08	703739.6	5610969.0	35.2	7.0	Positive Monopole	
RMP MAG 09	703822.6	5613099.8	42.9	3.3	Positive Monopole	
RMP MAG 10	704003.0	5611716.7	42.1	2.9	Asymmetric Dipole	
RMP MAG 11	704119.2	5614160.8	11.7	7.6	Positive Monopole	
RMP MAG 12	704167.9	5613384.3	34.6	7.7	Positive Monopole	
RMP MAG 13	704283.4	5611345.9	51.3	2.3	Positive Monopole	
RMP MAG 14	704363.3	5614586.3	40.1	6.6	Dipole	
RMP MAG 15	704535.2	5612238.2	22.4	2.9	Negative Monopole	

RMP MAG 16	704591.7	5613395.0	87.4	6.7	Dipole	
RMP MAG 17	704728.0	5611995.4	69.6	27.4	Dipole	
RMP MAG 18	705343.2	5612067.9	91.7	5.7	Negative Monopole	
RMP MAG 19	705526.4	5615033.3	38.5	4.8	Positive Monopole	
RMP MAG 20	705881.4	5611957.4	42.0	1.3	Dipole	
RMP MAG 21	706091.9	5612039.0	50.7	1.3	Dipole	
RMP MAG 22	706212.0	5615298.6	48.8	5.9	Negative Monopole	
RMP MAG 23	706262.9	5612700.8	201.9	45.9	Negative Monopole	S13
RMP MAG 24	706319.7	5615338.6	54.7	7.4	Positive Monopole	
RMP MAG 25	706453.9	5612177.2	42.8	3.0	Positive Monopole	
RMP MAG 26	706796.4	5612789.6	40.3	1.9	Dipole	
RMP MAG 27	706969.8	5612059.1	192.6	1550.8	Asymmetric Dipole	
RMP MAG 24	706319.7	5615338.6	54.7	7.4	Positive Monopole	
RMP MAG 25	706453.9	5612177.2	42.8	3.0	Positive Monopole	S16/S17
RMP MAG 28	706984.8	5612861.5	34.8	1.4	Dipole	
RMP MAG 29	707332.4	5613641.9	32.2	3.2	Negative Monopole	
RMP MAG 30	707394.4	5615885.7	42.1	5.9	Dipole	
RMP MAG 31	708239.6	5616077.2	29.5	5.0	Positive Monopole	

RMP MAG 32	708603.5	5613651.3	42.1	9.2	Dipole	
RMP MAG 33	708664.8	5612861.6	22.2	2.8	Positive Monopole	
RMP MAG 34	708790.0	5615160.6	22.6	3.5	Dipole	
RMP MAG 35	708853.4	5613259.0	49.5	2.3	Positive Monopole	
RMP MAG 36	708953.9	5613455.5	41.9	6.0	Dipole	
RMP MAG 37	708966.9	5614101.1	70.8	6.4	Positive Monopole	
RMP MAG 38	709078.6	5613834.7	19.9	2.1	Positive Monopole	
RMP MAG 39	709134.6	5616101.7	5.1	2.6	Positive Monopole	
RMP MAG 40	709216.2	5613721.3	27.2	5.0	Positive Monopole	
RMP MAG 41	709326.2	5613763.9	26.7	1.2	Dipole	
RMP MAG 42	709420.8	5613799.1	18.4	2.5	Positive Monopole	
RMP MAG 43	709526.3	5614505.5	25.0	1.7	Negative Monopole	
RMP MAG 44	709550.1	5615937.0	11.2	6.7	Positive Monopole	
RMP MAG 45	709561.1	5615941.1	21.1	24.3	Negative Monopole	
RMP MAG 46	709618.9	5614267.8	16.6	1.1	Dipole	
RMP MAG 47	709647.8	5613088.7	118.8	239.0	Positive Monopole	S24
RMP MAG 48	709744.7	5613949.0	16.4	1.1	Negative Monopole	

RMP MAG 49	709800.8	5616033.6	26.9	1.6	Dipole	
RMP MAG 50	709805.5	5616358.4	24.5	6.9	Positive Monopole	
RMP MAG 51	709820.4	5614267.1	275.1	660.1	Complex Negative Monopole	S25-S32
RMP MAG 52	709948.1	5616413.7	13.1	2.0	Positive Monopole	
RMP MAG 53	709973.9	5616424.1	10.8	329.1	Dipole	
RMP MAG 54	710048.0	5614040.2	18.3	1.5	Positive Monopole	
RMP MAG 55	710068.7	5616136.1	18.5	4.7	Dipole	
RMP MAG 56	710268.3	5615727.5	39.6	4.7	Positive Monopole	
RMP MAG 57	710421.1	5614021.7	26.0	1.3	Positive Monopole	
RMP MAG 58	710496.1	5614526.8	27.0	5.5	Positive Monopole	
RMP MAG 59	710524.1	5614537.3	23.4	2.3	Negative Monopole	
RMP MAG 60	710685.1	5615888.0	46.5	6.5	Positive Monopole	
RMP MAG 61	710762.5	5614314.9	18.3	1.5	Positive Monopole	
RMP MAG 62	710898.9	5613720.3	22.0	2.3	Positive Monopole	
RMP MAG 63	710974.7	5613749.5	48.1	3.8	Dipole	
RMP MAG 64	711054.3	5614427.2	38.9	15.2	Dipole	
RMP MAG 65	711182.0	5614152.6	30.4	13.2	Asymmetric	

					Dipole	
RMP MAG 66	711220.5	5614168.4	25.7	2.2	Asymmetric Dipole	
RMP MAG 67	711233.3	5614173.8	14.5	1.7	Negative Monopole	
RMP MAG 68	711343.4	5615506.0	42.6	2.4	Positive Monopole	
RMP MAG 69	711420.0	5613919.1	29.1	3.1	Dipole	
RMP MAG 70	711487.2	5614271.8	26.4	1.9	Positive Monopole	
RMP MAG 71	711691.4	5614349.9	28.9	13.6	Positive Monopole	
RMP MAG 72	711707.8	5614356.3	32.9	19.6	Asymmetric Dipole	
RMP MAG 73	711797.0	5614877.1	25.4	4.1	Positive Monopole	
RMP MAG 74	711853.6	5615377.7	48.7	6.5	Negative Monopole	
RMP MAG 75	711856.7	5614735.7	25.1	2.2	Negative Monopole	
RMP MAG 76	711963.3	5614454.4	43.9	9.1	Asymmetric Dipole	
RMP MAG 77	712173.9	5614209.8	30.5	3.3	Dipole	
RMP MAG 78	712635.0	5614711.3	30.5	2.7	Negative Monopole	
RMP MAG 79	712743.8	5614430.6	30.4	11.9	Complex Dipole	
RMP MAG 80	712863.1	5614638.3	32.6	4.3	Dipole	
RMP MAG 81	712964.8	5614677.0	23.3	1.5	Negative	

					Monopole	
RMP MAG 82	704260.8	5614066.0	167.3	11.1	Dipole	Wreck W58306

APPENDIX 3 SIDE SCAN SONAR ANOMALIES

Contact Number	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Description	Mag No.
RMP SSS 1	701796.4	5610810.2	4.7	1.4	0.5	Probable Boulder	
RMP SSS 2	701998.3	5610922.0	0.0	0.0	0.0	Small Boulder	
RMP SSS 3	702325.4	5613406.3	0.0	0.0	0.0	Small Boulder	
RMP SSS 4	702887.9	5612948.4	3.3	3.3	0.8	Probable Boulder	
RMP SSS 5	703979.4	5613593.4	7.4	3.8	0.6	Probable Boulder	
RMP SSS 6	704246.3	5611198.1	0.0	0.0	0.0	Small Boulder	
RMP SSS 7	704419.0	5612275.5	0.0	0.0	0.0	Small Boulder	
RMP SSS 8	704695.9	5611874.2	0.0	0.0	0.0	Small Boulder	
RMP SSS 9	705416.2	5612013.7	36.3	0.0	0.0	Possible area of debris or boulders	
RMP SSS 10	705457.2	5612317.7	2.6	1.6	0.4	Probable Boulder	
RMP SSS 11	705977.3	5611762.5	3.8	1.6	0.4	Probable Boulder	
RMP SSS 12	706190.6	5614433.8	0.0	0.0	0.0	Small Boulder	
RMP SSS 13	706270.7	5612707.5	39.6	8.1	2.6	Admiralty Wreck no: 20173	
RMP SSS 14	706336.8	5611764.7	3.8	1.1	0.5	Probable Boulder	
RMP SSS 15	706586.9	5612741.4	18.7	12.4	0.0	Possible debris or cluster of boulders	
RMP SSS 16	706963.7	5612056.9	18.1	7.1	4.9	Admiralty Wreck no: 20172	
RMP SSS 17	707021.6	5612061.9	3.3	3.4	0.9	Admiralty Wreck no: 20172	
RMP SSS 18	707511.5	5614077.6	4.7	1.1	0.3	Debris	

RMP 19	SSS	707816.9	5615158.3	0.0	0.0	0.0	Small Boulder	RMP 23	MAG
RMP 20	SSS	708759.5	5612843.2	0.0	0.0	0.0	Small Boulder		
RMP 21	SSS	708868.6	5612987.9	3.6	1.9	0.4	Probable Boulder		
RMP 22	SSS	708869.3	5612989.1	6.9	1.4	0.8	Probable Boulder	RMP 27	MAG
RMP 23	SSS	708895.7	5613018.7	7.7	0.0	0.0	Linear Target		
RMP 24	SSS	709649.9	5613108.3	12.9	11.1	0.0	Area of debris, wreck no: 19995	RMP 47	MAG
RMP 25-32	SSS	709798.5	5614247.2	18.1	0.0	0.0	Admiralty Wreck no: 20162	RMP 51	MAG
RMP 33	SSS	710117.1	5616458.1	0.0	0.0	0.0	Small Boulder		
RMP 34	SSS	710750.1	5613295.3	0.0	0.0	0.0	Small Boulder		
RMP 35	SSS	711016.8	5614761.6	0.0	0.0	0.0	Small Boulder		
RMP 36	SSS	711971.9	5614101.1	0.0	0.0	0.0	Small Boulder		
RMP 37	SSS	712806.7	5614763.7	0.0	0.0	0.0	Small Boulder		

APPENDIX 4 UKHO WRECK LISTING FOR THE SUBJECT SITE

Eastings (m)	Northings (m)	Description	Sonar Contact	Magnetic Contact
702088	5611160	'Porthkenny' – Wreck no 19978		
702064	5611777	'Tycho' – Wreck no 19983		
709576	5612585	Unknown – wreck no 19995	S24?	M47?
702242	5614289	Unknown trawler – wreck no 20017		
708674	5614759	'Leaches Romance' – wreck no 20021		

709874	5614250	Unknown – wreck no 20162	S25 – S32	M51
706952	5612063	Unknown – wreck no 20172	S16/S17	M27
706277	5612715	HMS Keryado – wreck no 20173	S13	M23
704337	5614031	Fishermans Fastener – wreck no W58306		M82