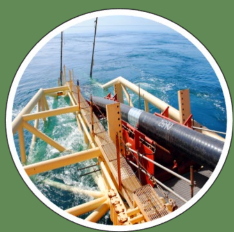
GREENLINK
MARINE ENVIRONMENTAL IMPACT ASSESSMENT REPORT- IRELAND

APPENDIX H - L

P1975_R4500_RevF2
July 2019

Greenlink Interconnector
- connecting the power markets
in Ireland and Great Britain



Greenlink
INTERCONNECTOR

GREENLINK
MARINE ENVIRONMENTAL IMPACT ASSESSMENT REPORT- IRELAND

APPENDIX H

Environmental Survey Report

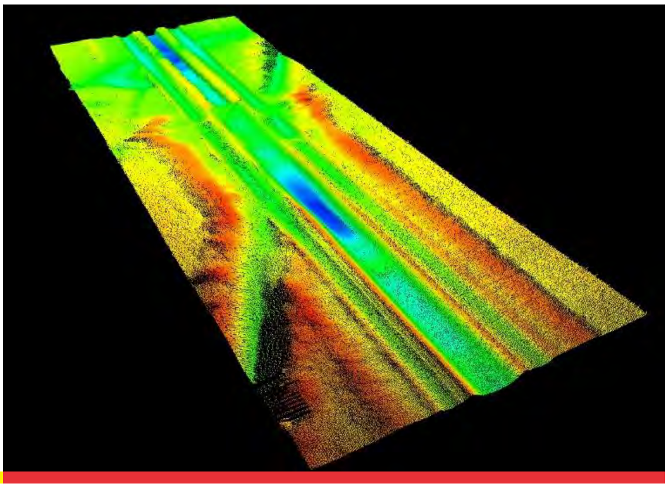
P1975_R4500_RevF1
July 2019

Greenlink Interconnector
- connecting the power markets
in Ireland and Great Britain

Greenlink
INTERCONNECTOR

ENVIRONMENTAL SURVEY REPORT

102953-GRL-MMT-SUR-REP-ENVIRORE
REVISION A | ISSUE FOR USE
JUNE 2019



Greenlink
INTERCONNECTOR

GREENLINK INTERCONNECTOR
BENTHIC SURVEY

IRISH SEA
SEPTEMBER-MARCH 2019

MMT SWEDEN AB | SVEN KÄLLFELTS GATA 11 | SE-426 71 VÄSTRA FRÖLUNDA, SWEDEN
PHONE: +46 (0)31 762 03 00 | **EMAIL:** INFO@MMT.SE **WEBSITE:** MMT.SE

MMT

EXECUTIVE SUMMARY

MMT was contracted by Greenlink Interconnector to conduct a geophysical, geotechnical and benthic survey for a proposed high voltage direct current submarine power interconnector between Pembrokeshire, Wales, UK and County Wexford, Ireland. This report presents the results of the environmental survey, encompassing habitat classifications, protected habitats and species as well as chemical and particle size analyses. The results are divided by country into two sections: UK and Ireland. Results are presented for the Final Route, as well as surveyed route options A and E wherever they deviate from the Final Route. The survey corridor was 500 m wide and divided into six survey blocks covering nearshore and offshore areas.

Environmental data acquisition comprised of sediment sampling, photography, and video recording to gather data on existing habitats and species present on the seabed; the survey data was used to ground truth the predictive habitat mapping. The survey was performed using Drop Down Video system a Day Grab, and a Hamon Grab for grab sampling, all deployed from the MMT survey vessels M/V Franklin as well as the M/V Olympic Challenger.

A total of 38 photo transects, each between 130 m and 500 m long, and 38 grab sample locations were selected for sampling. At each of the 38 grab sample locations, three samples were collected. Two of the samples at each grab sample location were collected for faunal analysis and the third sample for chemical and particle size analysis.

Geophysical data was acquired to determine water depths, surficial geology, seabed features, shallow geology, and object detection. Instruments used during the geophysical survey were multibeam echo sounder, side scan sonar, sub-bottom profiler, and magnetometer. The geophysical results combined with the environmental data was used as the basis for the EUNIS habitat classification, assessments of potential areas and species of conservation and charts.

The benthic sampling survey started on the 30th of September 2018 and was completed on the 1st of January 2019.

A total of 33 habitats were identified within the survey corridor, 12 of which were observed in the Irish section and 25 observed in the UK section. Three potential Annex I habitats, 1160 Large shallow inlets and bays, 1110 Sandbanks which are slightly covered by sea water all the time and 1170 Reefs, with its three subtypes “Bedrock Reef”, “Stony Reef”, and “Biogenic Reef” were identified within the corridor. Bedrock Reefs were mainly found near the landfalls, and on route alternative A.

REVISION HISTORY

REVISION	DATE	STATUS	CHECK	APPROVAL	CLIENT APPROVAL
A	2019-06-24	Issue for Use	ID	MG	
02	2019-03-22	Issue for Client Review	MB, ID	MG	
01	2019-03-21	Issue for Internal Review	AJ, ID	ID	

REVISION LOG

DATE	SECTION	CHANGE
2019-06-10	All Sections	Amended as per client comments in document "102953-GRL-MMT-SUR-REP-ENVIRORE-02_AF&KAG"
2019-06-10	All Sections	The final route was referenced as primary and final route within this report. This was amended to final route throughout the report and images.

DOCUMENT CONTROL

RESPONSIBILITY	POSITION	NAME
Content	Marine Biologist	Malin Tivefälth
Content	Marine Biologist	Felicia Ulltin
Content	Senior Marine Biologist	Svante Martinsson
Content	Marine Biologist	Rikard Karlsson
Content, Check	Environmental Supervisor	Andrea Johansson
Content, Check	Environmental Supervisor	Iris Duranovic
Check, Approval	Project Report Coordinator	Maria Blom
Approval	Project Manager	Martin Godfrey

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND DEFINITIONS

APEM	APEM Limited
BAC	Background Assessment Concentration
BAP	Biodiversity Action Plan
BC	Background Concentration
CCME	Canadian Council of Ministers of the Environment
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
DDV	Drop Down Video
DPR	Daily Progress Report
EAC	Environmental Assessment Criteria
EC	European Commission
EEZ	Exclusive Economic Zone
EQS	Environmental Quality Standards
ERL	Effect range-low
EUNIS	European Union Nature Identification System
GIS	Geographic Information System
HD	High definition
HVDC	High voltage direct current
ICP-MS	Inductively Coupled Plasma-mass Spectrometry
ISQG	Interim Sediment Quality Guidelines
JNCC	Joint Nature Conservation Committee
JUV	Juvenile
KP	Kilometre Post
LAT	Lowest Astronomical Tide
LED	Light-Emitting Diode
LOI	Loss On Ignition
MBES	Multibeam Echo Sounder
MDS	Multi-Dimensional Scaling
MMT	MMT Sweden AB
MPA	Marine Protected Areas
MSL	Mean Sea Level
NMBAQC	National Marine Biological Analytical Quality Control Scheme
NRW	Natural Resources Wales
ODMH	Ordnance Datum Malin Head
ODN	Ordnance Datum Newlyn
OSGM15	Ordnance Survey Geoid Model 15
OSPAR	OSPAR Oslo and Paris Conventions for the protection of the East Atlantic marine environment of the North-East Atlantic
PAH	Polycyclic Aromatic Hydrocarbon
PCA	Principal Component Analysis
PEL	Probable Effects Levels
PPS	Pulse Per Second
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSA	Particle Size Analysis
PSD	Particle Size Distribution
ROG	Recommended Operational Guidelines
RPL	Route Position List
SAC	Special Areas of Conservation
SBP	Sub-Bottom Profiler
SIMPROF	Similarity Profile Analysis
SPA	Special Protected Area
SSS	Side Scan Sonar
TOC	Total Organic Content
UK	United Kingdom
UKAS	United Kingdom Accreditation Service
USBL	Ultra-Short Base Line
UTC	Coordinated Universal Time
UXO	Unexploded Ordnance
VC	Vibrocore
VORF	Vertical Offshore Reference Frame

1 | INTRODUCTION

1.1 | PROJECT INFORMATION

Greenlink Interconnector Limited' proposes to develop a high voltage direct current (HVDC) submarine power interconnector, which will allow transfer of power between the high voltage grid systems of the United Kingdom (UK) and the Republic of Ireland. Greenlink will connect to the United Kingdom (UK) National Grid system at Pembroke substation in Pembrokeshire, United Kingdom and to the Irish network at Great Island substation in County Wexford, Ireland. Figure 1 presents an overview of the survey area and Final Route (Greenlink_WGS84_UTM30N_09112018_RPL_Rev0).

Project details are presented in Table 1.

Table 1 Project details.

CLIENT:	Greenlink Interconnector Limited
PROJECT:	Greenlink Interconnector
MMT SWEDEN AB (MMT) PROJECT NUMBER:	102953
SURVEY TYPE:	Geophysical, Geotechnical, Environmental, Topographic, UXO, ROV infrastructure crossing, land seismic
AREA:	Irish Sea
SURVEY PERIOD:	September 2018 – March 2019
SURVEY VESSELS:	M/V Edda Fonn, M/V Franklin, M/V Seabeam, M/V Olympic Challenger, M/V Sandpiper, Onshore Topography, Onshore Refraction Survey
MMT PROJECT MANAGER:	Martin Godfrey
CLIENT PROJECT MANAGER:	Stephane Theurich

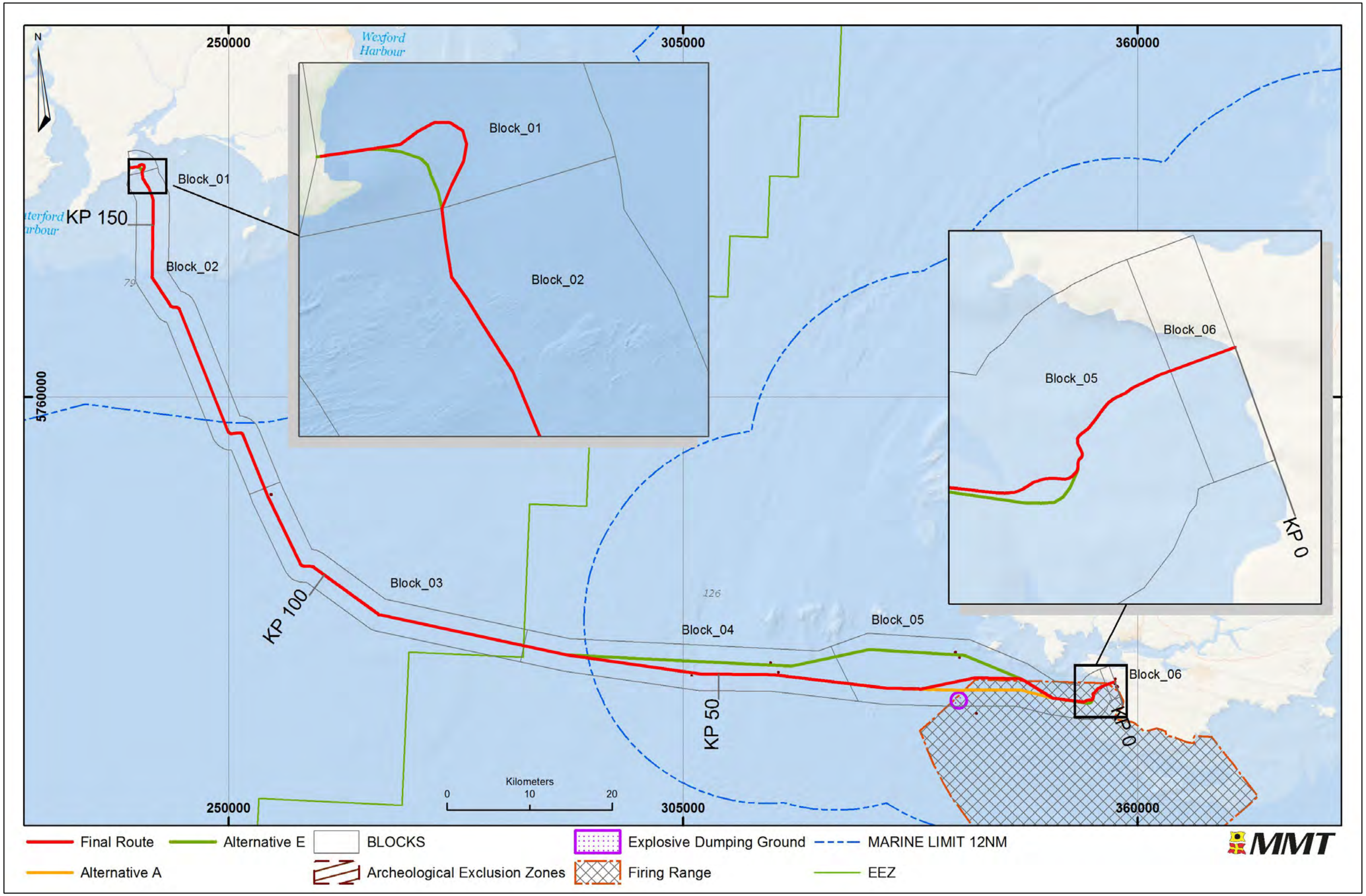


Figure 1 Overview of survey area.

1.2| SURVEY INFORMATION

The objective of the Greenlink Marine survey was to acquire all appropriate data for the conformation of a preferred route for the high voltage direct current (HVDC) cable, undertaking detailed mapping of shallow geology, seabed features and baseline environmental mapping along the entire route corridor and subsequently provide all geotechnical design data for the whole offshore and nearshore route with conformation of detail seabed character along the final offshore design route. Additionally, an unexploded ordnance (UXO) survey was performed to ensure route viability within the Castlemartin Firing Range area.

The Greenlink marine survey scope of work comprised:

- Onshore/intertidal topographic survey
- Geophysical/hydrographic nearshore and offshore data acquisition
- Geotechnical investigations along the proposed route with vibrocoring (VC) and cone penetration testing (CPT)
- Environmental sampling and imagery
- Infrastructure crossing survey with remotely operated vehicle (ROV)
- UXO survey
- Geotechnical boreholes to inform horizontal directional drilling
- Onshore reflection and refraction survey

1.3| SURVEY OBJECTIVES

The aim of the environmental part of the survey was to provide an environmental benthic survey to determine the presence of reef habitats prior to the establishment of a route. Seabed sampling was to be undertaken for physico-chemical analysis (sediment grain size and a suite of chemical determinants) and biological analysis (benthic infauna), in order to determine the occurrence and distribution of species/habitats within the survey corridor.

1.4| PURPOSE OF DOCUMENT

The purpose of the report is to present the environmental results from the Greenlink Marine Survey. This report together with Geographic Information System (GIS) database presents the results from the environmental survey.

Areas of special interest along the route corridor and within sites are presented in this report as well as in habitat charts presented in a GIS database. All existing MMT data from the survey corridor is correlated to the environmental survey data to strengthen the accuracy of the interpretations.

Separate reports are issued for the geophysical scope, geotechnical scope, UXO scope, as well as infrastructure crossing scope. A full list of reports is given in Table 2. It is recommended to read this report in conjunction with the Environmental Field Report, Geophysical report and the Operations Report for a wider understanding of the conditions along the cable routes.

1.5| REFERENCE DOCUMENTS

The reference documents for the project are presented in Table 2.

Table 2 Reference documents.

DOCUMENT NUMBER	TITLE	AUTHOR
102953-GRL-MMT-QAC-PRO-PMQAPLAN	Project Manual and Quality Assurance Plan	MMT
102953-GRL-MMT-QAC-PRO-ENVIRO	Environmental Sampling and Reporting Specification	MMT
102953-GRL-MMT-HSE-PRO-HIRA	Hazard Identification & Risk Assessment: Geophysical	MMT
102953-GRL-MMT-HSE-PRO-HSEFRANK	HSE Plan Franklin	MMT
102953-GRL-MMT-HSE-PRO-HSESEAON	HSE Plan Seabeam and Onshore	MMT
102953-GRL-MMT-QAC-PRO-CADGIS	CAD and GIS Specification	MMT
102953-GRL-MMT-SCH-PRO-SCHEDULE	Time schedule	MMT
102953-GRL-MMT-MAC-REP-FRANKLIN	Mobilisation and Calibration Report - Franklin	MMT
102953-GRL-MMT-MAC-REP-SEABEAM	Mobilisation and Calibration Report – Seabeam	MMT
102953-GRL-MMT-SUR-REP-OPERATRE	Operations Report	MMT
102953-GRL-MMT-SUR-REP-GEOPHYRE	Geophysical Report	MMT
102953-GRL-MMT-SUR-REP-UXOREP	UXO Report	MMT
102953-GRL-MMT-SUR-REP-GEOTECRE	Geotechnical Report	MMT
102953-GRL-MMT-SUR-REP-CABLECRE	Cable Crossing Report	MMT
102953-GRL-MMT-SUR-REP-ENVIRORE	**Environmental Report**	**MMT**
102953-GRL-MMT-SUR-REP-ENVFROFF	Environmental Field Report	MMT
102953-GRL-MMT-SUR-REP-INTEGRRE	Integrated Report	MMT
P1975_ExhibitB_ScopeofWork	Scope of work	GRL
P1975_ExhibitC_TechnicalSpecifications	Technical Specifications	GRL
P1975_ExhibitG_Greenlink UXO DBS	UXO Desktop Study	GRL
P1975 Greenlink Clarification	Clarifications	GRL
P1975 Greenlink Addendum_Rev0	Clarifications	GRL

2| SURVEY PARAMETERS

2.1| GEODETIC DATUM AND GRID COORDINATE SYSTEM

The geodetic and projection reference parameters used during the survey are presented in Table 3 and Table 4.

Table 3 Geodetic Parameters.

GEODETIC PARAMETERS	
Datum	World Geodetic System 1984 (6326)
Ellipsoid	World Geodetic System 1984 (7030)
Spheroid	WGS84
Semi Major Axis	6378137.000 m
Semi Minor Axis	6356752.31414035610 m
Inverse Flattening (1/f)	298.25722210100002
Unit	International metre

Table 4 Projection parameters.

PROJECTION PARAMETERS	
Projection	UTM Zone 30N (EPSG 16030)
Longitude at Central Meridian	003°00’00.0” W
Latitude of Origin	00°00’00.0” N
False Northing	0 m
Scale Factor (Central Meridian)	0.9996
Units	Metres
Time Datum	Coordinated universal time (UTC)

2.2| VERTICAL DATUM

The vertical reference parameters used during the survey are presented in Table 5.

Table 5 Vertical reference parameters.

VERTICAL REFERENCE PARAMETERS	
Vertical reference (offshore)	DTU10 Lowest Astronomical Tide (LAT)
Height model (offshore)	Vertical Offshore Reference Frame (VORF)
Height model (nearshore)	Ordnance Survey Geoid Model 15 (OSGM15)
Vertical reference (nearshore UK)	Ordnance Datum Newlyn (ODN) Mean Sea Level (MSL)
Vertical reference (nearshore IRL)	Ordnance Datum Malin Head (ODMH) Mean Sea Level (MSL)

2.3| TIME DATUM

Coordinated universal time (UTC) is used on all survey systems on board the vessel. The synchronisation of the vessel's onboard system is governed by the pulse per second (PPS) issued by the primary positioning system. All displays, overlays and logbooks are annotated in UTC as well as the Daily Progress Report (DPR) that is referred to UTC.

2.4| KP PROTOCOL

Four routes were considered during the preparation and survey phase of the project, see Figure 2, namely Route A which was the base route starting with KP 0 at the landfall in Freshwater West, UK and with an increasing KP towards the landfall in Baginbun, Ireland.

In addition to Route A, Alternative E also starts at the landfall in Freshwater West, UK and increasing in KP towards the landfall in Baginbun, Ireland. The difference between Route A and Alternative E is visible in Figure 2 where Alternative E runs north of Route A.

Option C deviates from Route A (as well as Alternative E) where it turns south to an alternative landing point in Boyce’s Bay, Ireland. Option C was never surveyed and no results are therefore present in this report.

Option D deviates from Route A (as well as Alternative E) and runs further north of Route A before it joins Route A towards the landing point at Baginbun, Ireland.

The Final Route, Greenlink_WGS84_UTM30N_09112018_RPL_Rev0, is presented in Figure 3 showing the Final Route starting at Freshwater West, UK with KP 0 and increasing towards the landfall in Baginbun, Ireland. The Final Route, is a mixture of Route A, Alternative E and Option D as well as re-routing conducted during survey.

The parts surveyed which does not coincide with the Final Route are the following:

Table 6 Route deviations from Final Route.

DEVIATION	START/END ROUTE	KP	COMMENTS
Route A deviation 1	Start KP (Final Route)	3.653057	
	Start KP (Route A)	3.646765	
	End KP (Final Route)	25.38879	The Final Route and the Route A runs perpendicular (max 0.12 m distance between the two routes) to each other from this point until KP 29.622 (Final Route KP). For reporting purposes this deviation is not presented after KP 29.622
	End KP (Route A)	24.9087	
Alternative E deviation 1	Start KP (Final Route)	13.17312	
	Start KP (Alternative E)	13.37349	
	End KP (Final Route)	68.60038	
	End KP (Alternative E)	69.22904	
Route A deviation 2	Start KP (Final Route)	156.667	

DEVIATION	START/END ROUTE	KP	COMMENTS
	Start KP (Route A)	156.187	
	End KP (Final Route)	158.7594	
	End KP (Route A)	157.4134	

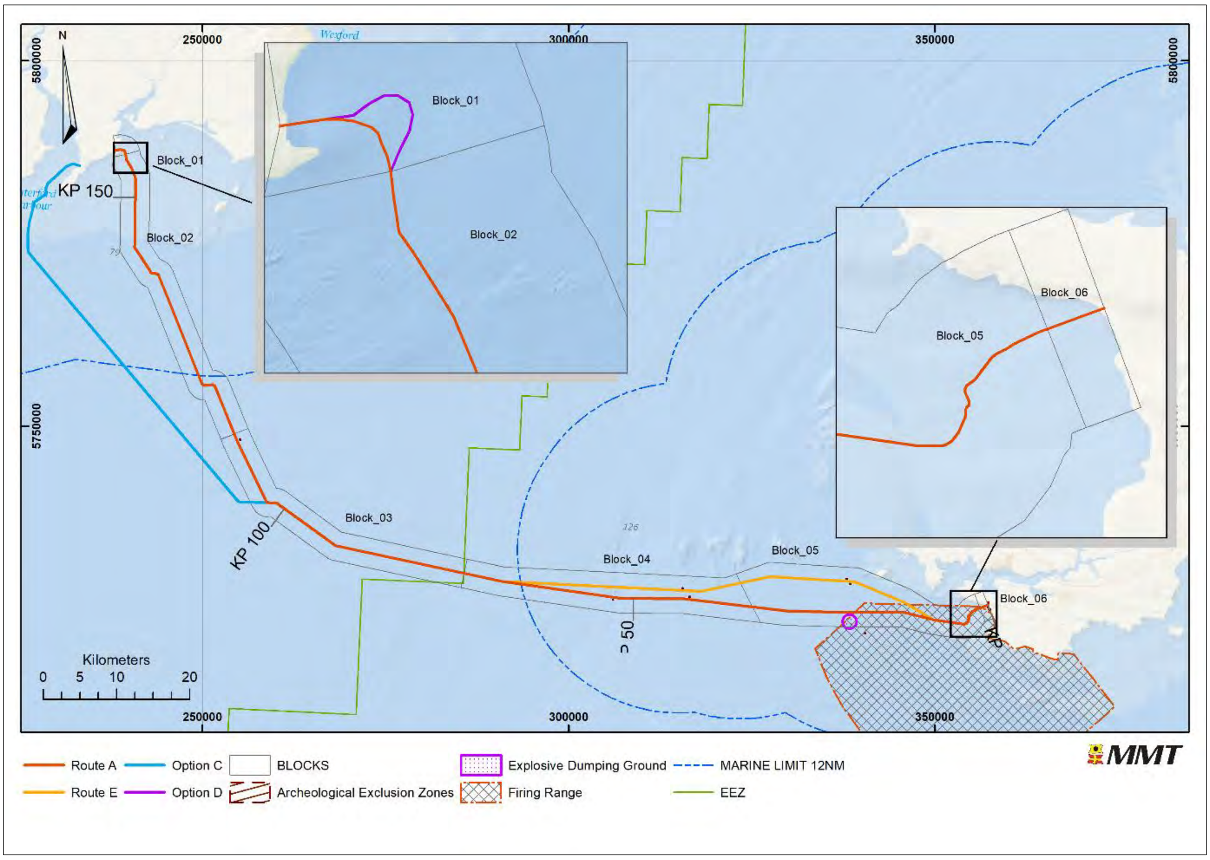


Figure 2 Initial route options.

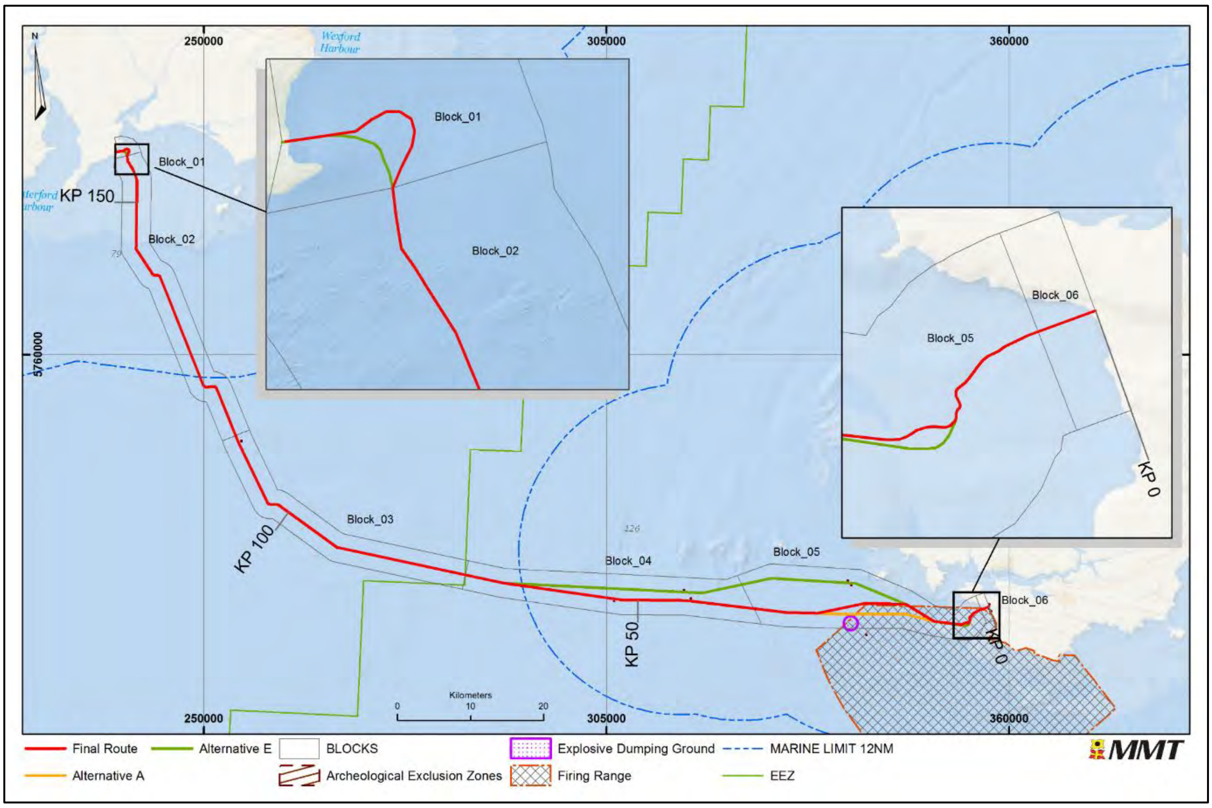


Figure 3 Final route (Greenlink_WGS84_UTM30N_09112018_RPL_Rev0) and reported route alternatives.

3| METHODOLOGY

The benthic survey was performed using grab samplers and a video and still camera system. Sample sites were selected using the information provided from the geophysical survey data and in accordance with the requirements from the Client.

A biologist on board during the geophysical survey planned the benthic survey based on the geophysical data and preliminary geological interpretations, ensuring that the different habitats interpreted from the SSS and MBES were ground truthed.

Sample sites were documented by video and still photography and by grab sampling. Where grab sampling was not possible due to hard seabed or coarse substrates, only video/still photo was used for sampling.

The method used correlates the geophysical information from MBES and SSS with information on substrate through Particle Size Analysis (PSA) and quantitative taxonomic analysis of the infauna. These survey and analytical methods provides a comprehensive view of present conditions.

3.1| FIELD METHODS

3.1.1| SURVEY DESIGN

The final number and location of environmental sample sites were decided on board the vessel based on depth variation, sediment, and habitat changes, as delineated during the acoustic survey, to provide benthic data of all habitats interpreted across the survey route. Grab sampling was planned at 38 sites, distributed among Ireland and Wales. Stills were acquired to connect the epifaunal and infaunal assemblage. In addition, 38 transects were also planned.

An offshore Reconnaissance survey was conducted in order to determine the presence of reef habitats prior to the establishment of a route (Table 7). The Reconnaissance survey covered the full 500 m corridor with MBES, SSS, SBP and DDV. Photo and video transects were planned in areas where indications of reef structures were present in the geophysical data, i.e. areas of bedrock or boulders and areas with a divergent seabed structure. The collected data from the reconnaissance survey was sent immediately ashore, after acquisition, for review by Natural Resource Wales (NRW) that provided a stand-alone assessment of the reefs along the different route alternatives and options.

Table 7 Reconnaissance survey lengths.

RECONNAISSANCE SURVEY SECTIONS	LENGTH (km)
Route A rev 1	24.84
Alternative E rev 0	27.62

Transects were required throughout the corridor within the reconnaissance survey areas. The location of the transects were selected based on the preliminary geophysical interpretations. The SeaSpyder DDV was used for transects over potential sensitive habitats/reef formations.

Two additional survey lines were added perpendicular to Route A and Alternative E in order to ascertain a broader knowledge about the surface conditions in-between the two route alternatives. The final survey route was routed between the original Route A and Alternative E. This resulted in an additional benthic Reconnaissance survey.

3.1.2| PHOTO AND VIDEO SAMPLING

A SeaSpyder system from STR was used for image acquisition at each grab sampling site prior to grab sampling and along photo transects.

This system used a Canon EOS 100D Digital Still Camera (18 megapixels) with dedicated strobe and an integrated video system capable of performing full HD recordings. Lighting for video was provided by a set of four LED lamps, each with adjustable intensity. Scaling was provided by a set of four laser units which produced a 20 x 20 cm pattern of dots on the seabed.

Prior to sampling, the stills of the seabed, acquired at each grab sample site, were reviewed by experienced marine biologists on board to confirm the presence/absence of any potentially sensitive habitats or features of conservation importance.

The stills were analysed to identify species and density. The different European Union Nature Identification System (EUNIS) habitat criteria were compared to the results of the stills analysis. Particular attention was paid to habitats above the elevated seabed level, together with their spatial extent, percentage biogenic cover and patchiness, as these are key criteria for evaluating areas of conservation importance and reef structures (Irving, 2009; Gubbay, 2007).

A log was maintained of the stills acquired, along each transect, for the habitat assessment and at each grab sample site and photo transect. The field notes are detailed in Appendix B| and Appendix C|. As a minimum, this included the drop number, start and end position, duration, and a summary of the sediment type and main species observed. A list of the stills, including their position, along with a clear indication of those taken at random for future assessment, and those taken to show particular features of interest, was also maintained.

3.1.3| FAUNAL GRAB SAMPLING AND SAMPLE PRESERVATION

Three grab samples were retrieved at each benthic grab sampling site. One grab sample was used for particle size and chemical analysis and two for infaunal analysis.

Two types of grab samplers (Day grab, and Hamon grab) were available during the benthic sampling. The Day grab was used for finer sediments and Hamon grab for coarser sediments.

The planned grab sample site positions were used as targets to guide the vessel as close as possible to each proposed sample site. The actual position of each sample was recorded each time the grab landed on the seabed using an attached ultra-short base line (USBL). This was conducted by taking a manual fix in QINSy.

A minimum obtained sediment depth of five cm (seven cm in fine sediments) was considered to be an acceptable sample. The accepted minimum sample volume for the Hamon grab was seven litres. If the first attempt was not acceptable, up to three additional attempts were made. The type of grab sampler was also changed to the other to maximise the probability of sampling success. If none of the four samples was acceptable, the attempt with the largest retrieved sample volume was saved with a note highlighting the volume in the field log. Samples that were not accepted were not included in any statistical analyses.

A field log of sample positions including time, sediment type, and water depth was kept for later reference. All samples were photo documented in-situ. Approved samples were carefully sieved using seawater in a 5 mm mesh sieve over a 1 mm mesh sieve using gentle hose pressure. Faunal samples were preserved on-board in 80 % ethanol directly after the sieving was completed. The 5 mm and 1 mm fractions were kept in separate jars, that were labelled with a unique label containing grab sample site ID and replicate number. For further information regarding sample volume and number of attempts, see Appendix B|.

3.1.4| PARTICLE SIZE ANALYSIS AND CHEMICAL SAMPLING

Sediment was sampled for PSA and chemical analyses at each benthic grab sample site. The PSA and chemical samples were sampled from a separate sample than the infaunal samples, normally from one of the two samples retrieved from the second drop with the grab sampler.

Samples for metals, polycyclic aromatic hydrocarbons (PAH) and organics (Loss of Ignition (LOI) and total organic content (TOC)) were sampled from an undisturbed surface. The sediments were collected with a plastic spoon for metals, and metal spoon for hydrocarbons and organics. This was to ensure minimal contamination risk. The grab sampler was cleaned between samples and sample sites.

The sediment for PSA was sampled by taking a representative sample (one litre) from the sample bucket using a big plastic spoon.

For the chemical analysis of hydrocarbon, organics and nutrients samples, 125 ml tin jars were used. One litre plastic containers were used for the metal samples. The difference in containers ensured that there was no outside contamination to the samples.

The sample containers were labelled with a unique sample site ID. All samples were stored frozen or refrigerated according to the analysing laboratory recommendations, before and during shipment for analysis.

Replicate samples for all the analyses were collected and stored as back-up samples (not analysed).

3.2| LABORATORY METHODS

3.2.1| PARTICLE SIZE ANALYSIS

The PSA was conducted by a UK based company “In Situ Site Investigation”. Sediment from each sample site was analysed to detail the different particle fraction components. This was achieved using a combination of sieving and sedimentation. Up to one litres of sediment from each sample location was analysed to detail the different particle fraction components.

In line with the (British Standard, 2010), wet sieving was applied in essentially cohesion-less sediments while dry sieving was only used for sediments that did not contain significant amounts of silt and clay, i.e. almost entirely granular sand and/or gravel.

To analyse the finer fractions such as silt and clay (<0.063 mm), the sedimentation by the hydrometer method was applied. This analysis is carried out when a certain percentage of material passing through the 0.063 mm wet/dry sieve is reached. This is usually 10 or 15 % due to the fact that, at this level, the ratio of silt and/or clay can have a substantial effect on the physical or engineering properties of a soil.

The particle sizes are grouped into the five large textural groups for descriptions purposes. The samples are described according to Table 8.

Table 8 British standard Methods of test for soils for civil engineering purposes (2010) PSA intervals.

CLASSIFICATION	PARTICLE SIZE INTERVALS (DIAMETER mm)	GROUPED CLASSIFICATION
Boulder	>75	Boulders/cobbles
Cobble	75-63	
Coarse Gravel	63-20	Gravel
Medium Gravel	20-6.3	

CLASSIFICATION	PARTICLE SIZE INTERVALS (DIAMETER mm)	GROUPED CLASSIFICATION
Fine Gravel	6.3-2	
Coarse Sand	2-0.6	Sand
Medium Sand	0.6-0.2	
Fine Sand	0.2-0.063	
Coarse Silt	0.063-0.02	Silt
Medium Silt	0.02-0.0063	
Fine Silt	0.0063-0.002	
Clay	<0.002	Clay

3.2.2| CHEMICAL ANALYSIS

The different compounds that were analysed along with detection limits are stated in Table 9, Table 10 and Table 11. The analyses included concentration analysis of metals, hydrocarbons (PAH) and organics (LOI and TOC). Detailed chemical results are presented in Appendix G|, with a brief summary presented below.

PAHs were analysed using Gas chromatography–mass spectrometry (GC-MS).

Table 9 Hydrocarbon analysis minimum limits of detection.

HYDROCARBONS	DETECTION LIMITS (µg Kg^{-1})	METHOD OF ANALYSIS
PAHs: 2 to 6 ring aromatics by GC-MS*	1	Documented in-house method using DTI specification by GC-MS, PAHSED

* indicate United Kingdom Accreditation Service (UKAS) accreditation (16 USEPA + Dibenzthiophene & Benzo(e)pyrene only)

All metals were analysed using the following method: Hydrofluoric acid and boric acid extraction followed by Inductively Coupled Plasma-mass Spectrometry (ICP-MS).

Table 10 Metal analysis minimum limits of detection.

METALS	DETECTION LIMITS (µg.g^{-1})	Method of analysis
Hg	0.01	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Cd	0.1	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Cr, Ni, Sn*	0.5	Hydrofluoric acid and boric acid extraction followed by ICP-MS
As*	1	Hydrofluoric acid and boric acid extraction followed by ICP-MS
Cu*, Pb*	2	Hydrofluoric acid and boric acid extraction followed by ICP-MS

* indicate United Kingdom Accreditation Service (UKAS) accreditation.

LOI was analysed by heating a ground sample at 450°C for 4 hours and the lost mass was calculated.

TOC was analysed by adding sulphurous acid to an air-dried ground sample. The sample was then dried at 100°C and analysed using Eltra induction furnace fitted with an NDRI cell.

Table 11 Organics analysis and minimum limits of detection.

ORGANICS	DETECTION LIMITS	METHOD OF ANALYSIS
LOI	0.2 %	Documented method using furnace combustion, LOI%(MM)
TOC	0.02 %	Documented method with carbonate removal and sulphurous acid/combustion at 800°C/NDIR, WSLM59

3.2.3| BIOLOGICAL ANALYSIS

The infaunal analysis was conducted by the UK based company APEM. Analysis was conducted in accordance with NMBAQC scheme (Worsfold & Hall, 2010) and at least 10 % of the samples were randomly quality controlled.

The infaunal samples were sorted from sediment residue, and the fauna was identified to the most detailed level possible, mainly species, counted and weighted. When the species could not be identified, the specimen was grouped into the nearest identifiable taxon of a higher rank, i.e. genus, or family, or order etc. If the species remained unknown but clearly separated from any other found specimen within the same genus, it was assigned a “Type” denomination, i.e. Type A or Type B. Juveniles were marked with the qualifier “juvenile”, and later excluded from further statistical analyses. For a detailed list of grab fauna identification results, see Appendix D|.

3.3| DATA ANALYSIS

3.3.1| VISUAL DATA ANALYSES

The stills were analysed to identify species and species densities, including seabed substrate. The video recordings were used to aid in the assessment of features and extent of habitats. Particular attention was paid to the elevation of habitats above ambient seabed level, together with their spatial extent, percentage biogenic cover and patchiness, as these are key criteria for evaluating areas of conservation importance and reef structures (Gubbay, 2007) (Irving, 2009).

Quantitative methods were used for the identification of biota in grab samples and still photographs, with all the data presented as individuals per square metre and percentage cover of colonial species. Stills were analysed in AutoCAD Map 3D 2016, where visual epibenthic fauna was counted and results summarised in a log, containing scientific name, position, date, time, and stills ID.

3.3.2| PARTICLE SIZE DISTRIBUTION

Sediment particle size distribution statistics for each sample were calculated from the raw data by the Insitu laboratory. The distribution curves of sediment composition along with uniformity coefficient and Coefficient of Curvature is provided in Appendix F|.

3.3.3| CHEMICAL ANALYSIS

Environmental Quality Standards (EQS) for metals and hydrocarbons in sediments are not yet developed for UK waters.

Assessment criteria developed by the Canadian Council of Ministers of the Environment (CCME) together with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) guideline action levels for disposal of dredged material have been considered common practice to use in the UK.

The OSPAR Environmental Assessment Criteria (EAC) have also been used as guidelines for metal and PAH concentrations, when applicable, within this report.

The Canadian sediment quality guidelines include two values as assessment criteria, the Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL). The ISQG are threshold levels which are set to protect all aquatic life during an indefinite period of exposure, and for values above PEL adverse effects are expected to occur frequently (Environment, 1995) (Environment, 2001). For concentrations between the ISQG and PEL adverse effects occur occasionally.

The CEFAS Action Levels are used as a part of assessing the contamination status in dredged material, where material below Action Level 1 (AL1) generally indicates that contaminant levels are of no concern, while contaminant levels above Action Level 2 (AL2) generally are considered unsuitable for disposal in the sea (MMO, 2015).

The OSPAR EACs are under development and OSPAR uses “Effect range-low” (ERL) values for sediment assessment of metals and PAHs, where EACs are not available. The ERL value indicates a concentration below which adverse effects on organisms are rarely observed (OSPAR, 2011). Background Concentration (BC) is the concentration of a contaminant found at a pristine site and considered not to be affected by anthropogenic sources. The Background Assessment Concentration (BAC) is a value for testing whether the concentrations [sediments; water; biota] at a site are at or close to background concentrations (OSPAR, 2011).

3.3.4| MULTIVARIATE STATISTICAL ANALYSES

Multivariate analysis was undertaken using the Plymouth Routines in Multivariate Ecological Research (PRIMER) v7.0 statistical package (Clarke K. &., 2015). The statistical analyses were based on macrofaunal data derived from the taxonomic analyses of two replicates from each sample site. Abundances were expressed as a number of individuals per 0.1 m^2.

The macrofaunal organisms were separated into non-colonial and sessile colonial fauna. Colonial fauna was not quantified in the laboratory analysis, and was treated separately in the statistical analyses. All colonial fauna was also considered being epifauna. Juvenile (JUV) taxa, eggs and fragments of an animal were excluded from the dataset. Foraminifera’s were excluded from the datasets. The faunal composition was linked to physical variables such as depth and sediment composition.

Square root transformation was applied to the non-colonial enumerated fauna before calculating the Bray-Curtis similarity measures. This transformation was made to prevent abundant species from influencing the Bray Curtis similarity index measures, excessively and also to take the rarer species into account (Clarke & Warwick, 2001).

The infaunal laboratory results were compared for faunal composition within and between sampling sites. Site related differences in community structure were examined in a clustering analysis using Euclidean distance and the Bray-Curtis similarity coefficient. This method is common when measuring ecological distance in biological sample data.

Multi-Dimensional Scaling (MDS) analysis was undertaken in conjunction with the cluster analysis. The MDS analysis is based on the same similarity matrix as that of the cluster analysis, and produces a multidimensional ordination of samples. The number of restarts was set to 100 with a minimum stress of 0.1. The MDS plot visualises the relative (dis)similarities between samples; the closer they are the more similar the species composition between the samples. The degree to which these relations can be satisfactorily represented is expressed as the stress coefficient statistic, low values (<0.1) indicate a good ordination with low probabilities of misleading interpretation. Generally, the higher the stress, the greater the likelihood of non-optimal solutions (Clarke & Warwick, 2001).

A Similarity profiling algorithm (SIMPROF) test was run in conjunction with the cluster analysis, which was used to identify significantly different natural occurring groups among grab samples. The results are presented in the cluster dendrogram as black lines indicating significant statistical differences.

Red lines represent samples that are not statistically different. The SIMPROF is based on taxa, and the abundance of each taxon in each sample, thus different SIMPROF groups may host similar fauna which differ in abundance.

PSA data was analysed in PRIMER, and normalised before included in any statistical analysis. Data for the percentage composition was analysed in a cluster analysis using the Euclidean distance. A Principal Component Analysis (PCA) was undertaken on the sediment data set in order to identify spatial patterns and relationships between variables.

3.4| HABITAT CLASSIFICATION

All data obtained from the geophysical, geotechnical and environmental survey are combined and correlated. The data are compared to existing background information, in order to ground-truth the survey results and to strengthen the accuracy of the interpretations.

Habitats were classified to the lowest hierarchic level possible and based on interpretations that combine biotope descriptions of species abundance, diversity, depth and seabed features from grab samples, video and photos acquired at each sample site.

The classification of the communities of the different habitat types is based on physical characteristics such as benthic geology, wave exposure, tidal currents, temperature and salinity together with key species present in the area.

The EUNIS classification (European Commission, 2007) is divided into six hierarchic levels (Figure 4). At Level 1, the marine habitats are divided into coastal and terrestrial habitats. At Level 2, the biological zone and presence/absence of rock is a classification criterion, and at Level 3, the softer substrata are divided into different sediment types. Hence, these three levels of classification are based on physical characters. Level 4 gives references to specific taxa, for rocky substrates the major epifauna is used, and for softer substrates the classification relies on both zonation and physical attributes. Further, at Level 5, the classification is based on both the physical and biological characters of the habitats. Classes are defined with both infauna and epifauna on different substrates. At the highest level, 6, the different characterising taxa are associated with differing environmental characteristics of the habitat.

Level 1	(A) Marine Habitats
Level 2	(A5) Sublittoral sediment
Level 3	(A5.5) Sublittoral macrophyte-dominated sediment
Level 4	(A5.53) Sublittoral seagrass beds
Level 5	(A5.533) Zostera beds in full salinity infralittoral sediments
Level 6	(A5.5331) *Zostera marina / angustifolia* beds on lower shore or infralittoral clean or muddy sand

Figure 4 Example of EUNIS Hierarchy.

3.5| PROTECTED HABITATS AND SPECIES ASSESSMENTS

For assessment and classification of potential areas and/or species of conservation importance, the following legislations and guidelines have been consulted.

The European Commission (EC) Habitat Directive specifies the European nature conservation policy. Species and habitats of special interest for conservation are specified in the different annexes to the directive. Annex I states the habitats of special conservation interest and Annex II states the species of special conservation interest. Among the habitats specified in Annex I are the “Reefs” (code 1170). Reefs can be of biogenic, e.g. mussel beds or corals, or geogenic origin, e.g. stony areas with epifauna.

The JNCC's lists of UK BAP (Biodiversity Action Plan) was also consulted (Brig, 2008 (Updated Dec 2011)).

The UK BAP species and habitats are defined nationally by the UK. Threatened species and habitats are listed to aid in the survival of species in accordance with the Convention of Biological Diversity (UN, 5 June 1992).

The Marine Protected Area (MPA) network is a term describing areas in the ocean which are protected in part or closed off completely by strict regulations. One example of MPAs is the Special Areas of Conservation (SAC), which are a part of defined in the European Commission (EC) Habitats Directive.

The Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic (OSPAR), lists protected species and habitats, as well as sensitive habitats and species in need of protection in the North-East Atlantic. This serves also as a complement to the EC Habitats Directive.

In the Habitat Directive’s interpretation manual (EUR 27, 2007) reefs are explained as follows:

> *“Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions.”*

The distinction between what is to be considered a “reef” is not yet precise. This is particularly the case in relation to colonies of the tube-building polychaete, *Sabellaria spinulosa* and stony reefs. If for example *S. spinulosa* or horse mussel (*Modiolus modiolus)* is found in an area, it does not automatically make the area a potential Annex I habitat. Therefore, a scoring system based on a series of physical, biological and spatial characteristic reef features is used to assess the degree of ”reefiness”.

The reefiness is weighted according to the perceived importance of each feature. Furthermore, the reefiness is increased with a score indicating the confidence in the feature score. Threshold ranges proposed, for the reef characteristics elevation, spatial extent and patchiness of *S. spinulosa,* are provided by (Gubbay, 2007) (Table 12) and for stony reefs by (Irving, 2009) (Table 13).

Table 12 Proposed chart for Sabellaria spinulosa reef identification (Gubbay, 2007).

CHARACTERISTIC	NOT A REEF	“REEFINESS”		
		LOW	MEDIUM	HIGH
Elevation (cm) (average tube height)	<2	2-5	5-10	>10
Extent (m^2)	<25	25 - 10,000	10,000 – 1,000,000	>1,000,000
Patchiness (% cover)	<10	10 - 20	20-30	>30

The general definition of biogenic reefs is made by (Holt, 1998) as;

> *“Solid, massive structures which are created by accumulations of organisms, usually arising from the seabed or at least clearly forming a substantial, discrete community or habitat which is very different from the surrounding seabed. The structure of the reef may be composed almost entirely of the reef-building organism and its tubes or shells or it may to some degree be composed of sediments, stones and shells bound together by the organism.”*

Table 13 Guidelines used to categorise 'reefiness' for stony reefs (Irving, 2009).

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	<10 %	10-40 % Matrix supported	40-95 %	>95 % Clast supported
Notes: Diameter of cobbles / boulders being greater than 64 mm. Percentage cover relates to a minimum area of 25 m^2. *This 'composition' characteristic also includes 'patchiness'.*				
Elevation	Flat Seabed	<0.064 m	0.064 m-5 m	>5 m
Notes: Minimum height (64 mm) relates to minimum size of constituent cobbles. This characteristic could also include 'distinctness' from the surrounding seabed.				
Extent	<25 m^2	>25 m^2		
Biota	Dominated by infaunal species			>80 % of species present composed of epifaunal species.

This scoring system indicates that stony reefs should be elevated by at least 0.064 m and with a composition of at least 10 % stones, covering an area of at least 25 m^2 and have an associated community of largely epifaunal species.

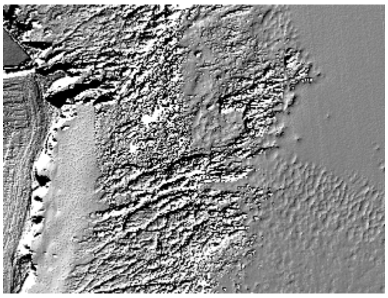
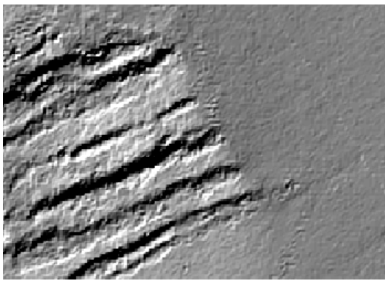
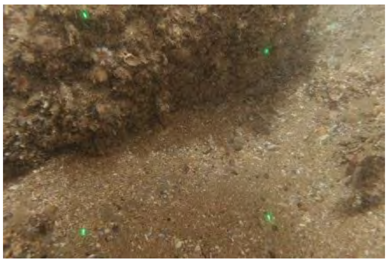
For "Bedrock Reefs" no similar scoring system exists. In areas where the geophysical data cannot provide information on the degree of exposure, on bedrock, these areas will be delineated as "Potential Bedrock Reefs". The qualifying criteria for the classification "Bedrock Reefs" is the presence of bedrock that could support an epifaunal community.

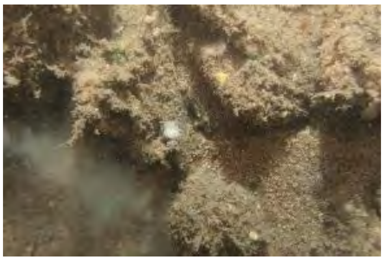
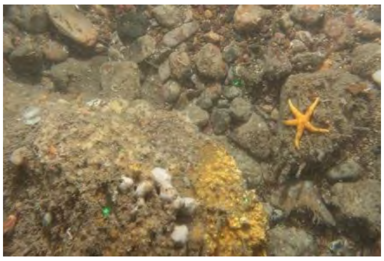
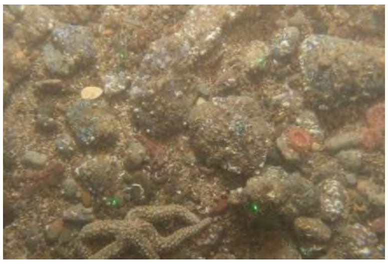
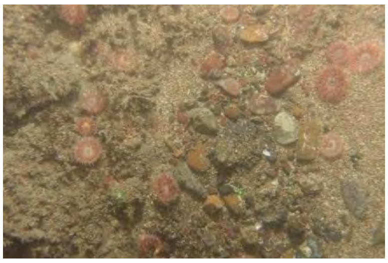
4| RESULTS

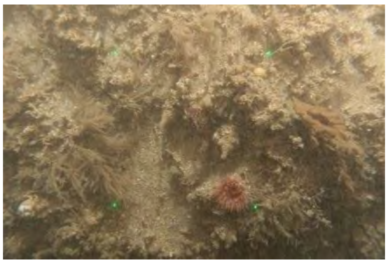
4.1| SUMMARY OF IDENTIFIED HABITATS

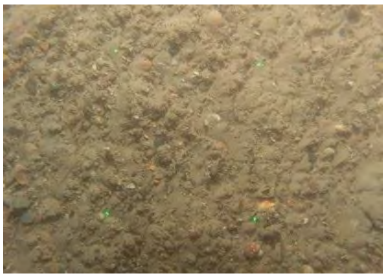
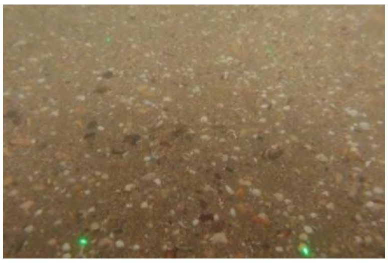
A total of 33 habitats were identified within the survey corridor (Table 14). An overview of the distribution of habitats and sample locations including areas of Annex I habitats within the UK are presented in Figure 6, Figure 11 to Figure 22 and within Ireland in Figure 52 to Figure 57 and Figure 65.

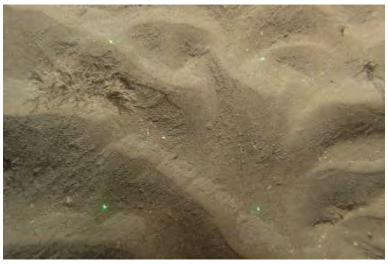
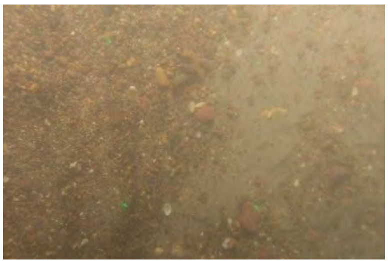
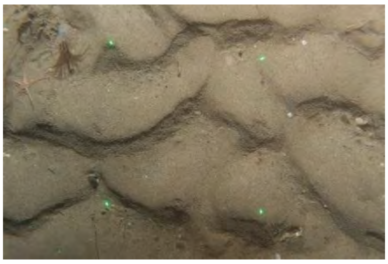
Table 14 Habitat description.

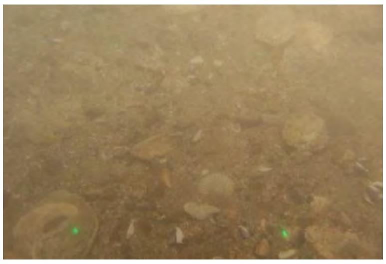
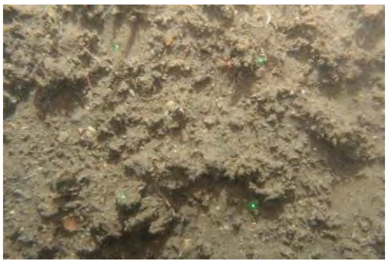
HABITAT IMAGE	HABITAT CLASSIFICATION	HABITAT CODE
	Kelp with cushion fauna and/or foliose red seaweeds	A3.11
	Atlantic and Mediterranean moderate energy infralittoral rock	A3.2
	Atlantic and Mediterranean high energy circalittoral rock	A4.1
	Mixed faunal turf communities on circalittoral rock	A4.13

HABITAT IMAGE	HABITAT CLASSIFICATION	HABITAT CODE
	Mixed turf of bryozoans and erect sponges with *Dysidia fragilis* and *Actinothoe sphyrodeta* on tide-swept wave-exposed circalittoral rock	A4.1312
	*Corynactis viridis* and a mixed turf of crisiids, Bugula, Scrupocellaria, and Cellaria on moderately tide-swept exposed circalittoral rock	A4.132
	*Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock	A4.138
	Echinoderms and crustose communities on circalittoral rock	A4.21
	*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	A4.213
	*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock/ *Mytilus edulis* beds with hydroids and ascidians on tide-swept exposed to moderately wave-exposed circalittoral rockA4.213/ A4.241	A4.213/ A4.241

HABITAT IMAGE	HABITAT CLASSIFICATION	HABITAT CODE
	*Sabellaria spinulosa* encrusted circalittoral rock	A4.221
	*Sabellaria spinulosa*, didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock	A4.2212
	*Mytilus edulis* beds with hydroids and ascidians on tide-swept exposed to moderately wave-exposed circalittoral rock	A4.241
	Infralittoral coarse sediment	A5.13
	Circalittoral coarse sediment	A5.14
	*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	A5.141

HABITAT IMAGE	HABITAT CLASSIFICATION	HABITAT CODE
	*Mediomastus fragilis*, *Lumbrineris spp*. and venerid bivalves in circalittoral coarse sand or gravel	A5.142
	*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand	A5.143
	Deep circalittoral coarse sediment	A5.15
	Infralittoral fine sand	A5.23
	Infralittoral muddy sand	A5.24
	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	A5.242

HABITAT IMAGE	HABITAT CLASSIFICATION	HABITAT CODE
	Circalittoral fine sand	A5.25
	*Echinocyamus pusillus*, *Ophelia borealis and Abra prismatica* in circalittoral fine sand	A5.251
	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	A5.252
	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
	Deep circalittoral sand	A5.27
	*Owenia fusiformis* and *Amphiura filiformis* in deep circalittoral sand or muddy sand	A5.272

HABITAT IMAGE	HABITAT CLASSIFICATION	HABITAT CODE
	Infralittoral mixed sediments	A5.43
	Circalittoral mixed sediments	A5.44
	Deep circalittoral mixed sediments	A5.45
	Polychaete-rich deep Venus community in offshore mixed sediments	A5.451
	*Sabellaria spinulosa* on stable circalittoral mixed sediment	A5.611

5| UNITED KINGDOM

Reported KP for the UK Exclusive Economic Zone (EEZ) Environmental survey are KP 0.325 to KP 73.906. A total of 35 transect (Table 15) were performed within the UK EEZ, distributed among route route A, alternative E, and the route Greenlink_WGS84_UTM30N_09112018_RPL_Rev0 (called "Final route" in this report). Transect T04 to T09 were located within the Final Route corridor in the UK EEZ, along with transect RR_T01 to RR_T07. Transect A_T01 to A_T10 were located within the route A corridor. Transect E_T01 to E_T11 were located within the route alternative E corridor (Figure 5).

Grab sample site S17 to S37 (Table 15) was located within the UK EEZ. All grab sample sites were located within the Final Route corridor (Figure 5). See Appendix A| for a full list of positions of grab sample sites and transects. Field protocols are available in Appendix B| and Appendix C|. Grab identification protocols and Transect identification protocols are found in Appendix D| and Appendix E|.

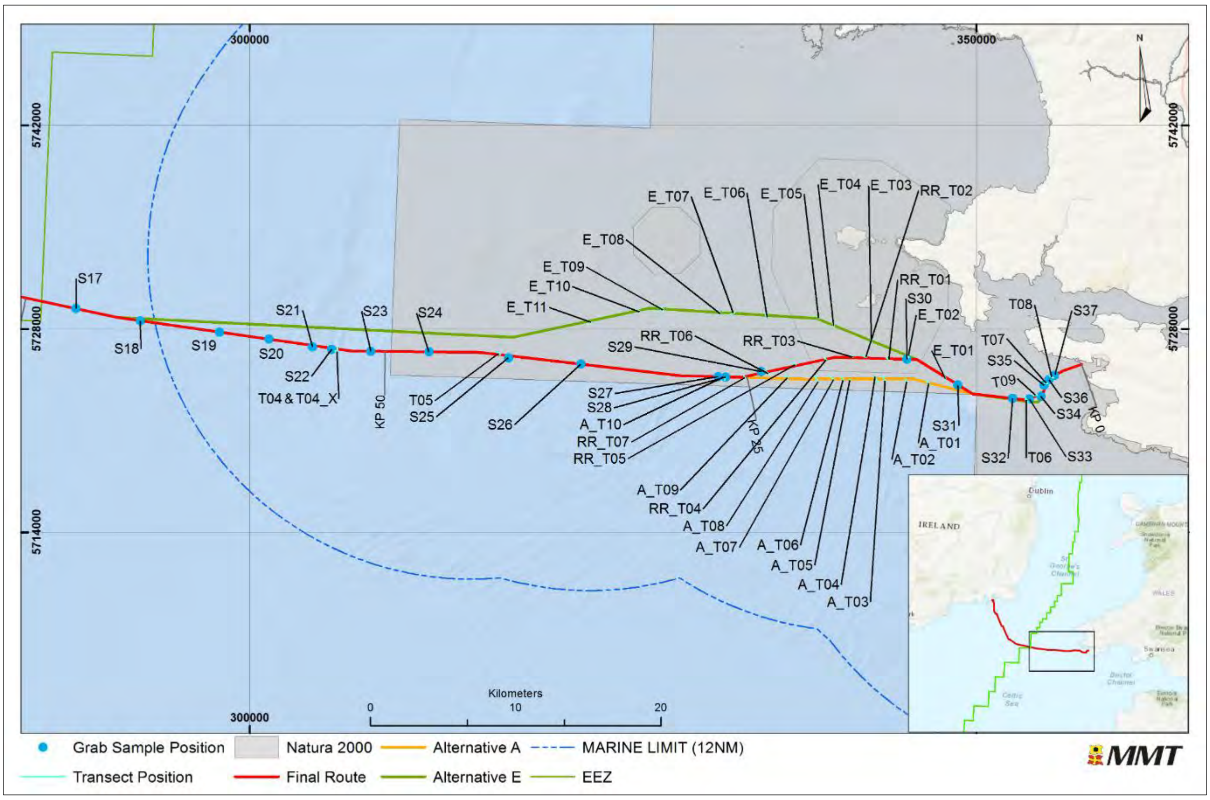


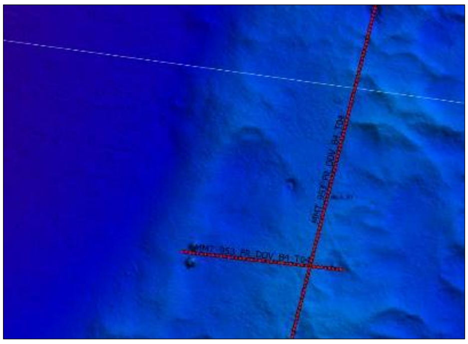
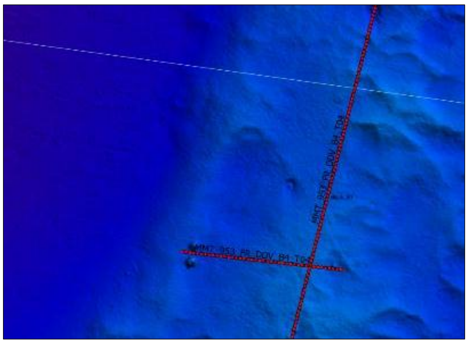
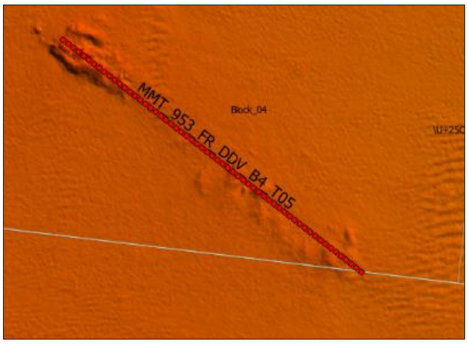
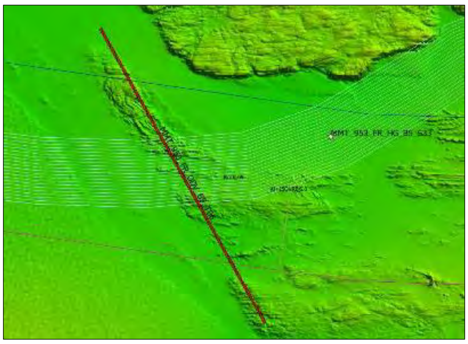
Figure 5 Overview of sampling and transect locations in the UK EEZ.

See Table 15 for the number of sample sites and Table 16 to Table 19 for details regarding planned location coordinates and geophysical features overview.

Table 15 Number of sample sites in the UK EEZ.

NUMBER OF SAMPLE SITES	PHOTO TRANSECT SITES	GRAB SAMPLE SITES	PSA/CHEM SAMPLE SITES
	35	21	21

Table 16 List of proposed transects along Final Route in UK waters.

TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_T04	309033	5726346	308930	5726529	
DDV_T04_X	305879	5726471	306010	5726456	
DDV_T05	317244	5726224	316998	5726411	
DDV_T06	355053	5724748	355286	5724642	

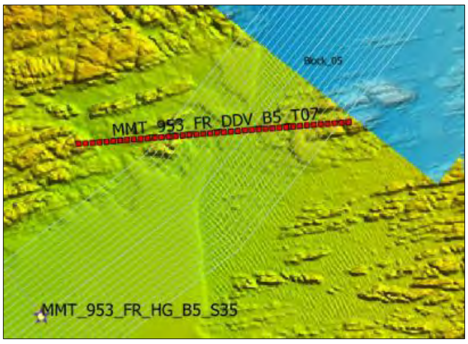
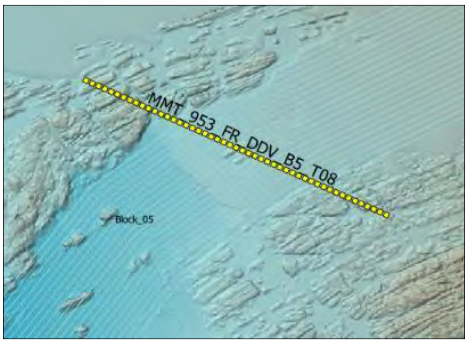
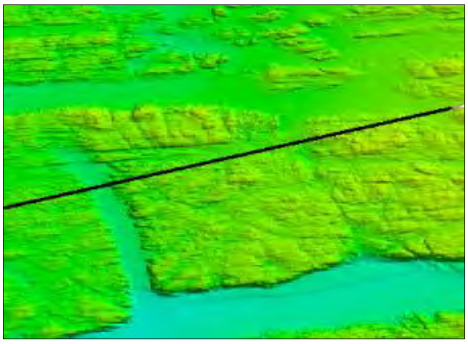
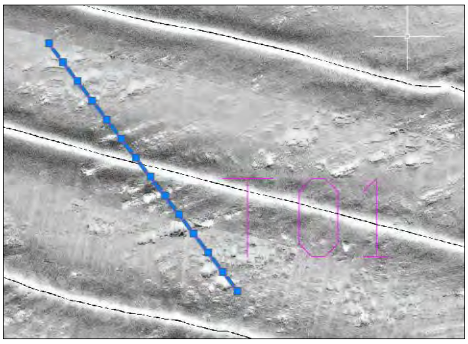
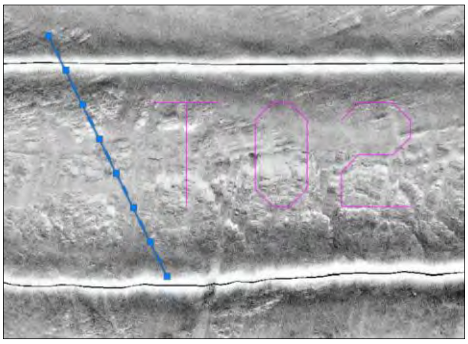
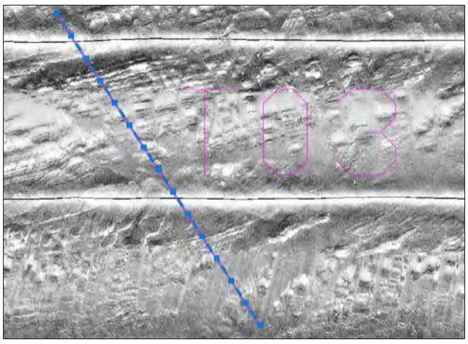
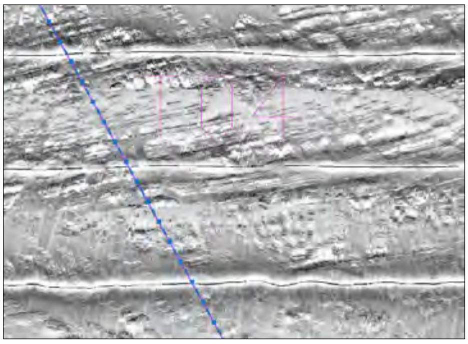
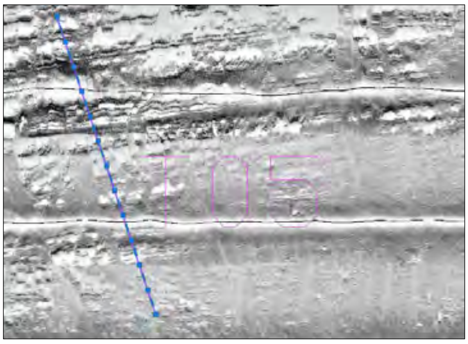
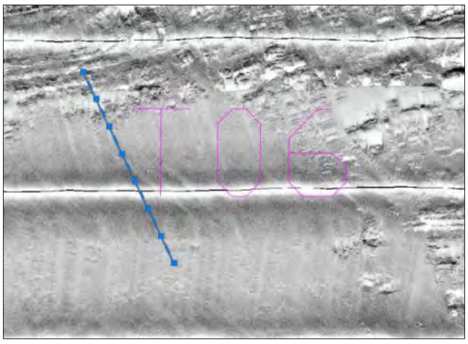
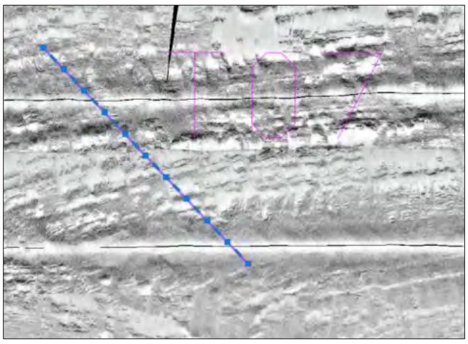
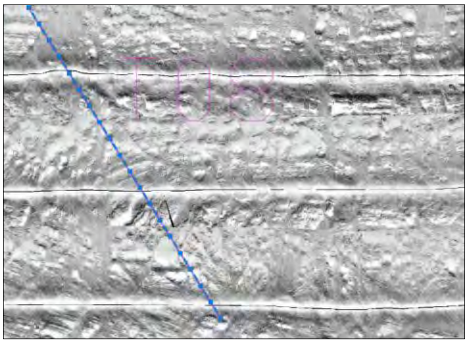
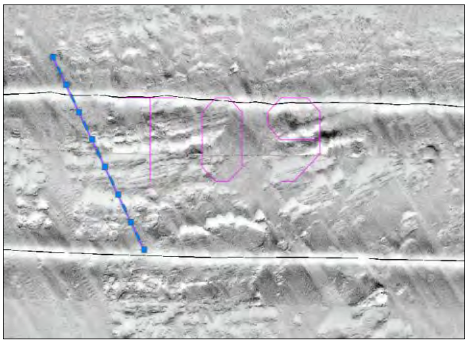
TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_T07	354677	5724250	354886	5724266	
DDV_T08	353304	5723333	353546	5722895	
DDV_T09	354267	5723467	353942	57523410	

Table 17 List of proposed transects along route alternative A in UK waters.

TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_A_T01	346571	5724421	346770	5724161	

TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_A_T02	345098	5724571	345195	5724379	
DDV_A_T03	343723	5724429	343535	5724727	
DDV_A_T04	343221	5724332	342985	5724767	
DDV_A_T05	341273	5724483	341150	5724800	

TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_A_T06	340823	5724477	340730	5724672	
DDV_A_T07	340187	5724510	339965	5724748	
DDV_A_T08	339112	5724378	338857	5724800	
DDV_A_T09	337003	5724573	336896	5724772	

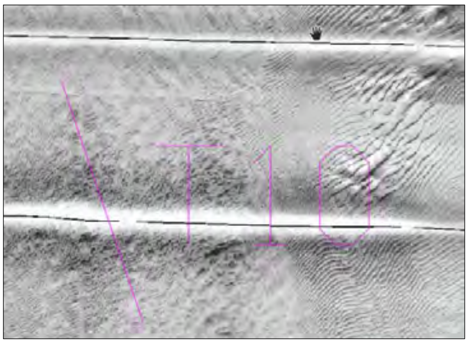
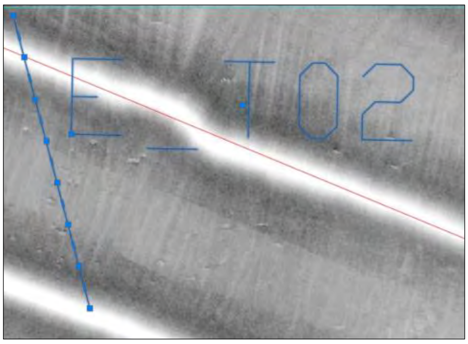
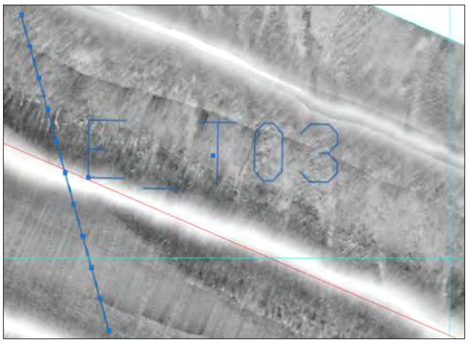
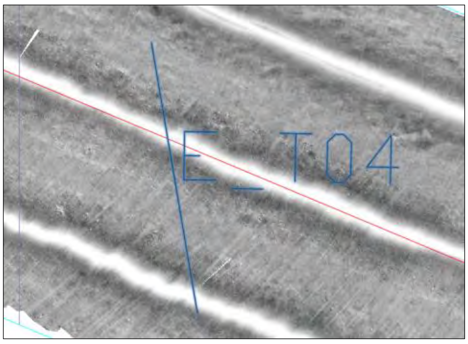
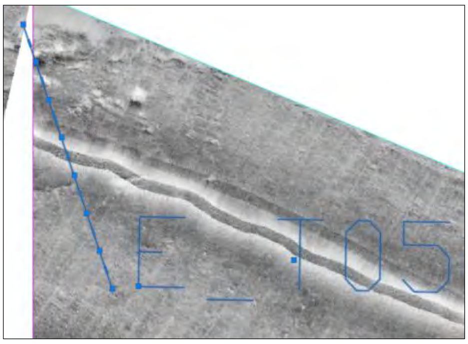
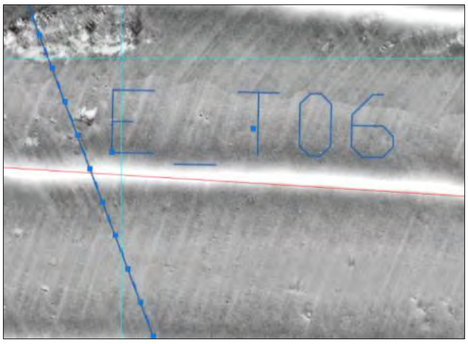
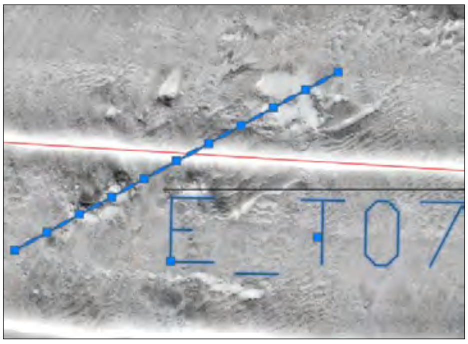
TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_A_T10	332698	5724465	332624	5724672	

Table 18 List of proposed transects along route alternative E in UK waters.

TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_E_T01	347790	5724769	347857	5724568	
DDV_E_T02	345270	5726234	345324	5726030	
DDV_E_T03	342716	5727313	342794	5727024	

TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_E_T04	340137	5728366	340176	5728146	
DDV_E_T05	339134	5728741	339066	5728946	
DDV_E_T06	335576	5728779	335463	5729068	
DDV_E_T07	333376	5729132	333101	5728995	

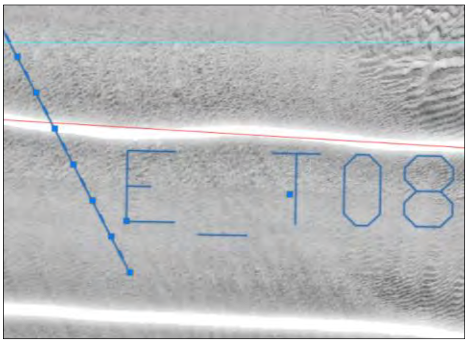
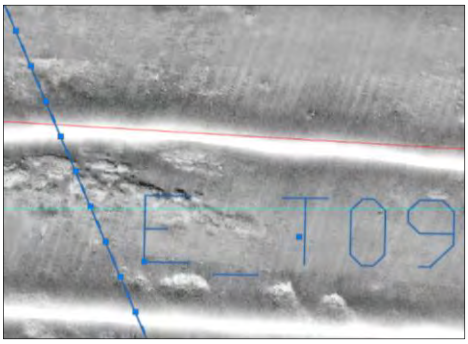
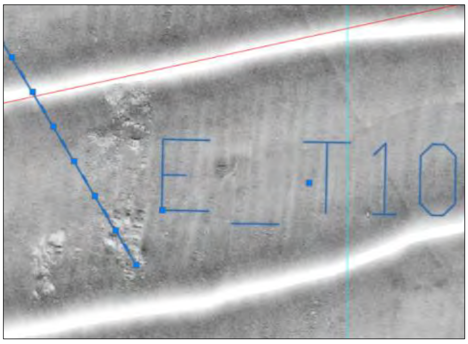
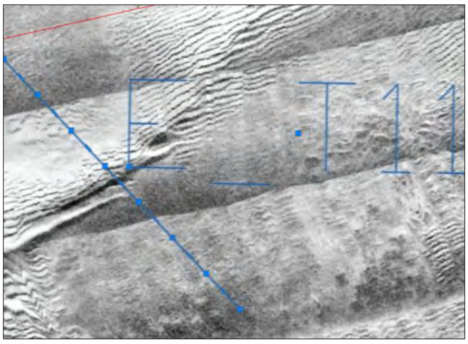
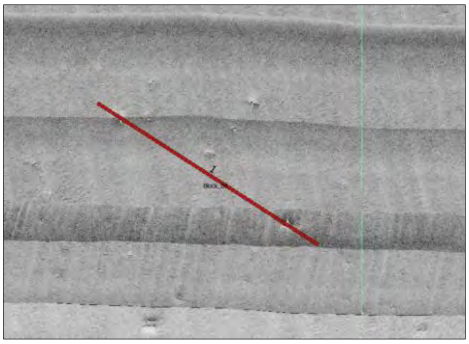
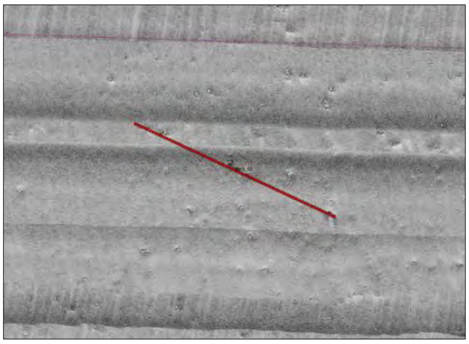
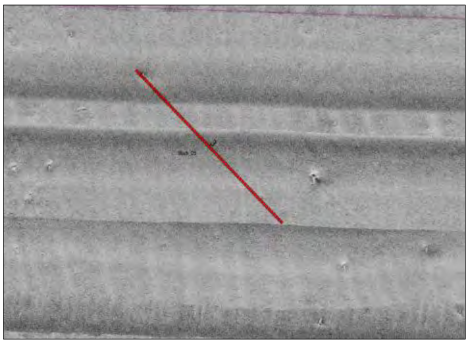
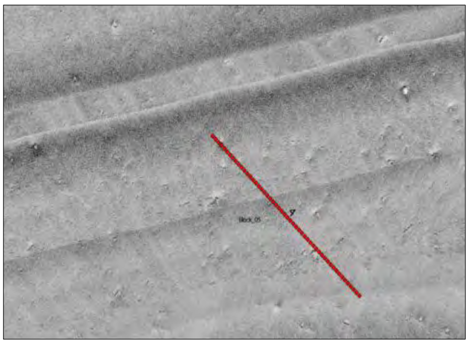
TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_E_T08	332397	5729022	332301	5729216	
DDV_E_T09	328465	5729210	328347	5729494	
DDV_E_T10	326821	5729159	326710	5729341	
DDV_E_T11	323546	5728380	323398	5728534	

Table 19 List of proposed transects along reconnaissance re-route option in UK waters.

TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_RR_T01	343793	5725999	343966	5725880	
DDV_RR_T02	342149	5726144	342408	5726045	
DDV_RR_T03	341334	5726200	341489	5726058	
DDV_RR_T04	339533	5725982	339664	5725859	

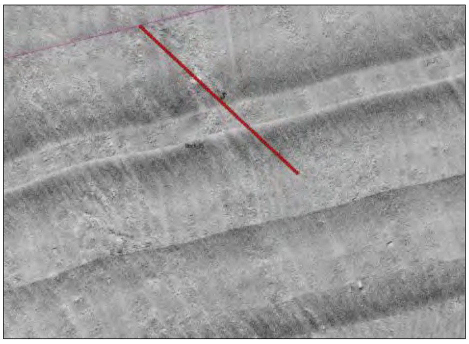
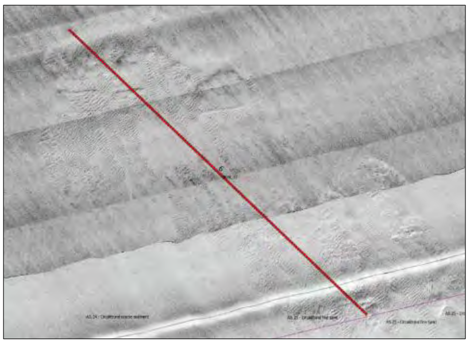
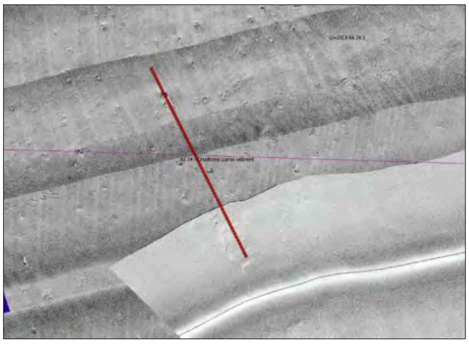
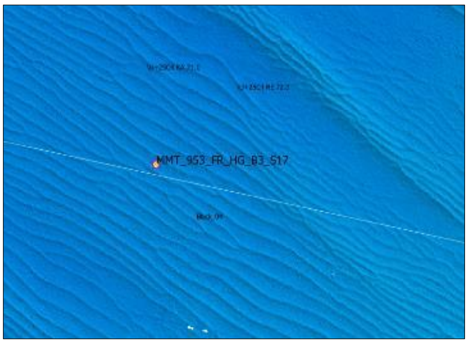
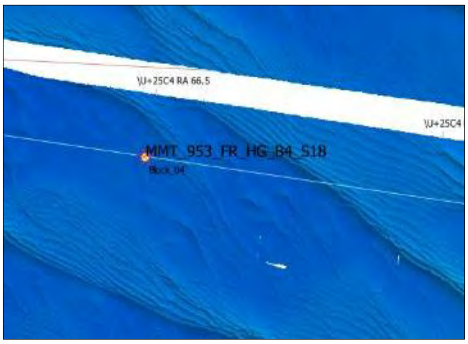
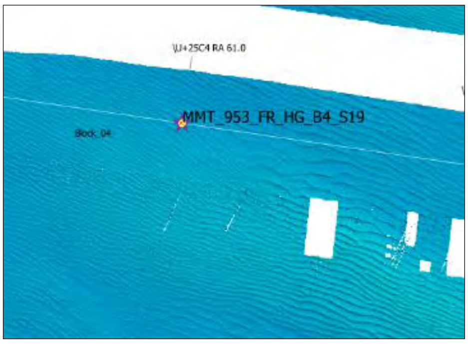
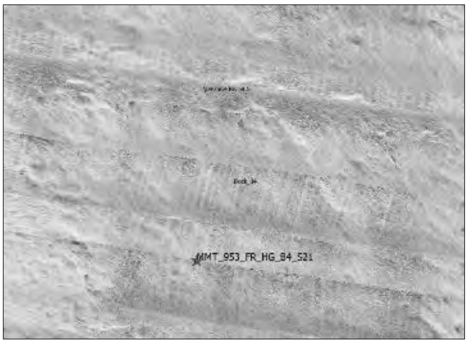
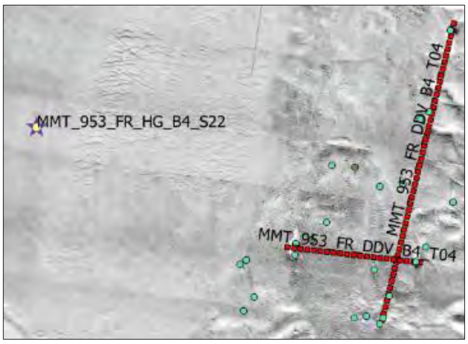
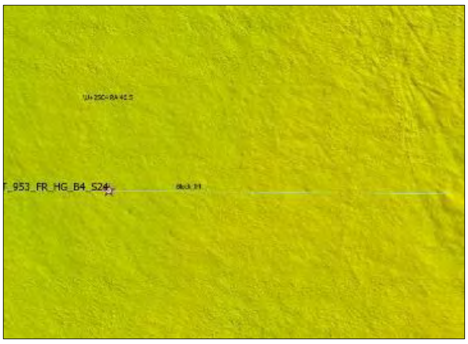
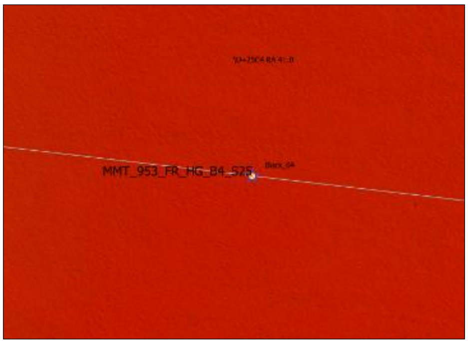
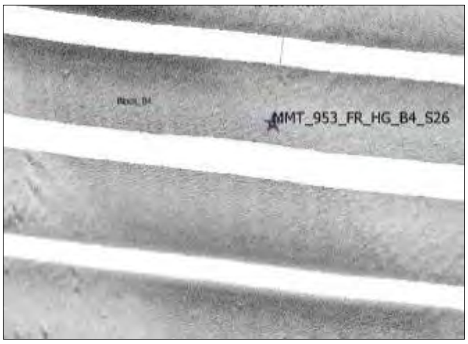
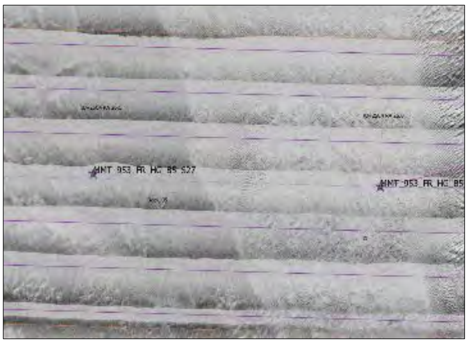
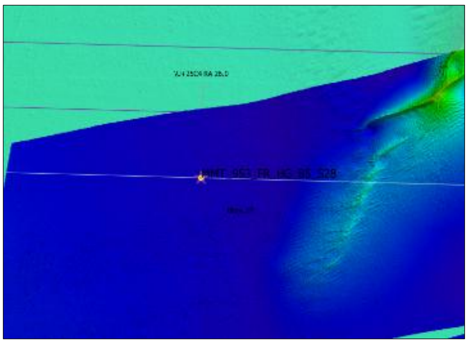
TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERVIEW
DDV_RR_T05	337382	5725670	337545	5725537	
DDV_RR_T06	335397	5725147	335777	5724822	
DDV_RR_T07	334013	5724735	334117	5724552	

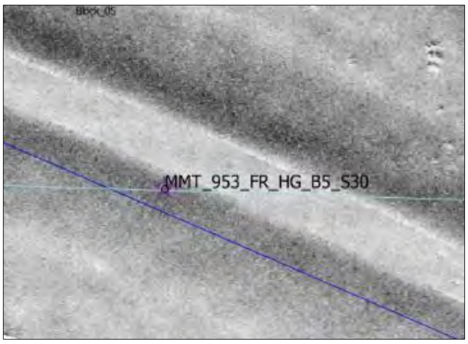
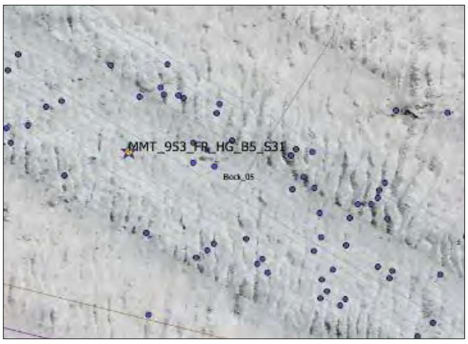
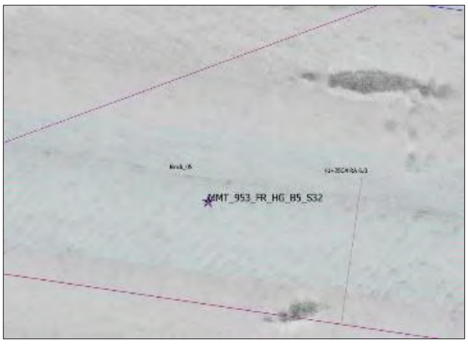
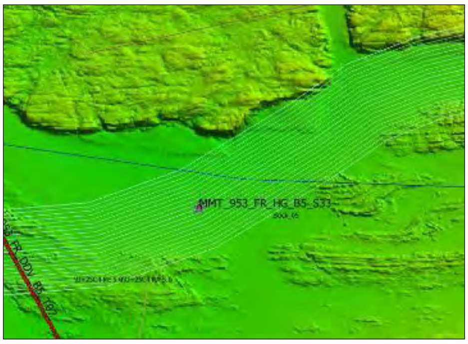
Table 20 Sample locations for grab samples performed.

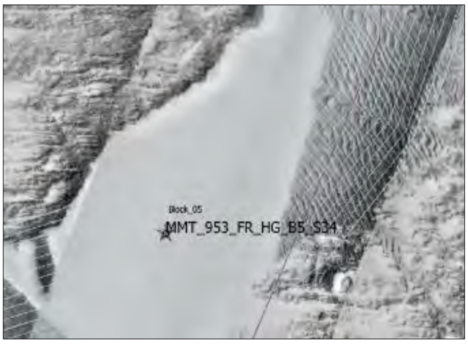
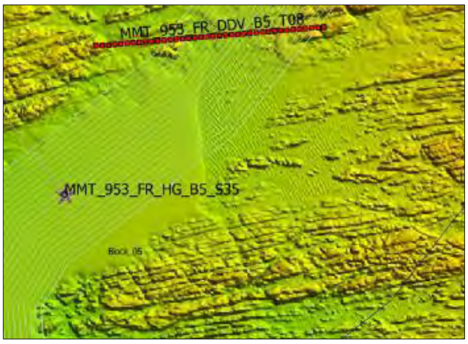
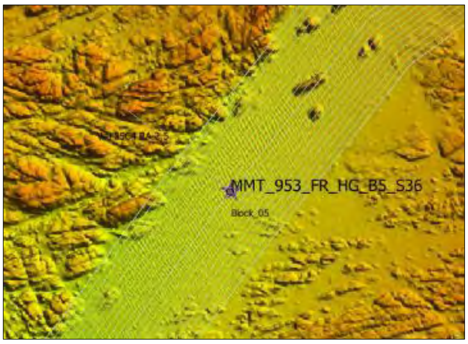
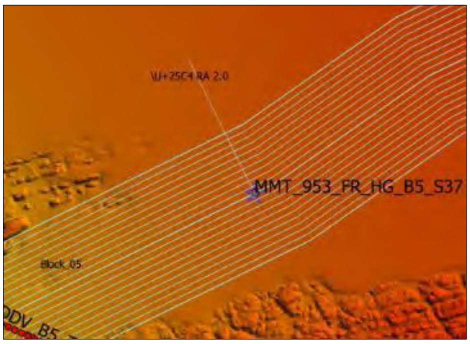
SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERVIEW
S17	288063	5729393	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERVIEW
S18	292478	5728547	
S19	297925	5727770	
S20	301337	5727291	
S21	304333	5726746	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERVIEW
S22	305639	5726586	
S23	308332	5726461	
S24	312332	5726422	
S25	317818	5726156	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERVIEW
S26	322784	5725573	
S27	332228	5724709	
S28	332737	5724687	
S29	335201	5725050	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERVIEW
S30	345214	5725894	
S31	348712	5724137	
S32	352742	5723209	
S33	353644	5723174	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERVIEW
S34	354471	5723403	
S35	354649	5724119	
S36	354980	5724488	
S37	355368	572789	

5.1| DETAILED AREA DESCRIPTIONS

The KP referenced within this section are based on the Final Route unless otherwise stated and measured from features crossing the Route Position List (RPL).

5.1.1| FINAL ROUTE

The shallow areas from KP 0.332 to KP 12.851 are located within the SAC area Pembrokeshire Marine/ Sir Benfro Forol (Site code UK0013116), which extends to KP 49.592.

The seabed is initially dominated by fine sediments closest to shore and classified as A5.24 - Infralittoral muddy sand, KP 0.332 to KP 0.463, followed by A5.13 - Infralittoral coarse sediment, from KP 0.463 to KP 0.636 (Figure 6).

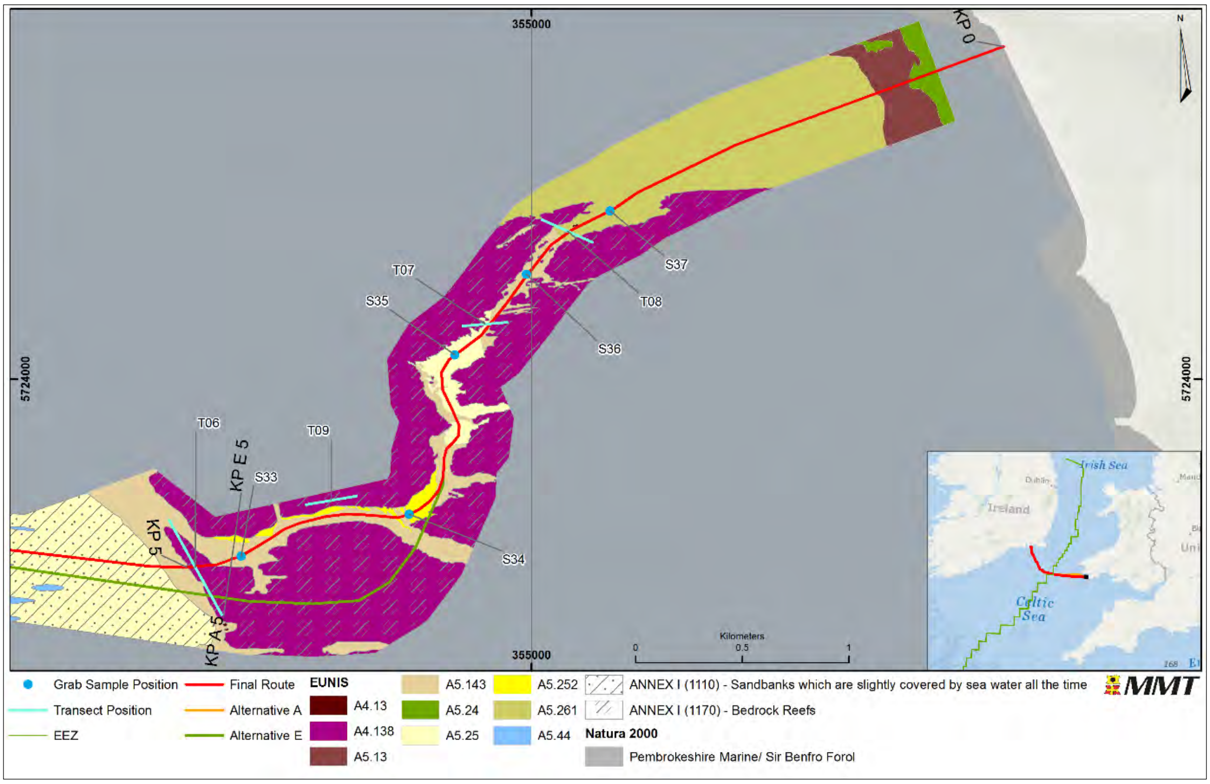


Figure 6 Overview of UK EEZ KP 0 to KP 5.

Habitat A5.261 - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment was classified between KP 0.463 to KP 2.267 throughout the corridor. The infauna at grab sample site S37, approximate KP 2.006, comprised predominantly of molluscs *A. alba*, *N. nitidosa*, *Fabulina fabula* as well as polychaetes *Magelona filiformis* and *Spiophanes bombyx*.

From approximate KP 2.027 and KP 4.998, the final route extends along a channel of finer sediments surrounded by sedimentary bedrock classified as A4.138 - *Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock and is further assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009).

Transects DDV_T06 to DDV_T09 (Figure 7 to Figure 10) were located in turbid waters on various sections of the bedrock feature A4.138.

The analysed imagery showed similar composition with high diversity and colonisation by ascidians *Dendrodoa grossularia*, *Polycarpa sp*. and sand covered ascidians interpreted to be *M. manhattensis*.

Other taxa identified present were poriferans, *Tubularia sp.*, *Caryophyllia smithii*, hydrozoans and bryozoans.

A few small outcrops are interpreted to cross the final route between KP 2.211 and KP 2.412, KP 2.783 with a larger section between KP 4.874 to KP 4.997 (DDV_T06).

Figure 7 Example image DDV_T09_005.

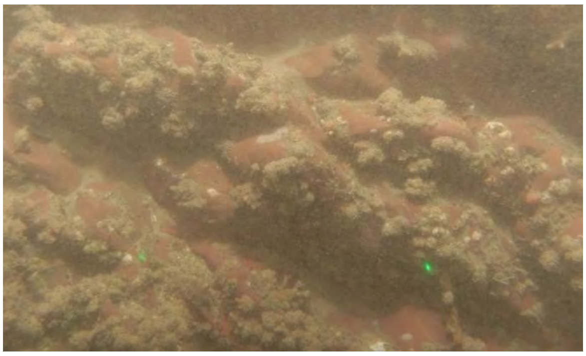


Figure 8 Example image DDV_T08_009. (KP 2.220)

Figure 9 Example image DDV_T07_008. (KP 2.797)

Figure 10 Example image DDV_T06_012. (KP 4.874 to KP 4.997)

The seabed substrate in the channel between KP 2.027 and KP 4.998 was generally dominated by finer sediment fractions with areas of gravelly sands.

An initial section from KP 2.267 to KP 2.863 was classified as A5.143 - *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand. Grab sample site S36, located within this section at approximate KP 2.507 showed low abundances of infauna which was characterised by polychaetes *P. kefersteini*, *Glycera lapidum, Exogone verugera* and Nematods as well as sipunculid *Phascolion strombus*.

The substrate between KP 2.863 and KP 3.491 was predominantly classified as A5.25 - Circalittoral fine sand and comprised grab sample site S35 at approximate KP 3.014. The analysed infauna showed similarly low diversity in taxa, but with higher abundances, compared to S36. The sample was characterised by molluscs *A. alba* and *Timoclea ovata, amphipod Bathyporeia elegans* and different polychaetes.

From KP 3.491 to KP 5.121 the majority of the final route was classified as A5.143 with a section classified as A5.252 - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand between KP 3.745 and KP 3.974.

Grab sample site S34 was located within the fine sand habitat A5.252, at approximate KP 3.899. The infauna analysed showed similar diversity and abundances as S36 and S35 with some species overlapping between these sites. The characterising fauna were molluscs *Abra prismatica*, *T. ovata,* polychaete*s Travisia forbesii, Ophelia borealis* and amphipod *B. elegans.*

Grab sample site S33 at approximate KP 4.740 showed similar faunal composition to that of S36 and was characterised by *P. kefersteini*, *G. lapidum*, Notomastus and Nematods.

The seabed between KP 5.121 and KP 10.031 is dominated by fine sands, A5.25, with pockets and small sections, found from KP 6.220 to KP 6.882 and from KP 8.840 to KP 9.450, classified as A5.44 - Deep circalittoral mixed sediments (Figure 11). The areas classified as A5.44 were derived from the interpretations of geophysical data.

From KP 5.122 to KP 8.841 and from KP 9.405 to KP 10.029, two areas with sand and coarse sediment were classified as Annex I (1110) - Sandbanks which are slightly covered by sea water all the time (Figure 11 and Figure 12).

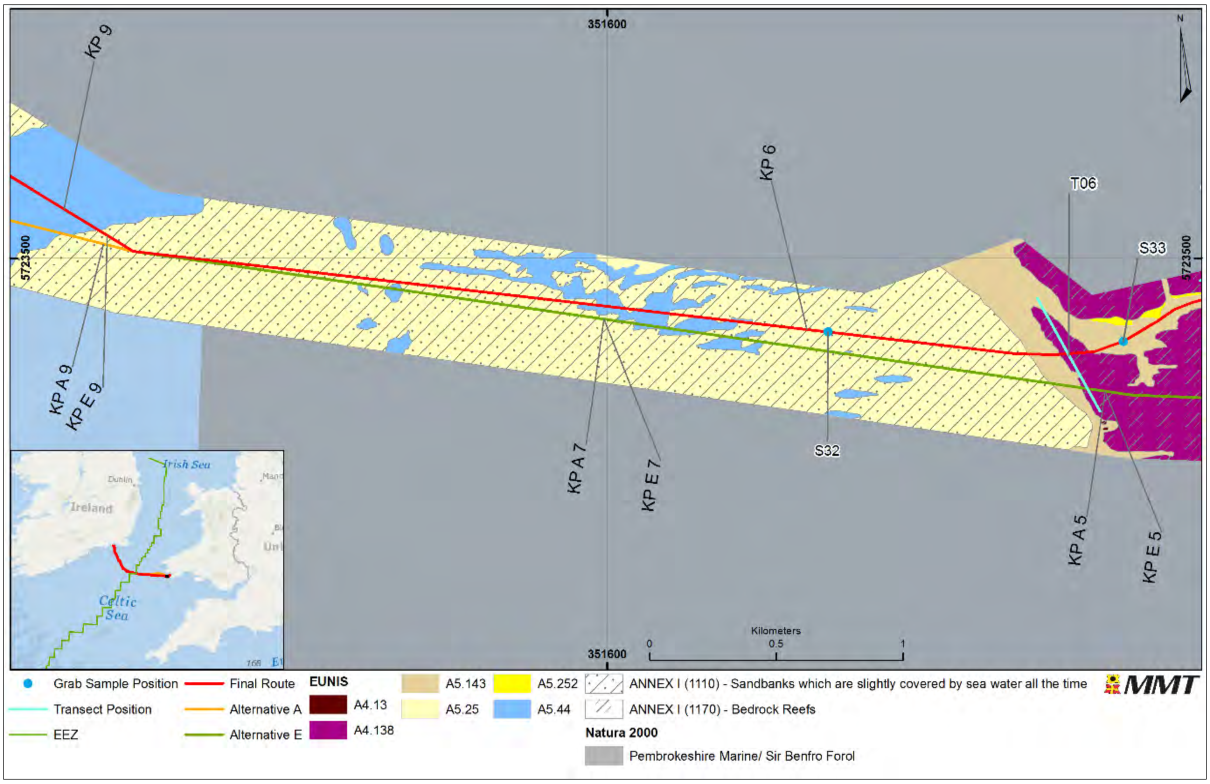


Figure 11 Overview of UK EEZ KP 5 to KP 9.

Grab sample sites S32, approximate KP 5.917, and S31 approximate KP 9.862 were located within A5.25. At site S32 the infauna was characterised by molluscs *Goodallia triangularis, Asbjornsenia pygmaea,* polychaete *Nephtys cirrosa.* Grab sample site S31 showed higher diversity and abundances in comparison to S32. The infauna was characterised by molluscs *A. prismatica, T. ovata*, *Kurtiella bidentata*, polychaetes *O. borealis, Lumbrineris cingulate, Glycinde nordmanni* and different amphipods.

Habitat A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments dominated the seabed between KP 10.031 and KP 14.528 but for a few rocky sections (Figure 12).

Areas of the habitats A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock and A4.221 - *Sabellaria spinulosa* encrusted circalittoral rock were present between KP 10.338 and KP 11.139 within habitat A5.451.

Habitats A4.213 and A4.221 were assigned to these sections through extrapolation, and based on the imagery data derived from transect A_T01, which was collected on the adjacent route Route A (Route A approximate KP 12.036) (Figure 12).

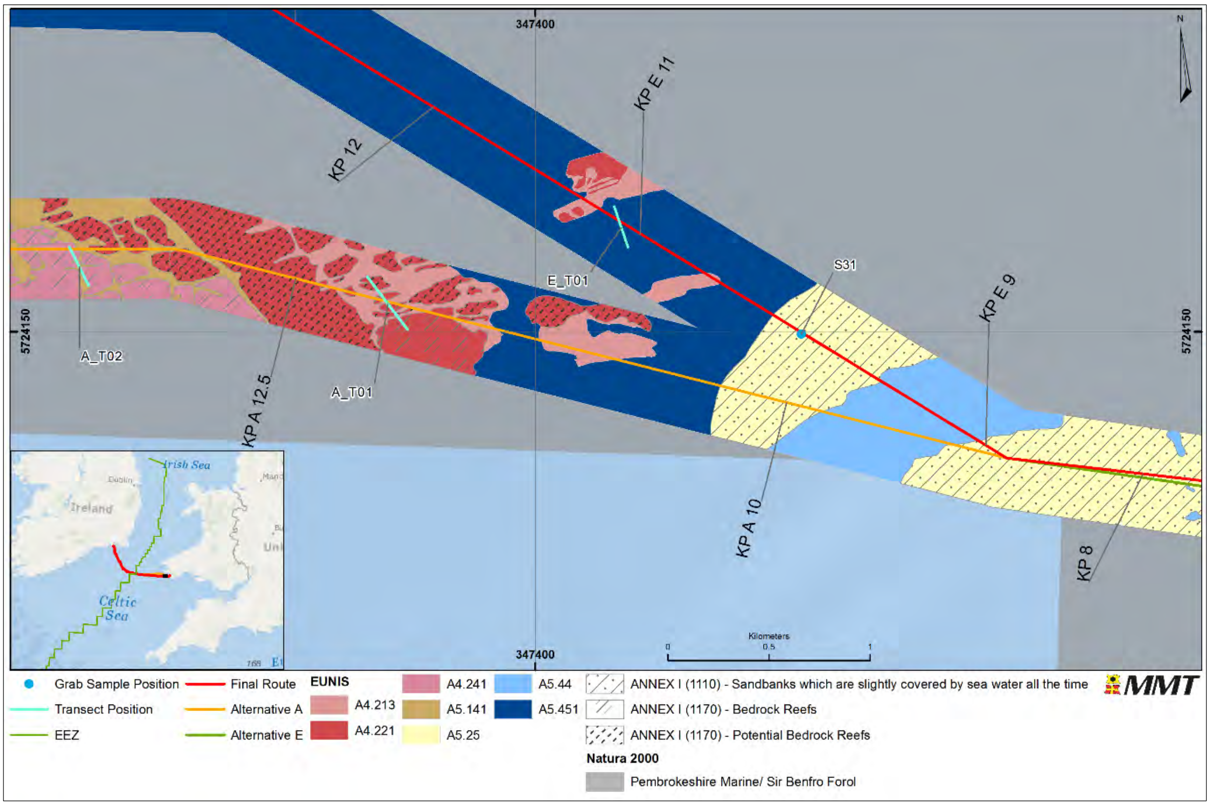


Figure 12 Overview of UK EEZ KP 9 to KP 12.

These two areas were however not assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009) as the geophysical data indicated that the bedrock was largely covered with sand and gravel and cobbles/boulders.

The imagery from transects E_T01, approximate KP 10.919 and E_T02, approximate KP 13.720, showed an increase in gravel on the surface with increasing KP and appeared superficially to be the same habitat (A5.451) as grab sample site S30 (Figure 13).

The analysis of infauna at grab sample site S30, approximate KP 13.856, indicated high diversity and abundances. The infauna was characterised by numerous polychaetes which were dominated by *Sabellaria spinulosa* and *Syllis armillarisa* as well as molluscs *Kellia suborbicularis*, *Modiolula phaseolina*, *Gari telinella, Venus casina, Hiatella arctica* and *Sphenia binghami*. The sample also contained numerous specimens of echinoderm *Amphipholis squamata*.

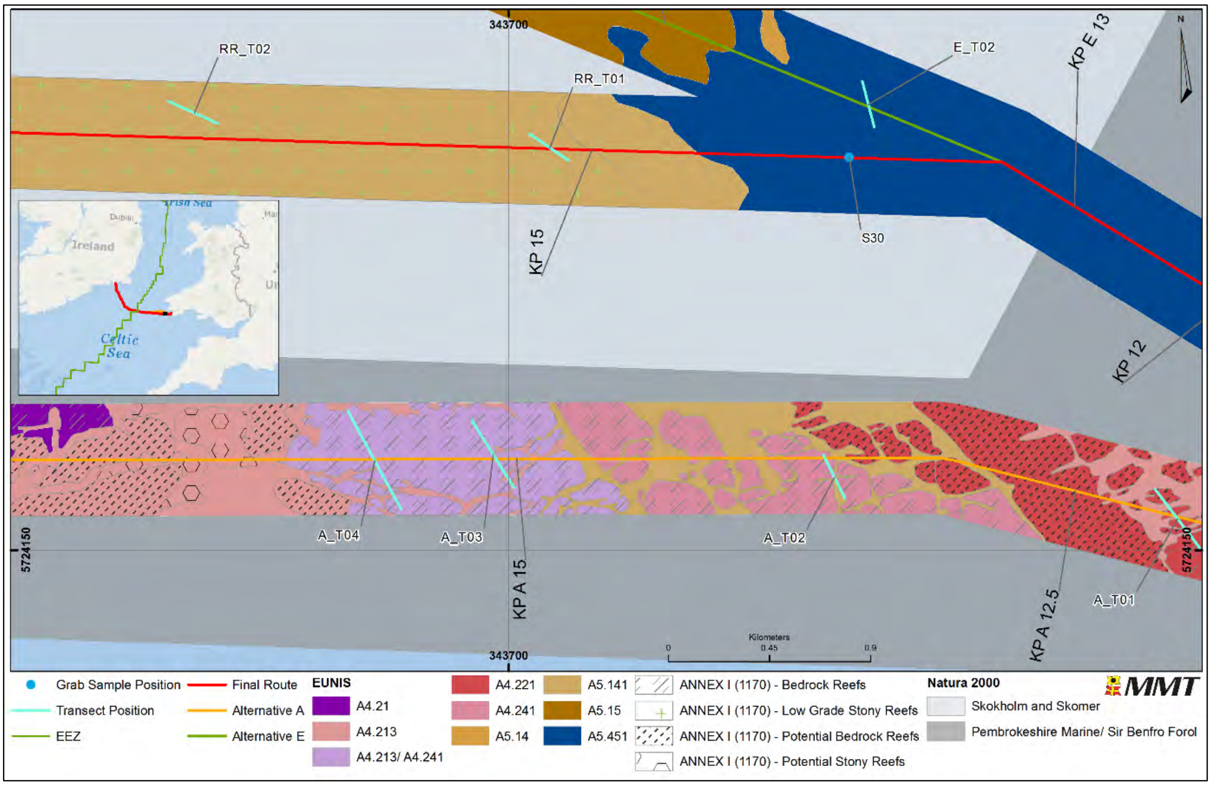


Figure 13 Overview of UK EEZ KP 12 to KP 18.

From KP 14.528 to KP 23.534 the seabed was characterised by heterogeneous coarse sediments, cobbles and boulders. The seabed was classified predominantly as A5.141 - Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles from KP 14.528 to KP 20.200, KP 20.622 to KP 21.309 and KP 21.462 to KP 22.091. Areas classified as A5.14 - Circalittoral coarse sediment extended from KP 20.209 to KP 23.534.

Transect RR_T01, which crosses the final route at approximate KP 15.181, showed cobbles and boulders, with intermediate muddy gravel and Ostrea shells. The encrusting fauna included small clusters, of low rugosity and of varying density, of *S. spinulosa.* Other characterizing taxa noted were bryozoans, Balanidae, Serpulidae, *Urticina sp*., and Paguridae.

Transects RR_T02, approximate KP 16.711, and RR_T03, approximate KP 17.650, were located in the same superficial substrate and comprised the same epifaunal coverage as RR_T01 but without any apparent presence of *S. spinulosa.*

Transects RR_T04, crossing the final route at approximate KP 19.457, and RR_T05, approximate KP 21.509, showed more similarity to RR_T01 than RR_T02 and T03 mainly with regards to the presence of *S. spinulosa* in small clusters as well as more silt coverage (Figure 14). The general characterizing epifaunal coverage was similar between all five transects. With increasing KP, from RR_T01 towards RR_T05, the heterogeneous appearance, which was cobble dominated, of the seabed surface faded towards coarser sands and gravel. These five transects were assessed to be more similar to habitat A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles than potentially A4.221 - *Sabellaria spinulosa* encrusted circalittoral rock. It is possible that the presence, or absence of larger clusters, of *S. spinulosa* at RR_T01 and T04 -T05 is the result of seasonal variation and scour action which can prevent establishment of *S. spinulosa*.

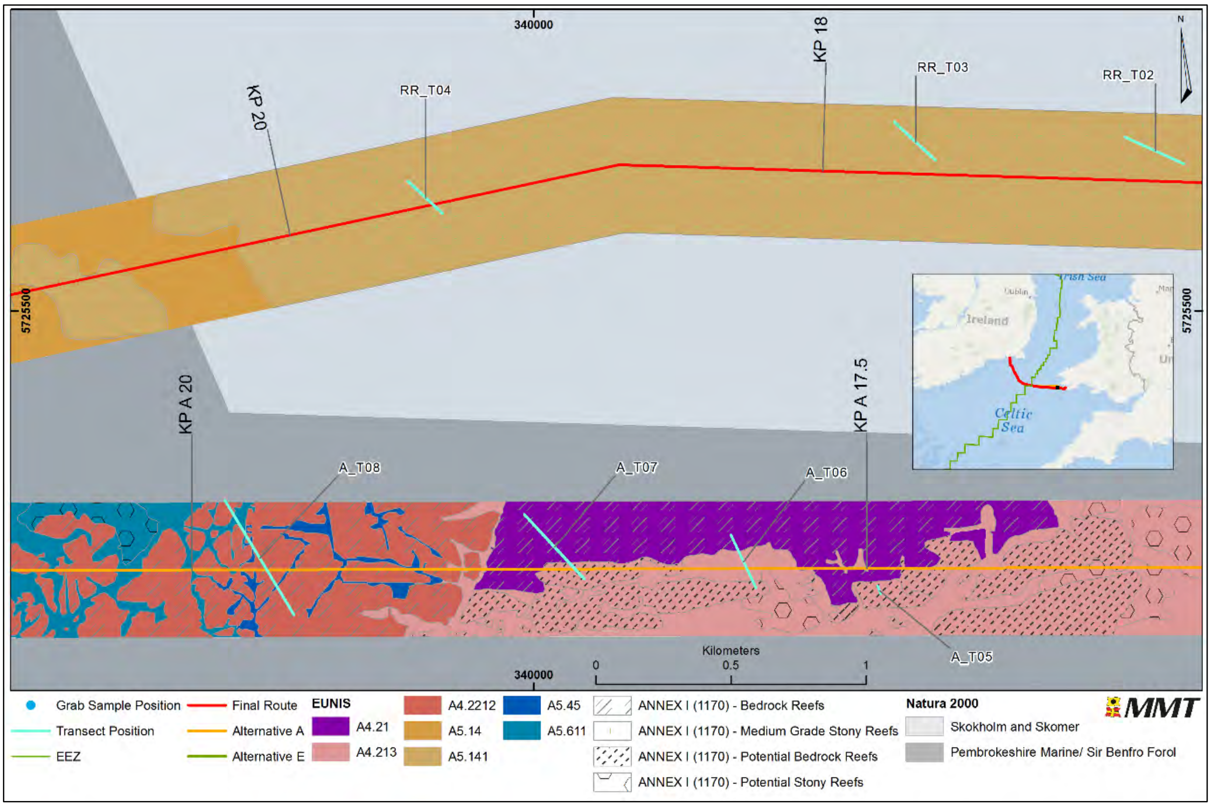


Figure 14 Overview of UK EEZ KP 18 to KP 22.

Four single camera drops (RR_D01 – D04) were performed to investigate large boulders prior to geotechnical sampling between KP 16.261 and KP 20.376. The imagery indicates the presence of habitat A4.111 - *Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock. It is possible that there are patches of A4.111 which are not distinguishable from A5.141 in geophysical data.

Areas of A5.141, between KP 15.002 and KP 22.091, were also assed to meet the criteria of Annex I (1170) – Medium Grade Stony Reefs (Irving, 2009).

The seabed between KP 23.534 and KP 24.925 was classified as A5.15 - Deep circalittoral coarse sediment (Figure 15). Areas of A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock were classified from KP 23.535 to KP 23.743 and crossing the final route at KP 24.192. An area classified as A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment was identified along the final route corridor, at the boundary of route Route A, KP 23.532 to KP 23.696.

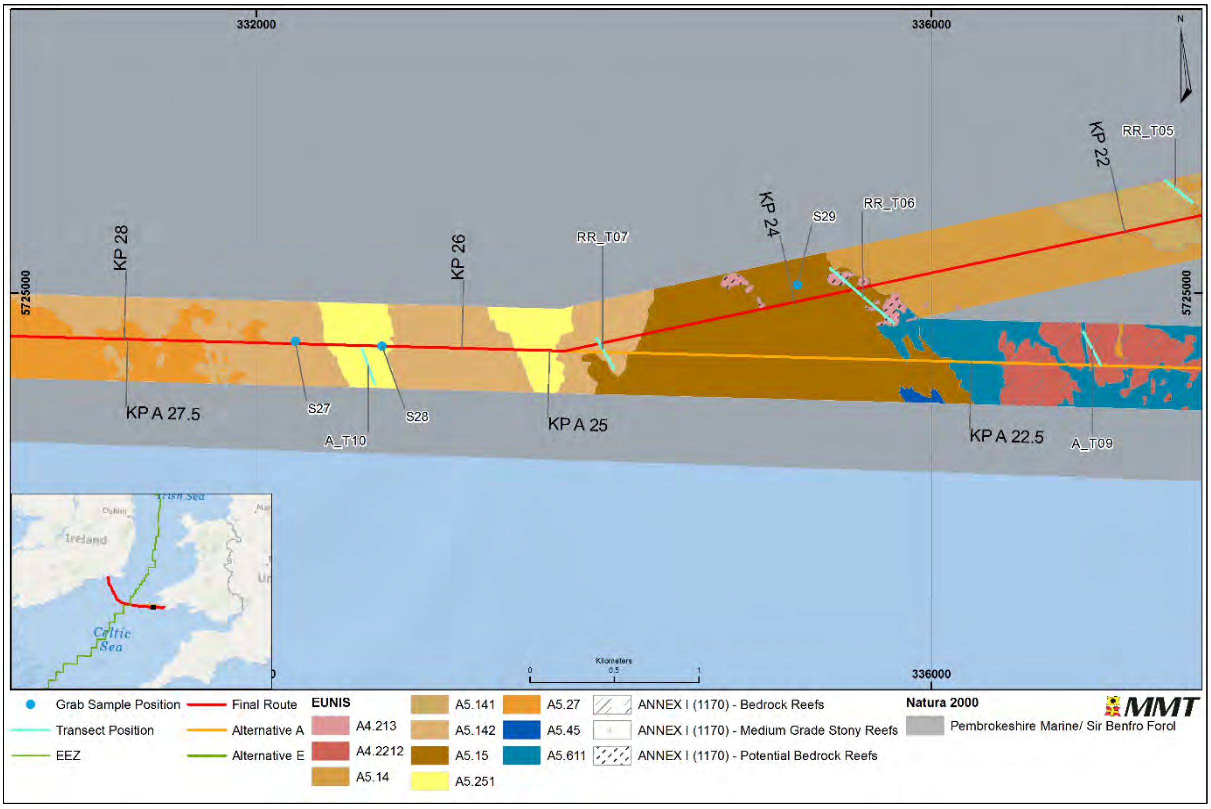


Figure 15 Overview of UK EEZ KP 22 to KP 28.

Transect RR_T06, crossing the final route at approximate KP 23.632, showed low laying and occasionally protruding Old Red Sandstone surrounded by coarse sands, pebbles and gravel. The characterizing epifauna comprised Balanidae, *Urticina sp., Sagartiidae, Tubularia sp.* with small cluster of *S. spinulosa.* Sections of RR_T06 where the bedrock was noted were classified as Annex I (1170) – Potential Bedrock Reefs due to the low degreed of bedrock visible (Irving, 2009). The surrounding coarse sands were classified as A5.15.

Grab sample site S29, at approximate KP 23.942, was located in A5.15. The infaunal assemblage was characterised by echinoderm *E. pusillus,* polychaetes *Paradoneis lyra* and *Lumbrineris cingulate*, Nemertea and mollusc *Clausinella fasciata.* Small isolated clusters of *S. spinulosa* were present.

From KP 24.925 to KP 27.170 the seabed was predominantly classified as A5.142 - *Mediomastus fragilis*, *Lumbrineris spp*. and venerid bivalves in circalittoral coarse sand or gravel based on the findings at S27 at KP 26.991.

Transect RR_T07, crossing the final route at approximate KP 25.182, showed embedded coarse surface which was heavily silted. The characterizing fauna from the analysed imagery shows small *S. spinulosa* aggregations which are heavily silted and abraded, Balanidae, hydroids and bryozoans, *Tubularia sp., Ophiura albida* and Pectinidae.

Sections of A5.251 - *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand were classified from KP 25.438 to KP 25.684 and from KP 26.408 to KP 26.803.

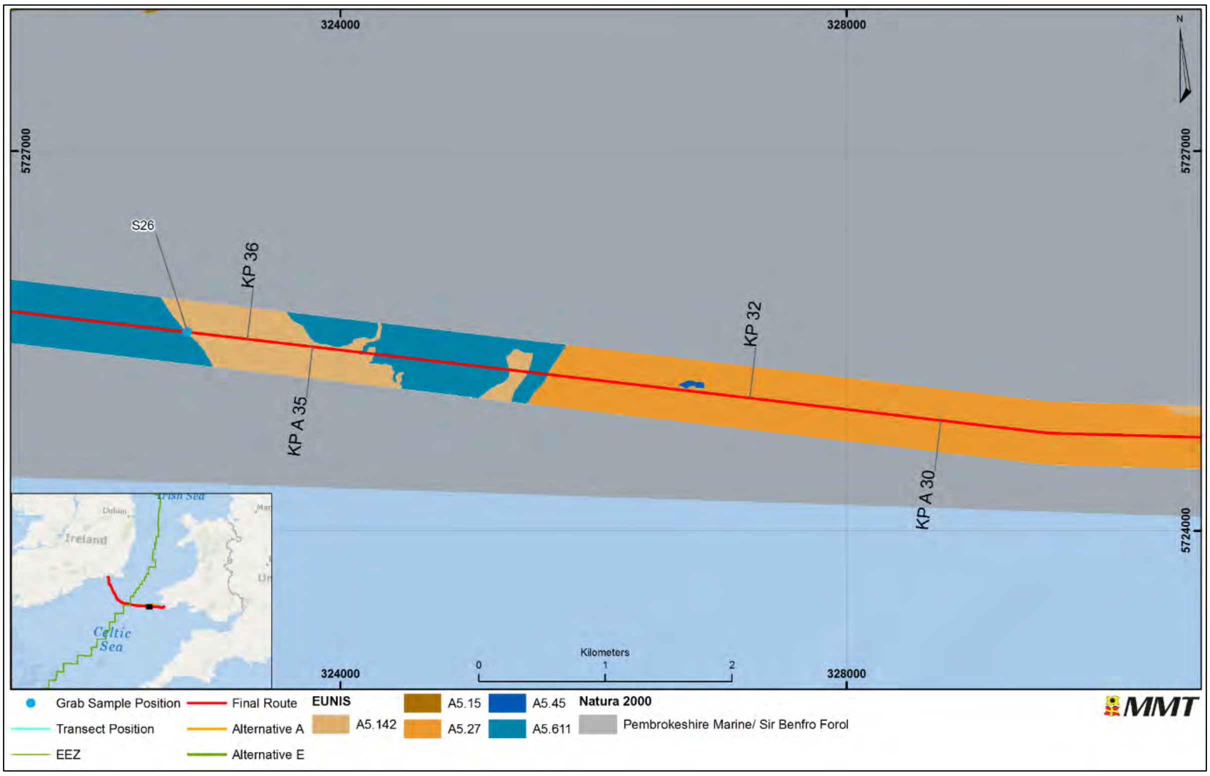


Figure 16 Overview of UK EEZ KP 28 to KP 37.

Grab sample site S28, at approximate KP 26.480, was located within A5.251 and was characterised by *echinoderm E. pusillus,* polychaetes *O. borealis* and *G. lapidum* and mollusc *C. fasciata.*

Transect A_T10, at approximate KP 26.601 and south of S28, was superficially similar to S28 in the analysed imagery. Epifauna was sparse and comprised small *S. spinulosa* presence, echinoderm *Marthasterias glacialis* and Paguridae.

Grab sample site S27, at approximate KP 26.26.989, was located within A5.142 and was characterised gravelly coarse sediments with echinoderm *Ophiura albida*, hydrozoa and bryozoans. The infaunal assemblage was characterised echinoderms *E. pusillus and Amphipholis squamata, numerous polychaetes* such as *Ampharete lindstroemi, Ampharete octocirrata, L. cingulate,* a high abundance of the amphipod *Ampelisca spinipes* as well as molluscs *Thracia villosiuscula*, *T. ovata* and *Diplodonta rotundata* Based on these characteristics the site was assessed to be a close match to A5.142.

From KP 27.170 to KP 28.287 the seabed transitioned between A5.142 and A5.27 - Deep circalittoral sand. From KP 28.287 the habitat A5.27 becomes the dominating habitat throughout the route corridor to KP 33.607. A small section of A5.45 - Deep circalittoral mixed sediments is interpreted to be present between KP 32.367 and KP 32.570. The habitat classified within these sections as A5.27 and A5.45 re based on the interpretations of the geophysical data.

From KP 33.607 to KP 58.587 the route corridor is predominantly classified into large sections as A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment but is interrupted by areas of A5.142, A5.15 - Deep circalittoral coarse sediment, A5.27, and A4.221 - *Sabellaria spinulosa*, didemnid and small ascidians on tide-swept moderately wave exposed circalittoral rock.

From KP 33.607 to KP 35.100, habitat A5.611 dominates the final route. Between KP 35.100 and 36.485, adjacent to the boundary of A5.611, the seabed was classified as A5.142.

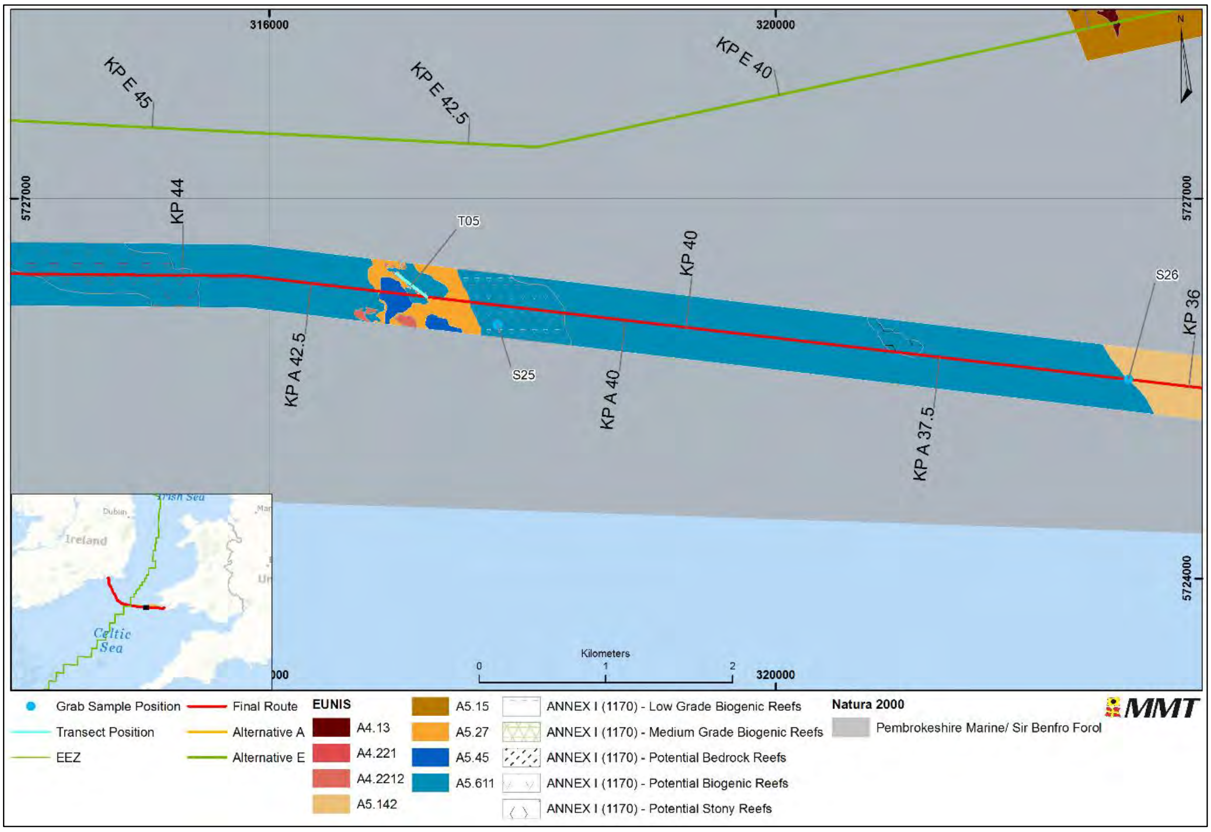


Figure 17 Overview of UK EEZ KP 36 to KP 45.

Grab sample site S26, at approximate KP 36.480, was located within habitat A5.142 (Figure 17). The substrate was composed of rippled coarse sands and gravel with pebbles, shells and *S. spinulosa* crusts in the ripple troughs. Fauna comprised *Lanice conchilegala* tubes, Actiniaria, Hydrozoa and echinoderm *Ophiura albida.* The infaunal assemblage was similar to S27 and characterised by echinoderm *E. pusillus*, and *A. squamata*, numerous polychaetes such as *A. lindstroemi*, *A. octocirrata*, *L. cingulata*, a high abundance of the amphipod *A. spinipes* as well as numerous molluscs *A. alba*, *Hiatella arctica, K. Suborbicularis* and *K. Bidentata*. Based on these characteristics the site was assessed to be a close match to A5.142.

From KP 36.485 to KP 41.720 the route corridor is dominated by A5.611. One area of A5.611, crossing the final route between KP 38.150 and KP 38.364 was interpreted as an Annex I (1170) – Potential Stony Reefs (Irving, 2009) due the density of cobbles and boulders interpreted from the geophysical data and its similarity to areas assessed between KP 40.957 and KP 42.634.

Between KP 40.961 and KP 41.721, one section of A5.611 was assessed to meet the criteria of Annex I (1170) – Low Grade Biogenic Reefs (Holt, 1998). Grab sample site S25 was located within this section and the infauna was dominated by *S. spinulosa* and other polychaetes. The analysed imagery showed silted mixed substrates with aggregations of *S. spinulosa* within distinct tube formations.

From KP 41.721 to KP 42.458 the dominating habitat was A5.27 with A5.611 crossing the route between 41.939 and 42.212. Patches of sand covered bedrock was identified crossing the final route between KP 42.066 and KP 42.106 and was classified as A4.2212. Habitat A4.2212 re-occurs north and south of the final route towards the outermost boundaries of the route corridor. A section of A5.45 crossed the final route between KP 42.212 and 42.430.

Transects T05, crossing the final route at approximate KP 42.061, showed rippled sand with high occurrences of *S. spinulosa* aggregation elevated from the surrounding seabed.

Sections of the transects classified as A4.2212 were assessed to meet the criteria of Annex I (1170) – Medium Grade Biogenic Reefs (Holt, 1998). The classification and reef assessment was extrapolated to the rocky areas at the northern most corridor boundary assessed to be of similar nature while the rocky areas as the southernmost corridor boundary indicate more flat bedrock and are possibly not colonised to the same extent thus those areas were assessed to be Annex I (1170) – Potential Biogenic Reefs (Holt et al, 1998).

Between KP 42.458 to KP 48.872 the route corridor was dominated by A5.611. Two areas crossing the final route between KP 43.911 and KP 45.234, and from KP 45.603 to KP 46.596 were assessed to be Annex I (1170) – Potential Biogenic Reefs (Holt, 1998) based on the texture difference seen in the geophysical data between these areas and the surrounding seabed classified as A5.611 and also with regards to the frequent occurrence of *S. spinulosa* at grab sample site S24.

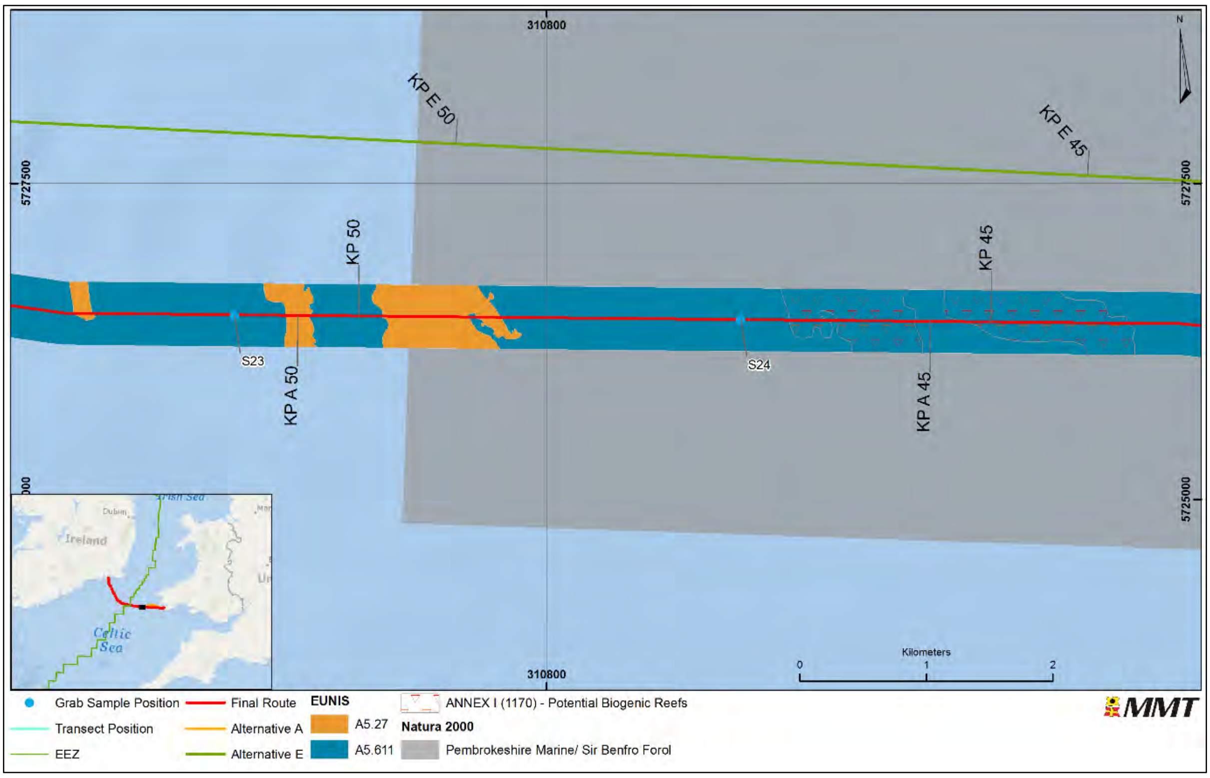


Figure 18 Overview of UK EEZ KP 44 to KP 53.

Grab sample site S24, at approximate KP 46.981, was located within habitat A5.611 (Figure 18). The visibility was poor at the current location and seabed comprised gravelly sand with *S. spinulosa* remnants and occasional cobbles and boulders. The infauna was characterised by an abundance of *S. spinulosa.* Other characterizing species were *A. lindstroemi, L. cingulate, Ampelisca spinipes, K. suborbicularis* and *K. suborbicularis.*

From KP 48.872 to KP 53.469 habitat A5.611 continued to dominate. Based on the geophysical interpretations, three locations (KP 48.872 to KP 49.824, KP 50.390 to KP 50.579, KP 52.098 to KP 52.255) crossing the final route were classified as A5.27.

Grab sample site S23, at approximate KP 50.981, was located within habitat A5.611. The substrate was dominated by coarse sand and gravel. The infauna was in line with the findings of S24 but showed lower abundances of the characterizing species.

Transect T04, crossing the final route at KP 53.305, and transect T04_X, located south of the final route at KP 53.305, were located within habitat A5.611 (Figure 19). The transects cover the same feature interpreted from geophysical data.

The analysed imagery, at T04 and T04_X, showed gravelly sediments with occasional cobbles and boulders. The gravelly sediments comprised *S. spinulosa* in the sediment, *Sabella sp.,* hydrozoans, actiniarians and bryozoans and different echinoderms. The cobbles and boulders are dominated by *Tubularia sp.,* hydrozoa and bryozoans and *Caryophyllia smithii*. The boulders within this transects could be classified as A4.111 but could not be delineated from the surrounding seabed in the geophysical data and was of small extent, and was thus not classified as A4.111.

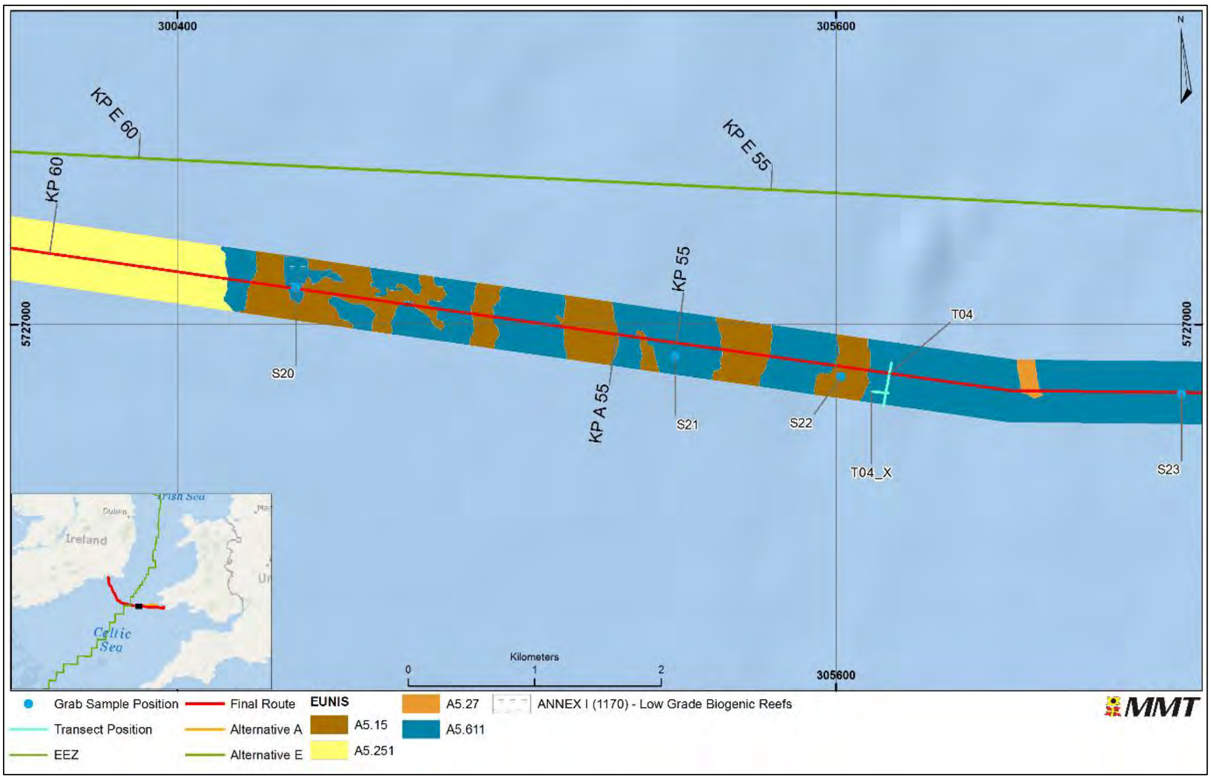


Figure 19 Overview of UK EEZ KP 51 to KP 60.

Between KP 53.469 and KP 58.578 the area alternated between A5.15 and A5.611.

Grab sample site S22, at approximate KP 53.669, was located within habitat A5.15 with coarse sands and the infauna was dominated by echinoderm *Amphiura filiformis.*

Grab sample sites S21, at approximate KP 54.989, and S20, at approximate KP 58.036, were located within habitat A5.611. The substrate was characterised by coarse sands and gravel with *S. spinulosa* clusters in the sediment. The infaunal analysis of these sites showed that *S. spinulosa* occurred frequently at both locations but with a higher density in S20. Other characterizing taxa were echinoderm *A. filiformis, and polychaetes Owenia sp.* and *L. cingulate.*

Grab sample site S20 and the surrounding seabed, crossing the final route, from KP 57.984 to KP 58.113 was further assed to meet the criteria of Annex I (1170) – Low Grade Biogenic Reefs (Holt, 1998).

From KP 58.579 to KP 73.906 the seabed was composed of fine rippled sands and classified predominantly as A5.251 (Figure 20). A section between KP 65.660 and KP 70.350 was classified as A5.272 - Owenia fusiformis and Amphiura filiformis in deep circalittoral sand or muddy sand.

Figure 20 Overview of UK EEZ KP 58 to KP 75.

Grab sample site S19, at approximate KP 61.481, was located within habitat A5.251. The infaunal composition was characterised by echinoderm *E. pusillus,* polychaetes *O. borealis, L. cingulate* and Nemertea.

From KP 65.660 to KP 70.350 the seabed was composed of sands with sand waves and large ripples and was classified as A5.272. Grab sample site S18, at approximate KP 66.982, was located within habitat A5.272. The infaunal composition was characterised by echinoderm *A. filiformis,* polychaetes *L. cingulate* and Owenia sp. and Nemertea.

Grab sample site S17, at approximate KP 71.485, was located within habitat A5.251. The infaunal composition was characterised by echinoderms *A. filiformis, E. pusillus,* polychaetes *O. borealis,* and *L. cingulate.*

5.1.2| ROUTE A

Route A diverges from the final route at approximate KP 8.881 (FR KP 8.680) and converges with the final route at approximate KP 24.905 (FR KP 25.385).

From KP 8.881 to KP 22.327 the seabed is dominated by bedrock across the route corridor with channels of homogenous coarse sands, cobbles and gravel (Figure 12).

From KP 8.885 to KP 9.150 and from KP 9.818 to KP 10.340, two areas with sand and coarse sediment were classified as Annex I (1110) - Sandbanks which are slightly covered by sea water all the time.

Along Route A, from KP 10.340 to KP 11.474, the seabed was classified A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments with habitat A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock between KP 10.868 and KP 11.245.

From KP 11.245 to KP 13.525 a large section of bedrock was classified as A4.221 - *Sabellaria spinulosa* encrusted circalittoral rock and in parts assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009) (Figure 13).

The bedrock is characterised by channels of A4.213. Several areas of this bedrock are heavily covered by mobile sediments and have thus been classified as Annex I (1170) – Potential Bedrock Reefs (Irving, 2009).

Transect A_T01, crossing Route A at approximate KP 12.038, showed *S. spinulosa* crust on the bedrock with hydrozoans, bryozoans, *Urticina sp.,* and Ascidiacea on the intermediate cobble substrate and was located within habitat A4.221 and further assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009).

From KP 13.525 to KP 14.731 the bedrock was surrounded by habitat A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. The bedrock within this section was classified as A4.241 - *Mytilus edulis* beds with hydroids and ascidians on tide-swept exposed to moderately wave-exposed circalittoral rock and was further assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009).

Transect A_T02, crossing Route A at approximate KP 13.626, showed an abundance of *Mytilus edulis*, occasional small *S. spinulosa* crusts, *Urticina sp.,* Ascidian *Dendrodoa grossularia*, hydrozoans and bryozoans. Transect A_T02 was located within habitat A4.241 and further assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009).

From KP 14.731 to KP 16.056 the bedrock was classified as a habitat complex of and A4.241. The majority of the bedrock was assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009) with some areas that appear sediment covered which were thus classified as Annex I (1170) – Potential Bedrock Reefs. The channel between the outcropping bedrock was classified as A4.213.

Transects A_T03, crossing Route A at approximate KP 15.082, and A_T04, crossing Route A at approximate KP 15.635, were located within habitat complex A4.213/ A4.241 and assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009). The bedrock was characterised by numerous species with a dense presence of Mytilids, patches of *S. spinulosa* between the Mytilids, crustaceans, Balanidae, hydrozoans, bryozoans, *Pentapora foliacea,* Ascidiacea, Didemnidae and porifernas.

The habitat was assigned as a complex of A4.213 and A4.241 as the individual habitat boundaries could not be delimited from the geophysical data.

Two areas, between KP 16.140 and KP 16.712 within habitat A4.213, based on the epifaunal coverage in the area and the density of boulders and cobbles interpreted from the geophysical data, were also classified as Annex I (1170) – Potential Stony Reefs (Irving, 2009).

From KP 16.786 to KP 18.906, the seabed south of Route A was primarily classified as A4.213 while the seabed north of Route A was primarily classified as A4.21 - Echinoderms and crustose communities on circalittoral rock (Figure 14).

Transects A_T05, crossing Route A at approximate KP 17.500, A_T06, crossing Route A at approximate KP 17.950 and A_T07, crossing Route A at approximate KP 18.583 were located crossing habitats A4.213 and A4.21. Areas of A4.21 within this section was assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009) while areas of A4.213 were in some areas classified as Annex I (1170) – Potential Bedrock Reefs.

The imagery analyses of A_T05 – T07 showed gravelly coarse sediments in the southern sections of the transects with *Urticina sp.* while the northern parts on bedrock were characterised by hydrozoans and bryozoan turf, numerous *Urticina sp.,* Sagartiidae*, Caryophyllia sp., Tubularia sp.,* occasional clusters of *S. spinulosa*, Balanidae, Ascidiacea, *Crossaster papposus* and *Marthasterias glacialis*.

Between KP 18.906 and KP 22.316 was classified as A4.2212 - *Sabellaria spinulosa*, didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock and was assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009). Channels of A5.45 – Deep circalittoral mixed sediments were classified on the bedrock with areas of A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment from KP 19.847 to KP 22.627.

Transects A_T08, crossing Route A at approximate KP 19.717, and A_T09, crossing Route A at approximate KP 21.731, were located within habitat A4.2212 and were characterised by dense cluster of *S. spinulosa, Alcyonidium diaphanum, Cellaria sp., Pentapora foliacea,* Ascidians*, Caryophyllia sp.,* Sagartiidae, *Urticina sp.* and porifernas.

Between KP 22.627 to KP 24.528 the seabed was classified as A5.15 - Deep circalittoral coarse sediment, and from KP 24.528 to 24.905 the seabed was classified as A5.142 - Mediomastus fragilis, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel.

5.1.3| ALTERNATIVE E

Route Alternative E diverges from the final route at approximate KP 13.376 (Final Route KP 13.175) and converges with the final route at approximate KP 69.227 (FR KP 68.598). However, the survey only extended to approximate KP 37.608.

Form KP 13.376 to KP 14.676 the seabed was classified as A5.451 - Polychaete-rich deep Venus community in offshore mixed sediments (Figure 21).

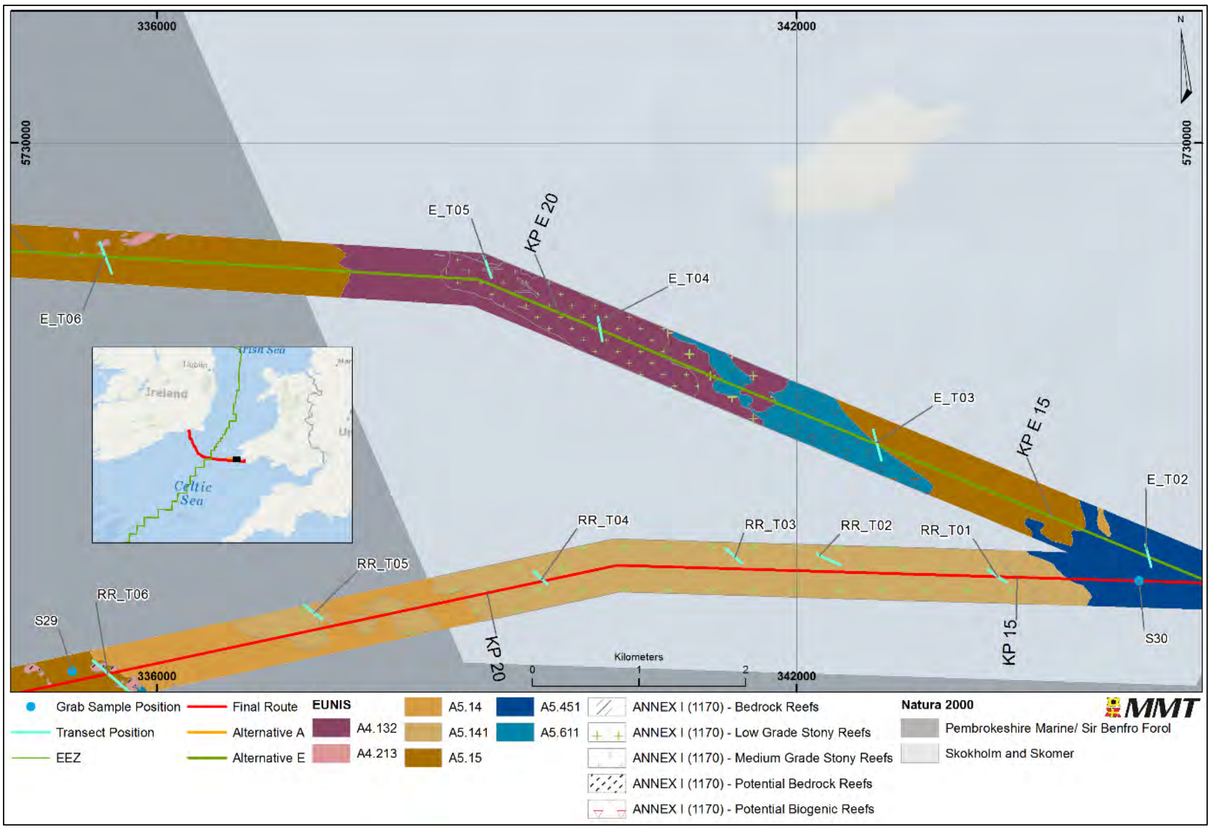


Figure 21 Overview of Alternative E in UK EEZ KP 13 to KP 25.

Transects E_T02, crossing Alternative E at approximate KP 14.017, was located within habitat A5.451. The analysed imagery showed silty gravelly sediment with Ostrea and Mytilid shells.

From KP 14.676 to KP 16.754 the seabed comprised rippled sands and was classified as A5.15 - Deep circalittoral coarse sediment, becoming coarser between KP 16.754 and KP 18.139 which was classified as A5.611 - *Sabellaria spinulosa* on stable circalittoral mixed sediment.

Transects E_T03, crossing Alternative E at approximate KP 16.769, was located to the north in habitat A5.15 and to the south in habitat A5.611.

The analysed imagery showed homogenous fine shell gravel to the north and *S. spinulosa* cluster south of Alternative E. Habitat A5.611, between KP 16.754 and KP 18.139 was further classified as Annex I (1170) – Potential Biogenic Reefs (Holt et al, 1998).

Areas classified as A4.132 - *Corynactis* viridis and a mixed turf of crisiids, Bugula, Scrupocellaria, and Cellaria on moderately tide-swept exposed circalittoral rock were identified from KP 17.805 to KP 22.015. One section of habitat A4.132, between KP 17.805 and KP 18.924, was further assessed to meet the criteria of Annex I (1170) – Low Grade Stony Reefs while a second section between KP 18.924 and KP 21.167 was asses to meet the Annex I (1170) – Medium Grade Stony Reefs (Irving, 2009).

Transects E_T04, crossing Alternative E at approximate KP 19.589, and E_T05, at approximate KP 20.762, were located within habitat A4.13 (Stony Reefs). The seabed was characterised by large boulders and cobbles with a hydrozoan and bryozoan turf, *Flustra foliacea,* Galatheidae, Ascidiacea, abundance of *Corynactis sp.* and Parazoanthidae with porifernas.

From KP 22.015 to KP 26.287 the seabed was classified as A5.15, with patches of outcropping bedrock between KP 24.329 and KP 24.634 classified as A4.213 - *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock. The bedrock areas were further assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009).

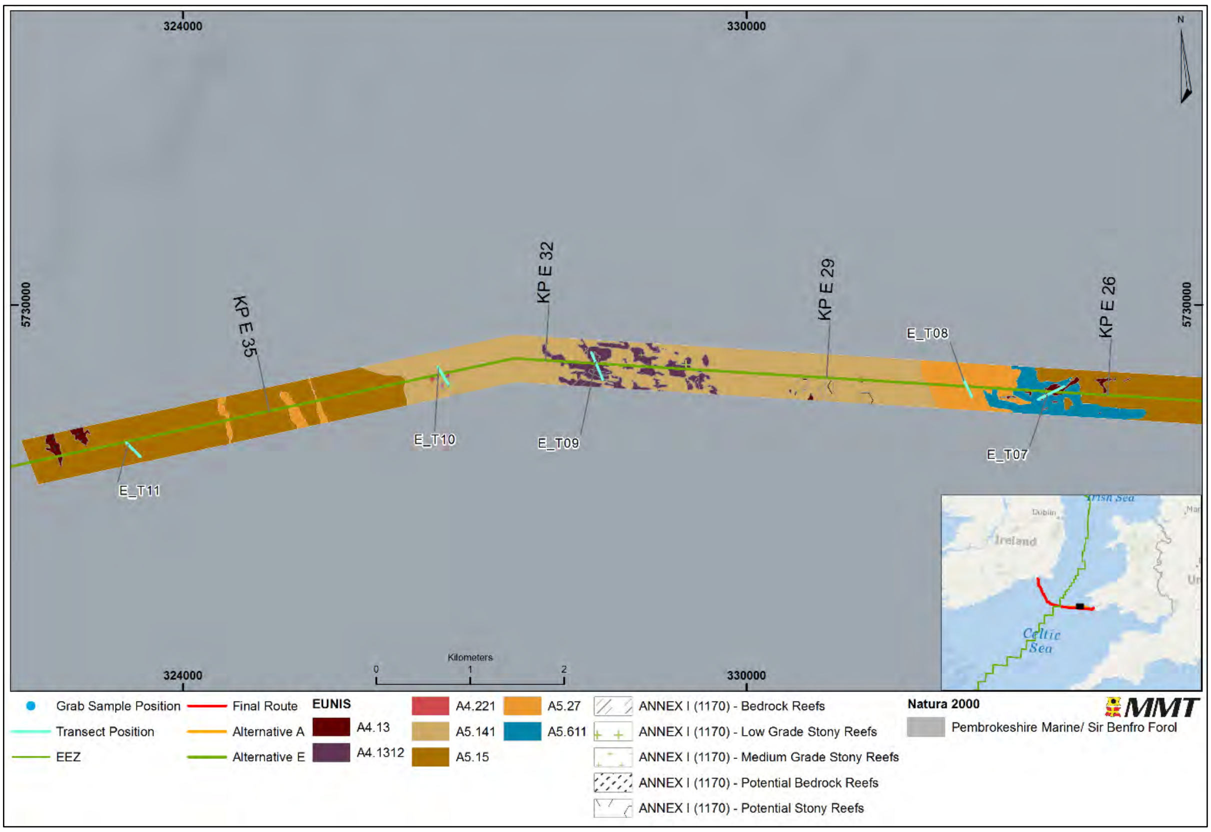


Figure 22 Overview of Alternative E in UK EEZ KP 25 to KP 37.

Transects E_T06, crossing Alternative E at approximate KP 24.322 was located predominantly in habitat A5.15 but crosses areas of A4.213. The rocky areas of the transect were characterised by Ascidiacea, *Tubularia sp., Urticina sp.* with and hydrozoans and bryozoans.

From KP 26.287 to KP 26.987 was classified as A5.611 followed by A5.27 - Deep circalittoral sand between KP 26.987 and KP 27.927. An area of outcropping bedrock, KP 26.475 to KP 26.646 was classified as A4.13 - Mixed faunal turf communities on circalittoral rock and further assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009) (Figure 22).

Transects E_T07, crossing Alternative E at approximate KP 26.594, was located within habitat A4.13. The rocky areas of the transect were characterised by Balanidae, small crusts of *S. spinulosa*, *F. foliacea, Urticina sp., Tubularia sp., Mytilus sp.,* hydrozoans and bryozoans as well as poriferans.

Transects E_T08, crossing Alternative E at approximate KP 27.505, was located within habitat A5.27. The seabed was characterised by silty sand with occasional buried cobbles and boulders. Sparse abraded *S. spinulosa* aggregations and *Mytilus sp.* were noted as well as *Urticina sp*. on the rocky substrate.

From KP 26.987 to KP 33.516 the seabed was predominantly classified as A5.141 - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles.

Between KP 28.489 and KP 29.312, four areas within habitat A5.141 were classified, based on geophysical interpretations, as Annex I (1170) – Potential Stony Reefs (Irving, 2009). The geophysical data was interpreted to show similar texture and topography as the seabed at transect E_T09. A few scattered outcrops of bedrock, at southern most edge of the corridor boundary at KP 29.236, were classified as A4.13 and Annex I (1170) – Potential Bedrock Reefs (Irving, 2009).

Between KP 30.255 and KP 32.036 the corridor was classified as A4.13 surrounded by A5.141. The rocky areas classified as A4.13 were further assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009).

Transects E_T09, crossing Alternative E at approximate KP 31.457, was located within habitat A4.13 and characterised by a hydrozoan and bryozoan turf with Ascidiacea, *Caryophyllia smithii*, *Corynactis sp.,* Sagartiidae and porifernas.

From KP 33.025 to KP 33.278 rocky areas were identified and classified as A4.221 - *Sabellaria spinulosa* encrusted circalittoral rock which were further assessed to meet the criteria of Annex I (1170) – Low Grade Stony Reefs (Irving, 2009) interrupted by A5.141.

Transect E_T10, crossing Alternative E at approximate KP 33.116, was located within habitats A4.221 and A5.141. The transect was characterised by coarse sediments and bedrock with *S. spinulosa*, Balanidae, Ascidiacea, *Corynactis sp., Urticina sp.* and Sagartiidae.

From KP 33.516 to KP 37.608 the seabed was predominantly classified as A5.15 with intrusions of A5.27 – Deep circalittoral sand.

Transect E_T11, Alternative E at approximate KP 36.561, was located within habitats A5.15 and was characterised by coarse, gravelly mixed sediment with sparse Tubularia sp. and Sertularioidea.

An area of outcropping bedrock was identified between KP 36.869 and KP 37.317 and was classified as A4.13 and Annex I (1170) – Potential Bedrock Reefs (Irving, 2009) based in the interpretations of the geophysical data.

5.2| SEDIMENT PARTICLE SIZE DISTRIBUTION

Samples for sediment particle distribution were acquired along the Final Route only. The full laboratory analyses results are presented in Appendix F|.

The results of the particle size analysis show that the sediment at the grab sample sites consisted mainly of coarse sediment. The main component in the sediment was sand, amounting to an average of 69 ± 22 % of the total sediment, together with gravel (25 ±22 %). However, the proportions of the two varied greatly (Figure 23 and Table 21). The mud content (clay and silt) was low throughout all of the samples (6 ± 4 %).

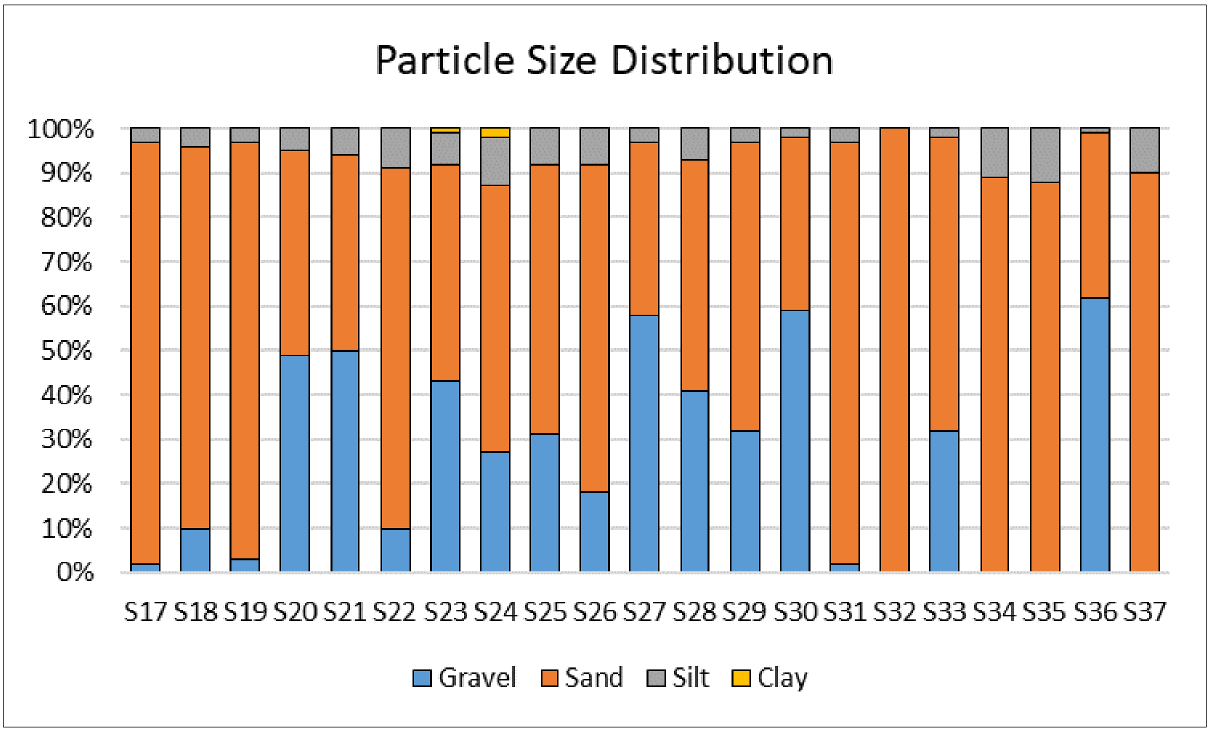


Figure 23 Bar chart displaying sediment fraction distribution across all grab sample sites.

Table 21 Summary of sediment distribution across all grab sample sites in the Wales area.

GRAB SAMPLE ID	AREA	DEPTH	SEDIMENT FRACTION				MUD (CLAY & SILT)	FOLK
			GRAVEL	SAND	SILT	CLAY		
S17	UK	114	2	95	3	0	3	Sand
S18	UK	116	10	86	4	0	4	Gravelly muddy sand
S19	UK	111	3	94	3	0	3	Sand
S20	UK	115	49	46	5	0	5	Sandy gravel
S21	UK	119	50	44	6	0	6	Sandy gravel
S22	UK	127	10	81	9	0	9	Gravelly muddy sand
S23	UK	107	43	49	7	1	8	Gravelly muddy sand
S24	UK	84	27	60	11	2	13	Gravelly muddy sand
S25	UK	67	31	61	8	0	8	Gravelly muddy sand
S26	UK	63	18	74	8	0	8	Gravelly muddy sand

GRAB SAMPLE ID	AREA	DEPTH	SEDIMENT FRACTION				MUD (CLAY & SILT)	FOLK
			GRAVEL	SAND	SILT	CLAY		
S27	UK	58	58	39	3	0	3	Sandy gravel
S28	UK	59	41	52	7	0	7	Gravely muddy sand
S29	UK	55	32	65	3	0	3	Gravelly sand
S30	UK	49	59	39	2	0	2	Sandy gravel
S31	UK	47	2	95	3	0	3	Sand
S32	UK	31	0	100	0	0	0	Sand
S33	UK	35	32	66	2	0	2	Gravelly sand
S34	UK	31	0	89	11	0	11	Muddy sand
S35	UK	29	0	88	12	0	12	Muddy sand
S36	UK	27	62	37	1	0	1	Sandy gravel
S37	UK	19	0	90	10	0	10	Muddy sand
Mean			**25**	**69**	**6**	**0**	**6**	**-**
SD			**22**	**22**	**4**	**0**	**4**	**-**
Min			**0**	**37**	**0**	**0**	**0**	**-**
Max			**62**	**100**	**12**	**2**	**13**	**-**
Median			**27**	**66**	**5**	**0**	**5**	**-**

5.2.1| MULTIVARIATE ANALYSES FOR SEDIMENT

Multivariate analyses were undertaken on the PSA data set, to identify spatial patterns in the sediment distribution. Analyses included hierarchical clustering employing the Euclidean distance resemblance matrix and the principal component analysis (PCA). The dataset was normalised prior to analysis being undertaken.

The results from the hierarchical clustering analysis are presented in Figure 24 and Figure 25.

The SIMPROF analysis for the PSD output identified eight groups (black lines) separating the 20 grab sample sites within the survey area. Of these 20 groups, four sub-groups were identified with similar characteristics.

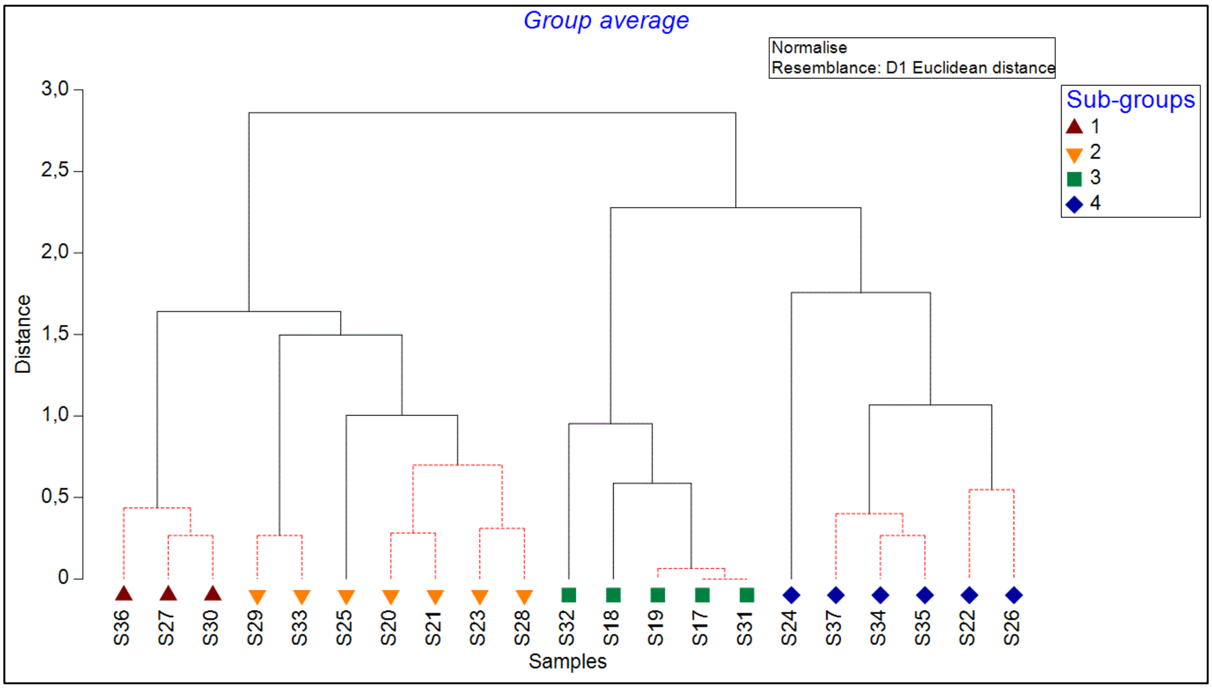


Figure 24 SIMPROF dendrogram based on sediment composition for each grab sample site.

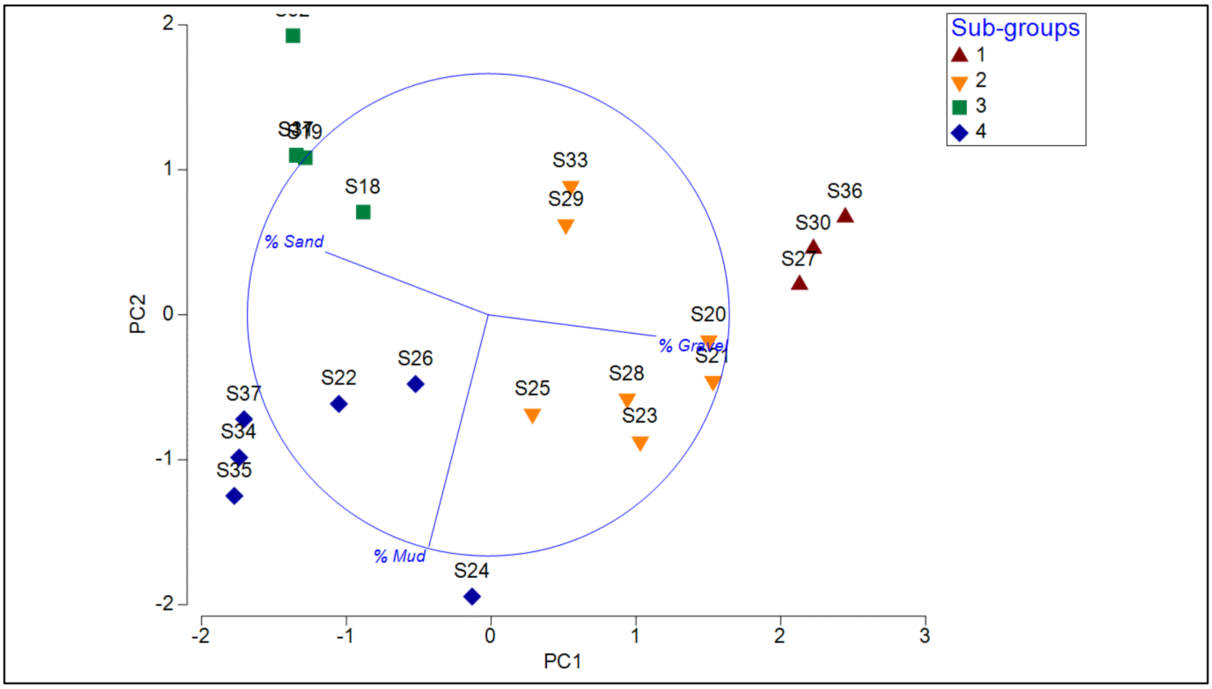


Figure 25 PCA plot of sediment data for each grab sample site, groups based on SIMPROF.

5.3| CHEMICAL ANALYSES

All grab sample sites were selected for analyses of concentration of metals, organics and PAHs. Detailed results from the chemical analyses are stated in Appendix G|. Grab samples for chemical analyses were not received from site S20, S21, S24, S25, S27, S29, S32 and S36 due to insufficient sample volume.

5.3.1| METALS

Metal concentrations were low across all grab sample sites and rarely exceeded any threshold values with the exception of Arsenic (As) that exceeded CCME ISQG threshold value for all sites except S17, S35 and S37 (Figure 26 and Table 22).

Table 22 Summary of metal concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.
Highlighted cells indicate where threshold values have been exceeded.

ANALYTE	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	TIN
Limit of Detection	1	0.1	0.5	2	2	0.01	0.5	0.5
OSPAR ERL	-	1.2	81	34	47	0.15	-	-
CEFAS AL2	100	5	400	400	500	3	200	-
CEFAS AL1	20	0.4	40	40	50	0.3	20	-
CCME PEL	41.6	4.2	160	108	112	0.7	-	-
CCME ISQG	7.24	0.7	52.3	18.7	30.2	0.13	-	-
Dutch RIVM	85	14	380	240	580	10	210	-
Units	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
S17	6.1	<0.1	15.3	7.5	12.1	<0.01	8.9	0.6
S18	11.6	<0.1	12.6	7	15.1	<0.01	6.5	2.8
S19	9.2	<0.1	21.3	8.6	13.9	<0.01	11.1	1.1
S22	16	<0.1	25.3	8.3	18.4	0.01	16.9	1.2
S23	7.4	<0.1	10.7	5.5	7.3	0.01	6.3	0.7
S26	7.7	<0.1	19.2	15	11.6	0.01	9.9	1.1
S28	9.3	0.1	14.6	7	7.8	<0.01	10	0.6
S30	12.8	0.1	15.8	8.6	7.9	<0.01	15.9	0.8
S31	9.9	<0.1	9.5	7.2	8.5	<0.01	5.7	<0.5
S33	10.9	<0.1	3.2	5.3	9.6	<0.01	5.7	0.7
S34	8.8	<0.1	17.2	9.5	10.9	<0.01	9.1	0.7
S35	6.8	<0.1	15.2	8.1	11.3	0.02	7.1	0.7
S37	6.7	<0.1	21.7	8.4	9.8	0.01	6.5	0.7
Mean	**9.5**	**0.0**	**15.5**	**8.2**	**11.1**	**0.00**	**9.2**	**0.9**
SD	**2.8**	**0.0**	**5.8**	**2.4**	**3.2**	**0.00**	**3.7**	**0.6**
Min	**6.1**	**0.1**	**3.2**	**5.3**	**7.3**	**0.01**	**5.7**	**0.6**
Max	**16.0**	**0.1**	**25.3**	**15.0**	**18.4**	**0.02**	**16.9**	**2.8**
Median	**9.2**	**0.1**	**15.3**	**8.1**	**10.9**	**0.01**	**8.9**	**0.7**

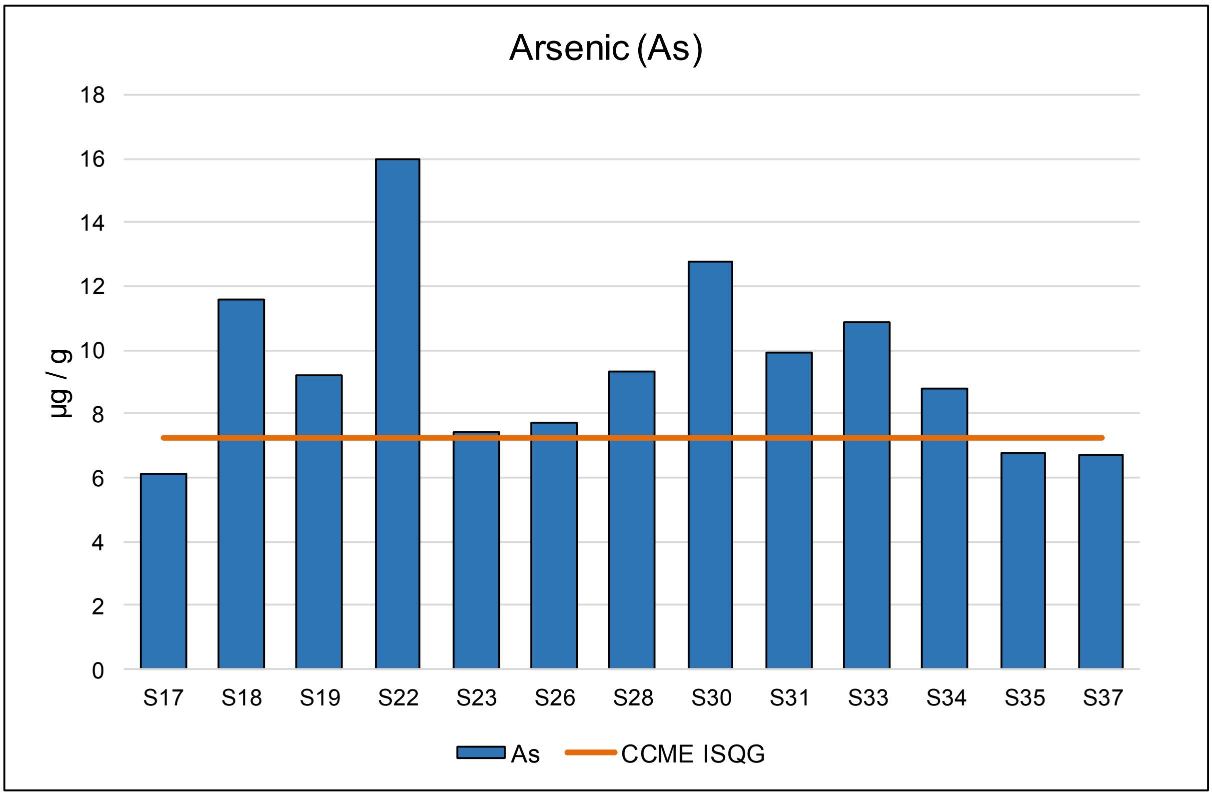


Figure 26 Arsenic (As) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values for CCME ISQG.

5.3.2| ORGANICS AND MOISTURE

Concentrations of organics and moisture content showed moderate variation between grab sample sites (Table 23).

Table 23 Summary of organics and moisture concentrations in sediment across grab sample sites.

ANALYTE	TOC	LOI	MOISTURE
Limits of detection	0.02	0.2	0.2
Units	%	%	%
S17	0.14	1.4	26.0
S18	0.24	1.7	29.4
S19	0.17	1.9	29.0
S22	0.30	2.3	29.8
S23	0.34	2.3	24.2
S26	0.32	1.5	24.0
S28	0.10	0.8	21.8
S30	0.17	1.4	24.2
S31	0.20	1.0	26.7
S33	0.38	1.9	16.0
S34	0.18	1.0	27.9
S35	0.21	1.0	28.0
S37	0.24	1.1	23.6
Mean	**0.23**	**1.5**	**25.4**
SD	**0.08**	**0.5**	**3.6**
Min	**0.10**	**0.8**	**16.0**
Max	**0.38**	**2.3**	**29.8**
Median	**0.21**	**1.4**	**26.0**

5.3.3| PAH

Concentrations of PAH’s varied greatly between grab samples sites (Table 24). Grab sample sites S22, S23 and S37 had markedly higher concentrations of PAH’s, whereas grab sample sites S28 had markedly low concentrations. Threshold values were exceeded at grab sample site S33 for naphthalene (36.1 µg/Kg) for CCME ISQG (34.6 µg/Kg).

Table 24 Summary of PAH concentrations (µg/Kg dry weight) across grab sample sites. Highlighted cells indicate where threshold values have been exceeded.

ANALYTE	NAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	DIBENZOTHIOPHENE	ANTHRACENE	FLUORANTHENE	PYRENE	BENZO[A]ANTHRACENE	CHRYSENE	BENZO[B]FLUORANTHENE	BENZO[K]FLUORANTHENE	BENZO[E]PYRENE	BENZO[A]PYRENE	INDENO[123,CD]PYRENE	DIBENZO[A,H]ANTHRACENE	BENZO[GHI]PERYLENE	SUM OF ALL
LIMIT OF DETECTION	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
OSPAR ERL	160	-	-	-	240	190	85	600	665	-	384	-	-	-	430	240	-	85	-
CEFAS AL1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-
CCME PEL	391	128	88.9	144	544	-	245	1494	1398	693	846	-	-	-	763	-	135	-	-
CCME ISQG	34.6	5.87	6.71	21.2	86.7	-	46.9	113	153	74.8	108	-	-	-	88.8	-	6.22	-	-
UNITS	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg
S17	3.64	<1	<1	1.89	5.40	<1	<1	6.47	4.50	2.74	4.70	5.77	3.33	4.50	3.30	5.19	1.04	5.16	57.63
S18	2.50	<1	<1	1.11	3.41	<1	<1	3.84	2.78	1.54	2.91	3.65	1.82	2.69	2.01	3.28	<1	2.95	34.49
S19	1.11	<1	<1	<1	1.68	<1	<1	1.86	1.37	<1	1.47	1.68	<1	1.39	<1	1.25	<1	1.47	13.28
S22	5.13	<1	1.28	2.82	10.90	1.33	2.32	15.1	11.40	6.84	10.50	10.10	4.06	7.56	7.34	7.77	1.62	7.81	113.88
S23	9.20	1.20	1.43	4.54	14.30	2.08	3.20	20.2	14.4	10.30	16.0	15.40	9.54	12.80	10.70	13.60	2.96	13.00	174.85
S26	6.45	<1	1.27	2.93	10.4	1.44	2.01	11.6	9.11	5.35	8.69	9.71	3.30	7.40	5.73	6.95	1.57	6.58	100.46
S28	<1	<1	<1	<1	<1	<1	<1	1.07	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.07
S30	1.98	<1	<1	<1	2.43	<1	<1	2.12	1.54	<1	2.09	1.84	1.08	1.45	<1	1.38	<1	1.61	17.52

ANALYTE	NAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	DIBENZOTHIOPHENE	ANTHRACENE	FLUORANTHENE	PYRENE	BENZO[A]ANTHRACENE	CHRYSENE	BENZO[B]FLUORANTHENE	BENZO[K]FLUORANTHENE	BENZO[E]PYRENE	BENZO[A]PYRENE	INDENO[123,CD]PYRENE	DIBENZO[A,H]ANTHRACENE	BENZO[GHI]PERYLENE	SUM OF ALL
LIMIT OF DETECTION	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
OSPAR ERL	160	-	-	-	240	190	85	600	665	-	384	-	-	-	430	240	-	85	-
CEFAS AL1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-
CCME PEL	391	128	88.9	144	544	-	245	1494	1398	693	846	-	-	-	763	-	135	-	-
CCME ISQG	34.6	5.87	6.71	21.2	86.7	-	46.9	113	153	74.8	108	-	-	-	88.8	-	6.22	-	-
UNITS	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg
S31	2.36	<1	<1	<1	2.67	<1	<1	2.38	2.05	1.22	2.11	2.34	1.18	1.70	1.30	1.67	<1	1.62	22.59
S33	36.1	<1	2.31	3.42	16.1	2.75	<1	1.95	1.73	1.22	3.77	2.21	<1	1.70	<1	1.08	<1	1.28	75.63
S34	1.07	<1	<1	<1	1.32	<1	<1	1.44	1.04	<1	1.38	1.53	1.00	1.42	1.08	1.42	<1	1.38	14.06
S35	1.38	<1	<1	<1	1.92	<1	<1	1.77	1.24	<1	1.64	1.99	1.31	1.53	<1	1.51	<1	1.48	15.77
S37	1.31	<1	4.44	3.78	14.1	1.29	2.11	20.8	13.9	9.55	14.4	13.8	5.65	9.73	10.4	7.87	2.07	7.36	142.58
Mean	**5.56**	**0.09**	**0.82**	**1.58**	**6.51**	**0.68**	**0.74**	**6.96**	**5.00**	**2.98**	**5.36**	**5.39**	**2.48**	**4.14**	**3.22**	**4.07**	**0.71**	**3.98**	**60.29**
SD	**9.80**	**-**	**1.35**	**1.15**	**5.68**	**0.63**	**0.54**	**7.37**	**5.24**	**3.74**	**5.27**	**5.09**	**2.70**	**3.93**	**3.93**	**3.95**	**0.72**	**3.73**	**56.55**
Min	**1.07**	**1.20**	**1.27**	**1.11**	**1.32**	**1.29**	**2.01**	**1.07**	**1.04**	**1.22**	**1.38**	**1.53**	**1.00**	**1.39**	**1.08**	**1.08**	**1.04**	**1.28**	**1.07**
Max	**36.12**	**1.20**	**4.44**	**4.54**	**16.08**	**2.75**	**3.20**	**20.76**	**14.40**	**10.30**	**16.00**	**15.40**	**9.54**	**12.80**	**10.70**	**13.60**	**2.96**	**13.00**	**174.85**
Median	**2.43**	**1.20**	**1.43**	**2.93**	**4.41**	**1.44**	**2.21**	**2.38**	**2.41**	**4.04**	**3.34**	**3.00**	**2.56**	**2.19**	**4.52**	**2.47**	**1.62**	**2.28**	**34.49**

5.4| MULTIVARIATE ANALYSIS OF GRAB SAMPLES

Multivariate analysis was undertaken using the Plymouth Routines in PRIMER v7.0 statistical package (Clarke K. &., 2015). The statistical analyses are based on macrofaunal data derived from the taxonomic analysis of the grab samples at each location. All grab samples were located along the Final Route.

The SIMPROF analysis on faunal composition produced ten statistically distinct groups (black lines). Of these ten groups, three sub-groups were identified (Figure 27, Figure 28 and Table 25).

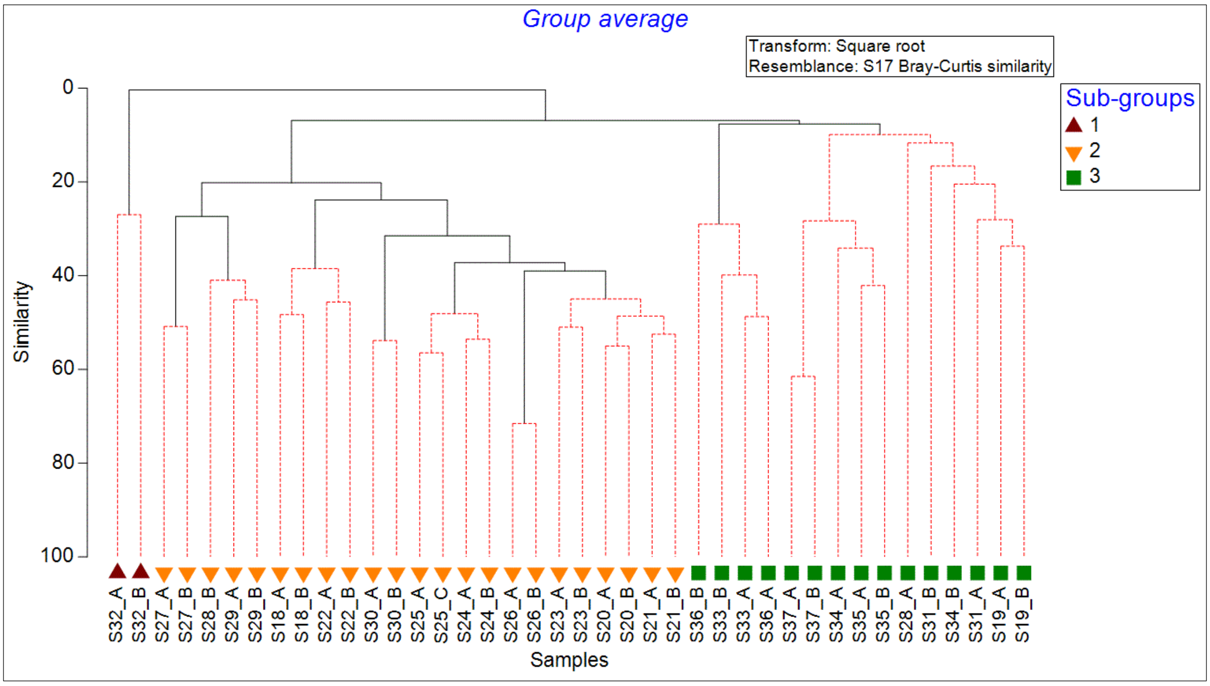


Figure 27 SIMPROF dendrogram based on faunal composition for each grab sample site and replicate.

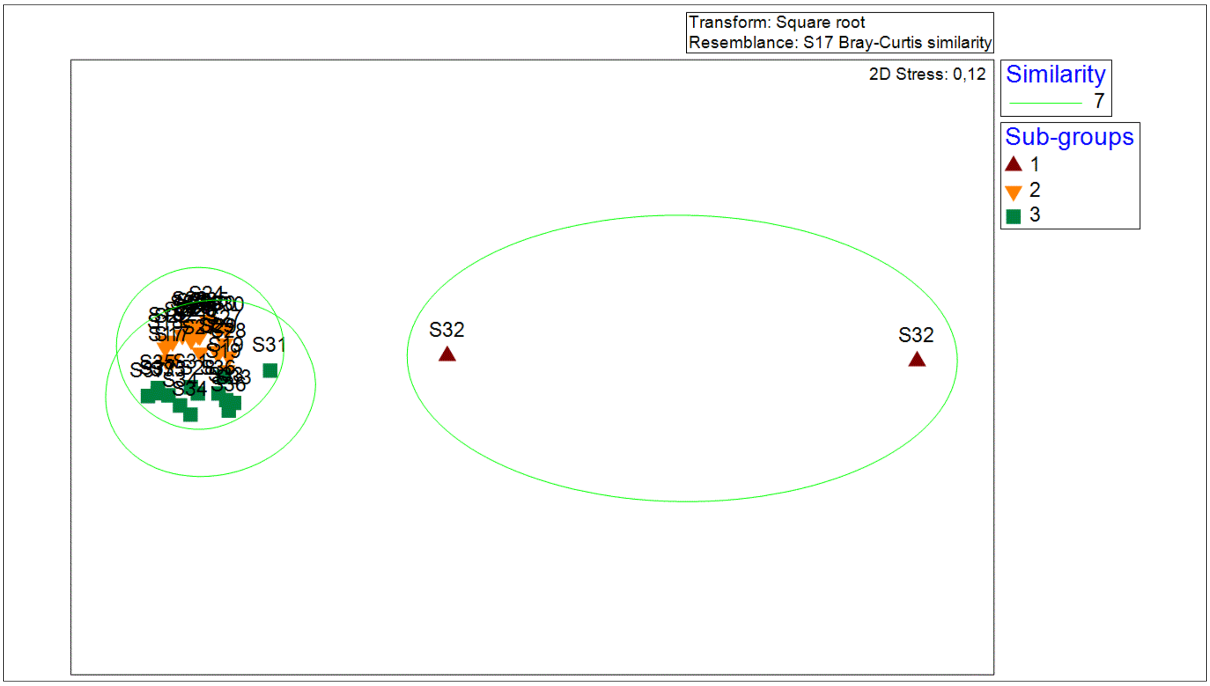


Figure 28 nMDS plot on faunal composition for each grab sample site and replicate, groups based on SIMPROF.

Group 1 consisted of both replicates from site S32 (S32_A, S32_B) and group 2 consisted of the majority of grab sample sites and group 3 was the group with the second most samples. There was no significant intra-variability within the replicates in the samples, except in sample S19 and S38, where one replicate (S19_A and S28_B) grouped into Group 2 and the other (S19_B and S28_A) grouped into Group 3. The highest average similarity was found in group 2 (26.32 %) and the lowest in group 3 (14.01 %). This low similarity within groups suggest a difference in faunal composition within the groups. Grab site S32 showed a big difference from the rest of the samples. This site was the only one with 100 % sand in the PSD, with a low diversity relative to the rest of the samples.

Table 25 Characteristics of groups identified by SIMPROF analysis on abundance of non-colonial fauna.

GROUP	SAMPLES	PHYSICAL FEATURES	SPECIES	AVERAGE ABUNDANCE	CONTRIBUTION (%)
1 Average Similarity: 26.98 %%	S32 (A&B)	Depth:31 m Sediment: Sand	*Gastrosaccus spinifer*	1	100
2 Average Similarity: 26.32 %	S17 (A&B) S18 (A&B) S19_A S20 (A&B) S21 (A&B) S22 (A&B) S23 (A&B) S24 (A&B) S25 (A&C) S26 (A&B) S27 (A&B) S28_B S29 (A&B)	Depth: 49 – 127 m Sediment: Gravelly muddy sand, Sandy gravel, Gravelly sand	*Echinocyamus pusillus* *Amphiura filiformis* *Lumbrineris cingulata* *Sabellaria spinulosa* Nemertea *Aspidosiphon muelleri* *Galathowenia oculata* *Modiolula phaseolina* *Ampharete lindstroemi* *Owenia sp.* *Ampelisca spinipes* *Kurtiella bidentata* *Glycera lapidum*	10.2 14.0 5.3 39.2 3.4 3.9 11.3 6.8 6.5 1.4 4.2 3.7 1.3	8.8 7.22 6.57 6.11 3.51 3.27 3.17 3.04 2.62 2.47 2.4 2.23 2

GROUP	SAMPLES	PHYSICAL FEATURES	SPECIES	AVERAGE ABUNDANCE	CONTRIBUTION (%)
	S30 (A&B)				
3 Average Similarity: 14.01 %	S19_B S28_A S31 (A&B) S33 (A&B) S34 (A&B) S35 (A&B) S36 (A&B) S37 (A&B)	Depth: 19 – 111 m Sediment: Muddy sand, Sand, Gravelly muddy sand, Sandy gravel, Gravelly sand	Nematoda *Timoclea ovata* *Abra alba* *Ophelia borealis* *Abra prismatica* Nemertea *Glycera lapidum* *Bathyporeia elegans*	1.4 1.0 6.4 1.1 0.7 0.4 0.6 0.7	25.19 11.95 9.55 6.32 5.81 5.15 4.44 4.19

The resulting EUNIS habitat classification for each site is presented in Figure 29. Sub-group 1, with grab sample site S32, was classified as A5.25. Sub-group 2, that contained most of the samples, included six different classifications (A5.142, A5.15, A5.251, A5.252, A5.451 and A5.611. Sub-group 3 contained five classifications (A5.143, A5.261, A5.25 A5.251 and A5.252). The different habitats do not have a strong relation to the identified sub-groups. EUNIS habitat classification A5.611 and A5.143 were the only two habitats (of those habitats that were found in more than one grab sample site) that were grouped in the same sub-group by the SIMPROF analysis.

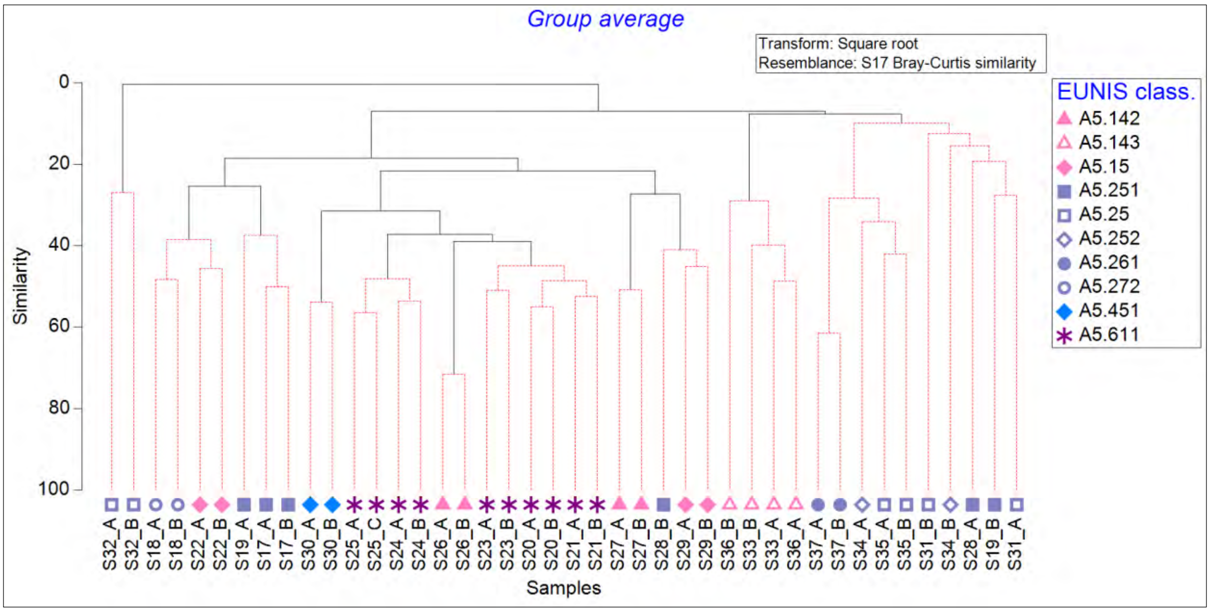


Figure 29 SIMPROF dendrogram based on faunal composition with EUNIS habitat classification overlay for each grab sample site and replicate.

5.5| POTENTIAL AREAS AND SPECIES OF CONSERVATION

The habitats in the UK EEZ corresponding to those defined in the EC Habitats directive (EUR 27, 2007) are listed in separate sections for each route alternative.

Figures displaying detailed overview of the potential areas of conservation concern is displayed in Figure 30 to Figure 37.

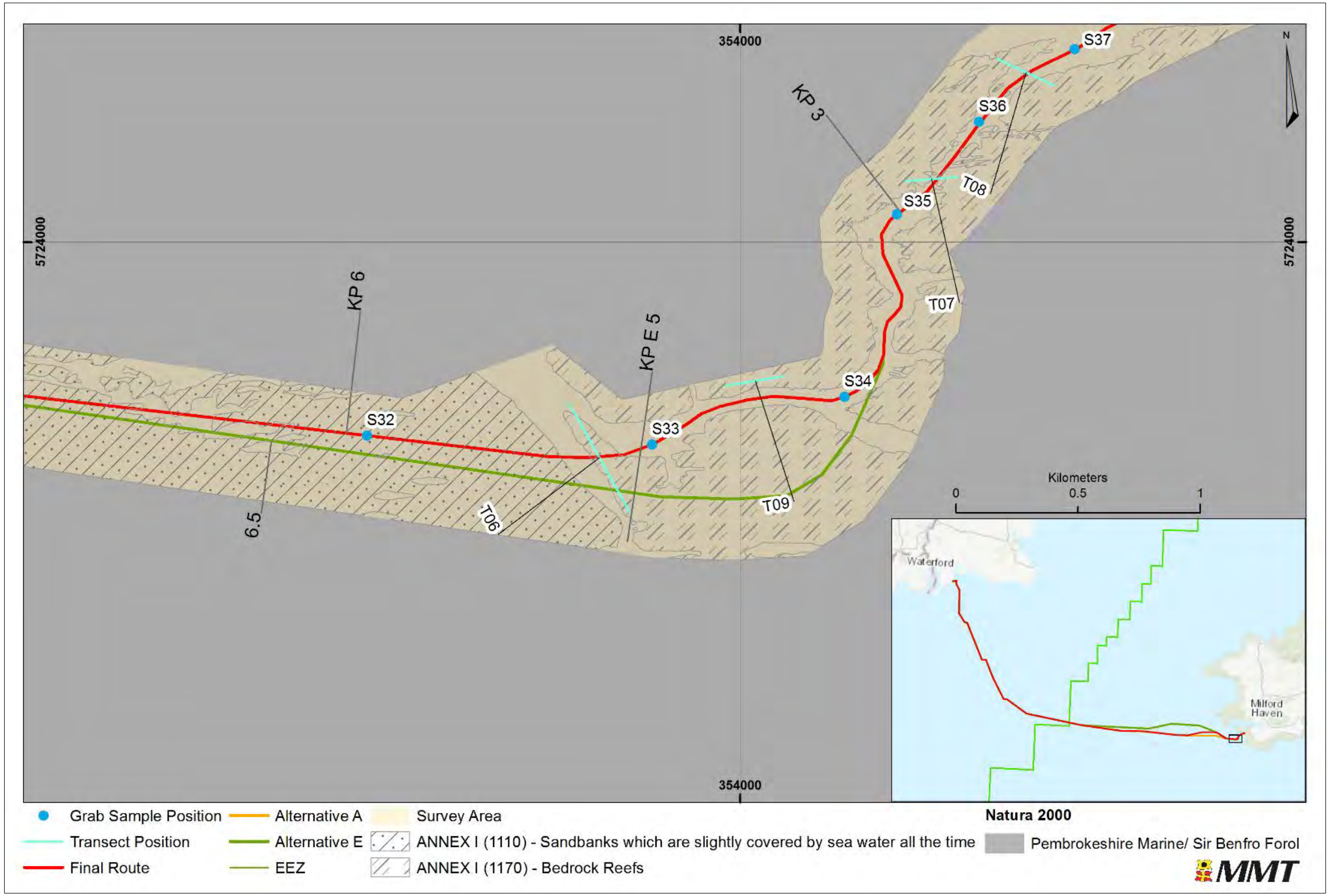


Figure 30 Overview of Annex I areas in UK EEZ between KP 1 and KP 7.5.

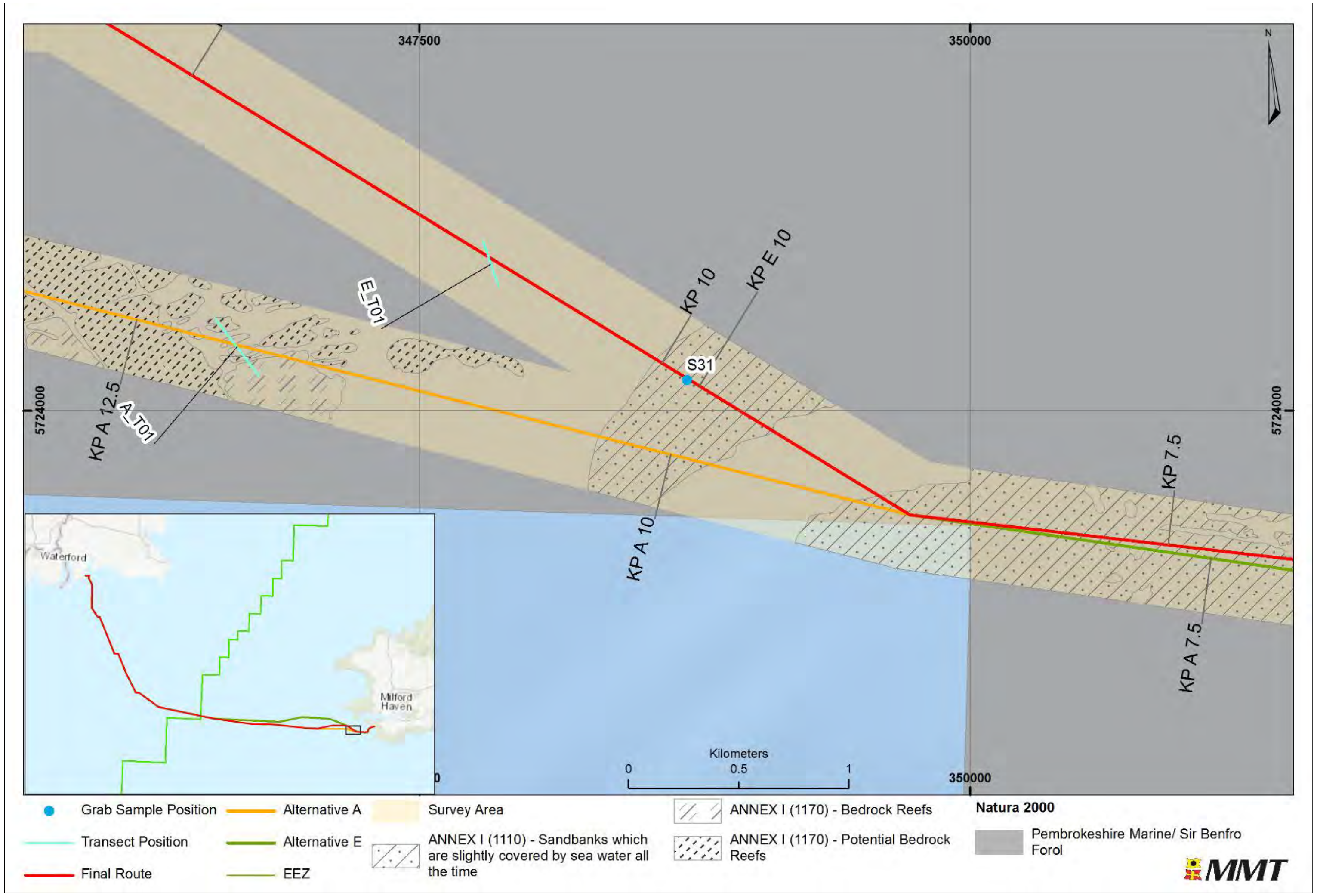


Figure 31 Overview of Annex I areas in UK EEZ between KP 7 and KP 13.

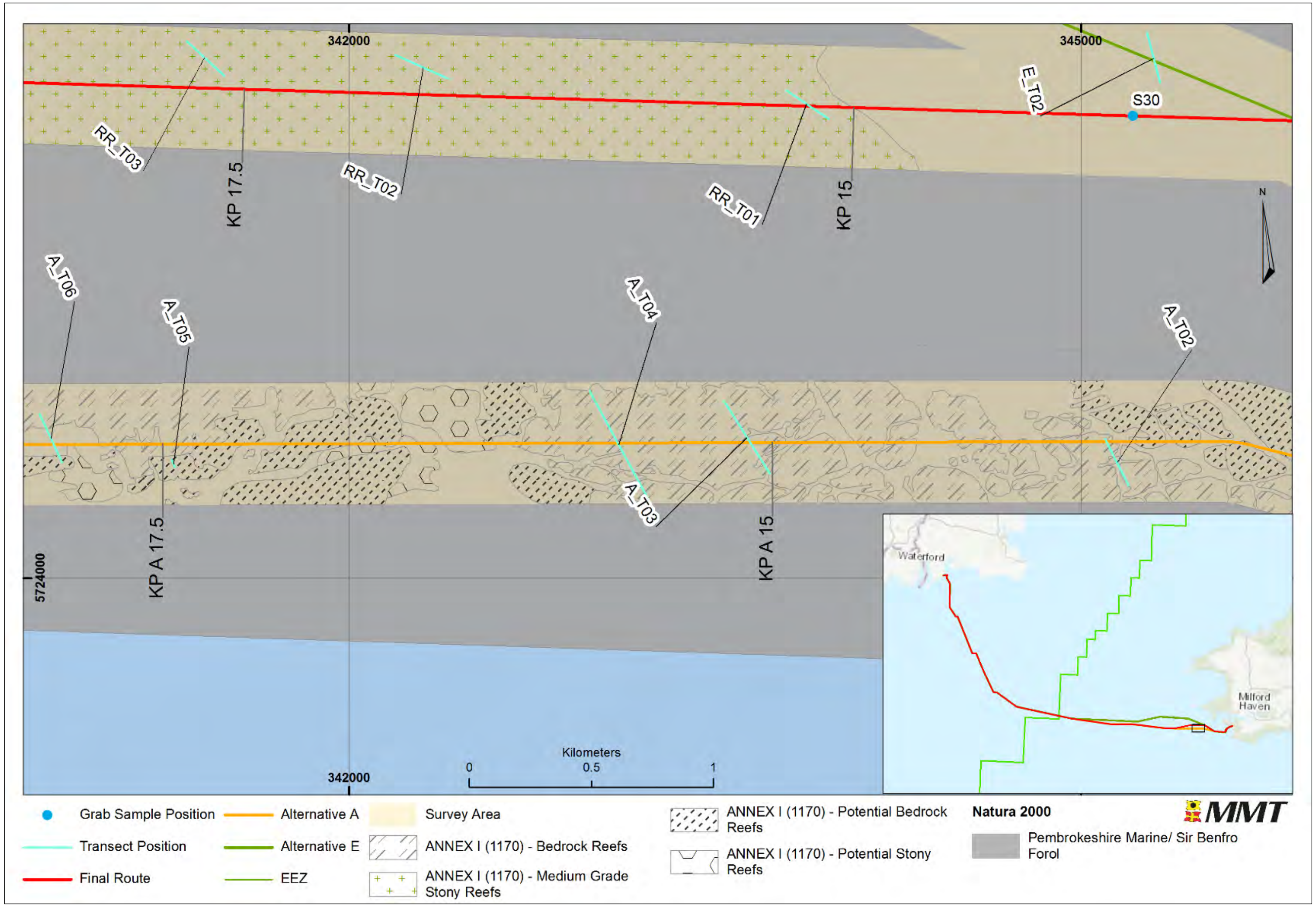


Figure 32 Overview of Annex I areas in UK EEZ between KP 14 and KP 18.

Figure 33 Overview of Annex I areas in UK EEZ between KP 16 and KP 21.

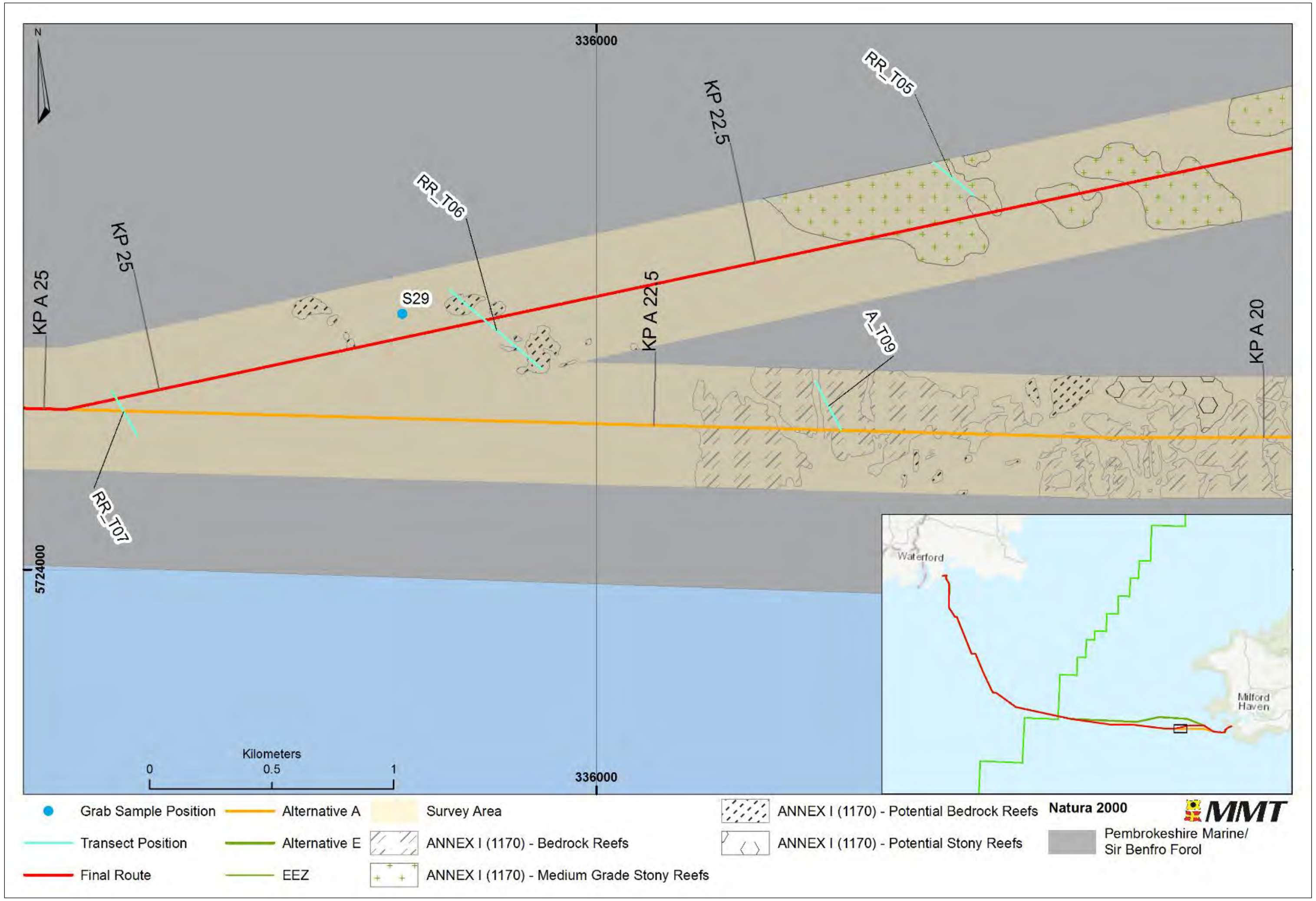


Figure 34 Overview of Annex I areas in UK EEZ between KP 20 and KP 25.

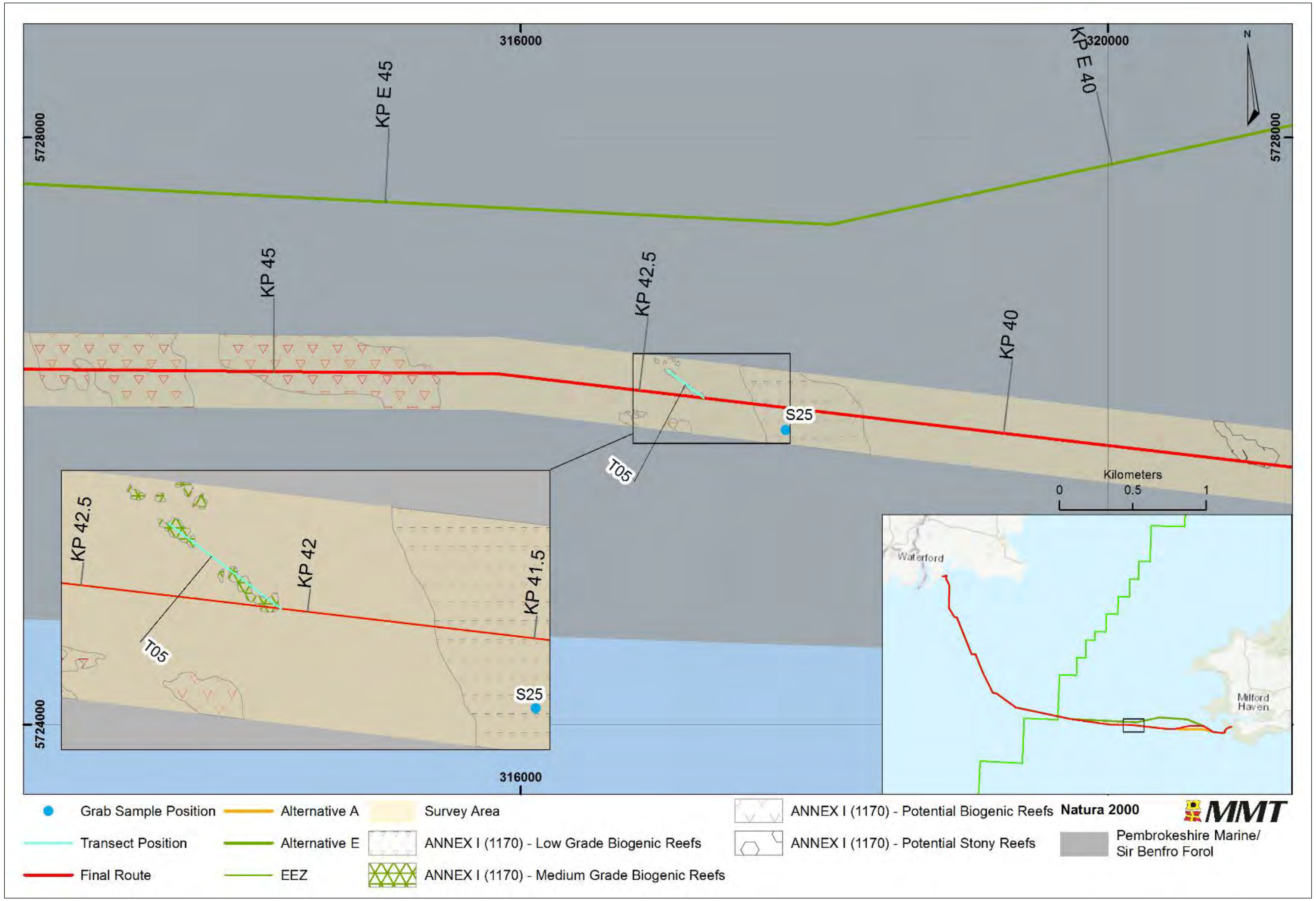


Figure 35 Overview of Annex I areas in UK EEZ route Route A between KP 38 and KP 47.

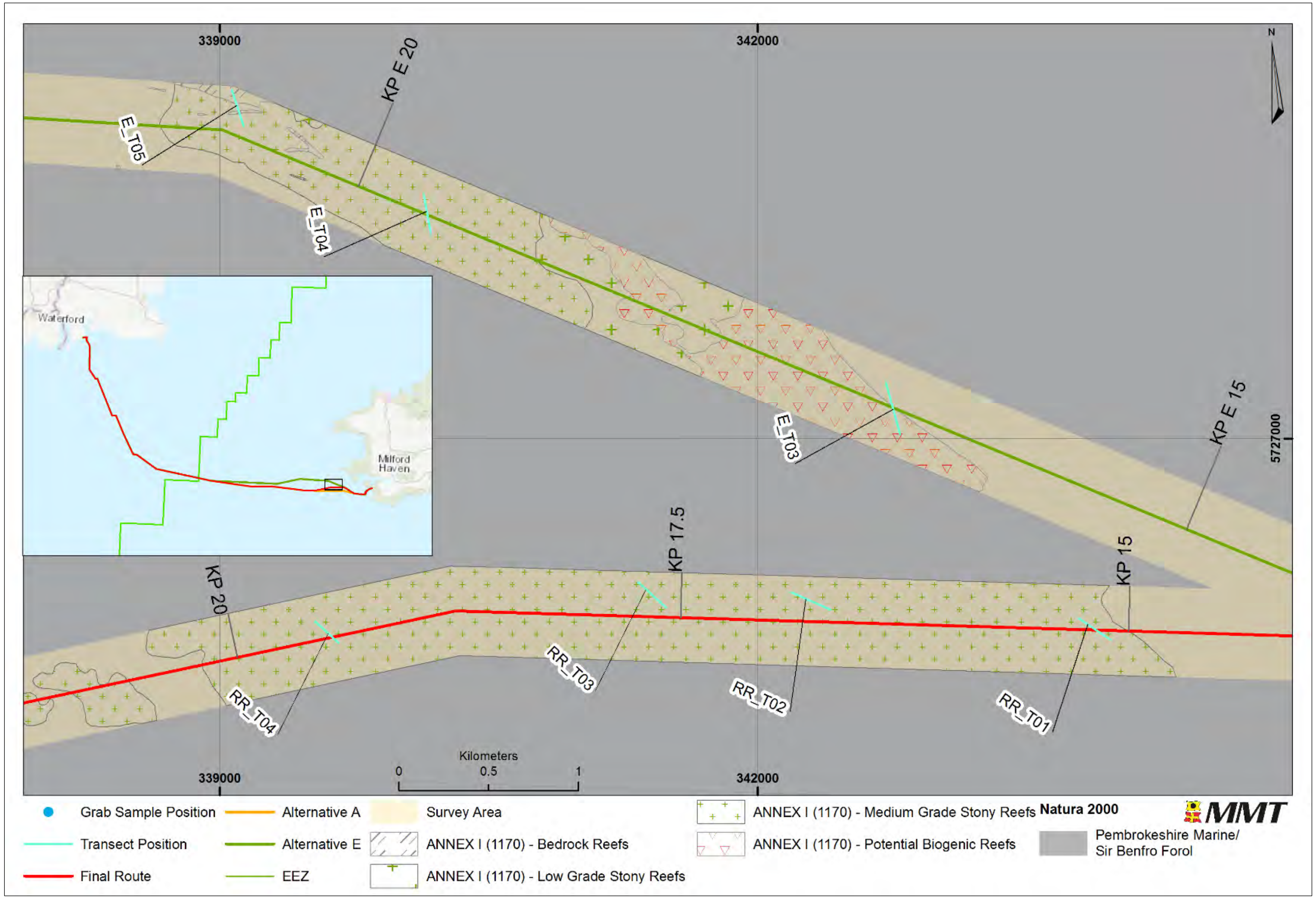


Figure 36 Overview of Annex I areas in UK EEZ route Alternative E between KP 15 and KP 22.

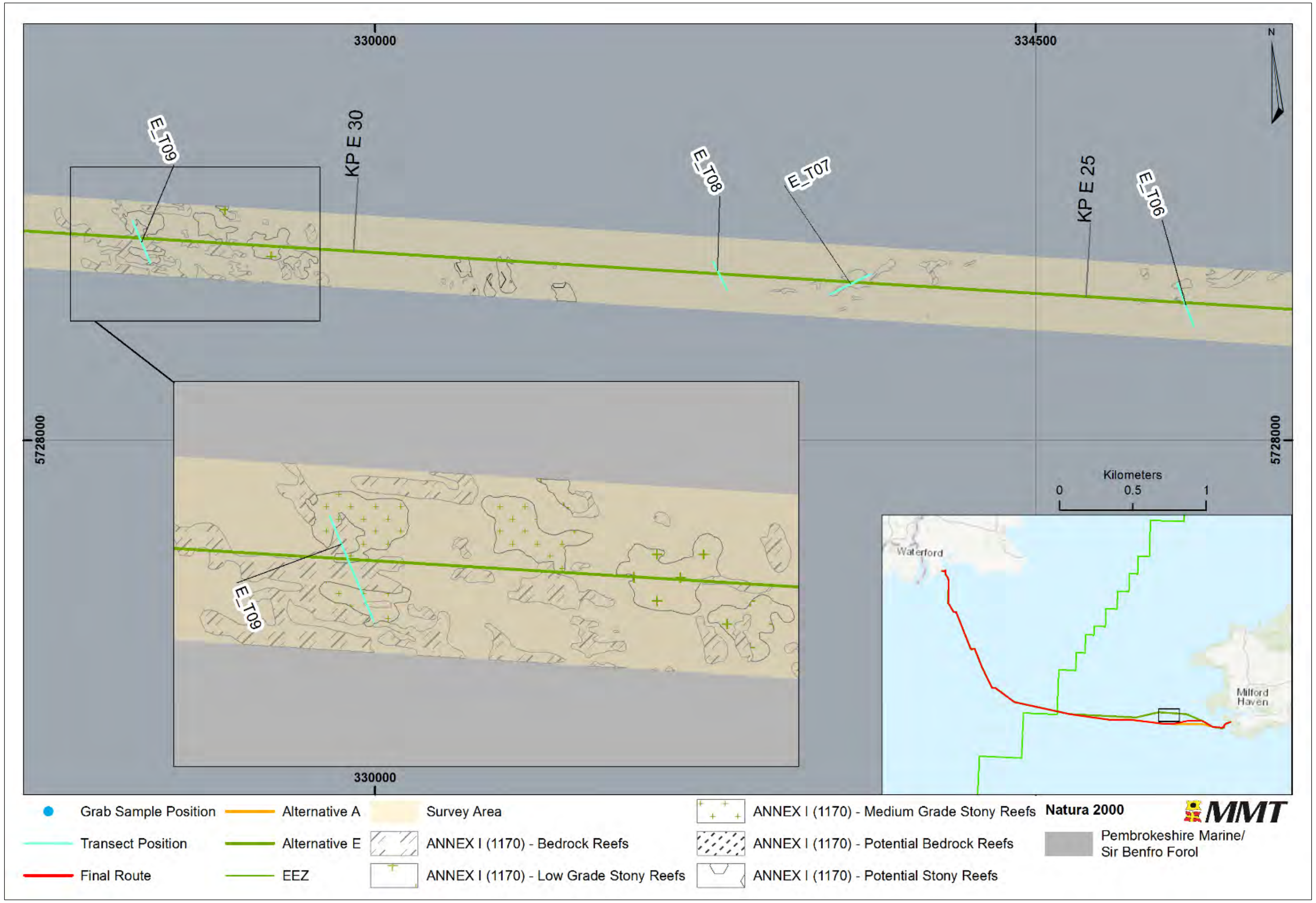
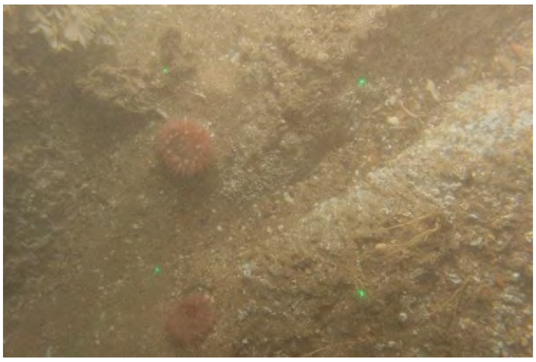
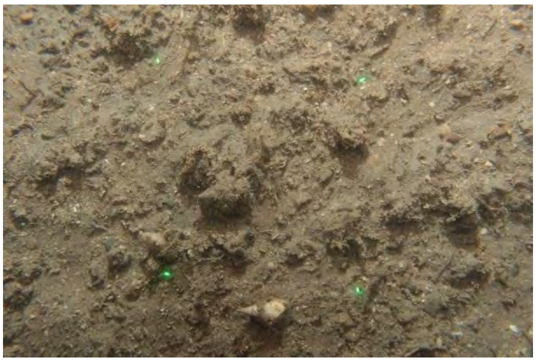


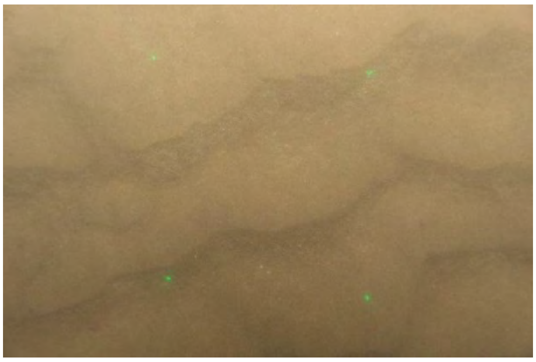
Figure 37 Overview of Annex I areas in UK EEZ route Alternative E between KP 24 and KP 32.

5.5.1 | FINAL ROUTE

Annex I habitats identified within the final route survey corridor are presented in Table 26.

Table 26 Annex I habitats identified within the survey corridor.

HABITAT IMAGE	ANNEX I	OSPAR/MPA	SITE ID
	Annex I (1170) - Bedrock Reefs	Pembrokeshire Marine/Sir Benfro Forol SAC area	T06, T09, T08, T07
	Annex I (1170) - Potential Bedrock Reefs	Pembrokeshire Marine/Sir Benfro Forol SAC area	RR_T06
	Annex I (1170) – Medium Grade Stony Reefs	Pembrokeshire Marine/Sir Benfro Forol SAC area	RR_T01, RR_T02, RR_T03, RR_T04, RR_T05
	Annex I (1170) – Low Grade Biogenic Reef	Pembrokeshire Marine/Sir Benfro Forol SAC area	S25, T05,

HABITAT IMAGE	ANNEX I	OSPAR/MPA	SITE ID
	Annex I (1170) – Low Grade Biogenic Reef		S20
	Annex I (1110) - Sandbanks which are slightly covered by sea water all the time	Pembrokeshire Marine/Sir Benfro Forol SAC area	S31, S32

ANNEX I (1170) - STONY REEFS

Transect T08 crosses the Final Route centre line at KP 2.213. The centre line is surrounded by muddy sand. The start and end of the transect runs across Annex I (1170) – Bedrock Reefs, dominated by ascidians and hydrozoans.

Transect T07 (crossing the centre line at KP 2.786) and transect T06 (crossing the centre line at KP 4.961) showed similar characteristics and the bedrock surrounding the narrow channel of sand was also classified as Annex I (1170) – Bedrock Reefs (Figure 38).

Transect T09 also showed Annex I (1170) - Bedrock Reefs, as it ran along the direction of the corridor on the northern side of the route around KP 4.100.

Figure 38 Image T06_014 of Annex I (1170) – Bedrock reefs with the habitat A4.138 – Molgula manhattensis *with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock.*

Transect RR_T01, RR_T02, RR_T03 (Figure 39), RR_T04 and RR_T05 were all located in an area with boulders and cobbles with a rich epifauna community. Cobbles greater than 0.064 m in diameter covered between 50 % to 80 % of the area along the transects, and were in general clast supported with a maximum elevation of approximately 0.2 m. The seabed in this area meets the criteria of a medium grade stony reef (Table 27 to Table 31).

Table 27 Reef assessment for assessed stony reef in RR_T01.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	-	-	50 %- 70%	-
Elevation	-	≤0.064 m	-	-
Extent	-	>25 m^2		

Table 28 Reef assessment for assessed stony reef in RR_T02.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	-	-	70 %- 80%	-
Elevation	-	-	0.064 – 0.2 m	-
Extent	-	>25 m^2		

Table 29 Reef assessment for assessed stony reef in RR_T03.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	-	-	70 % - 80%	-
Elevation	-	-	0.064 – 0.2 m	-
Extent	-	>25 m²		

Table 30 Reef assessment for assessed stony reef in RR_T04.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	-	-	50 % - 60%	-
Elevation	-	-	0.064	-
Extent	-	>25 m²		

Table 31 Reef assessment for assessed stony reef in RR_T05.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	-	10% - 40%	-	-
Elevation	-	-	0.064	-
Extent	-	>25 m²		

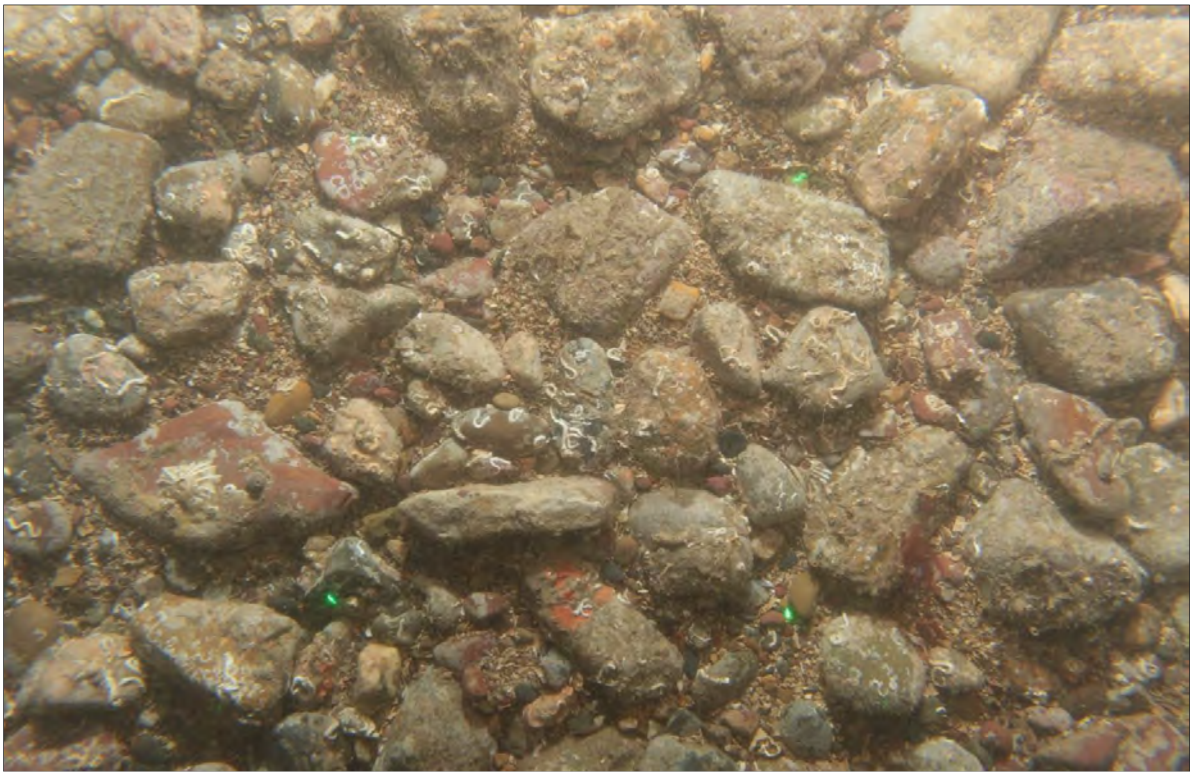


Figure 39 Image RR_T03_001 of Annex I (1170) – Medium Grade Stony Reef with the habitat A5.141 – Pomatoceros triqueter *with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles.*

Transect RR_T06 crossed smaller areas of bedrock that was identified in the geophysical data. The bedrock was largely covered by sediment, with only small outcropping patches. The outcropping bedrock had a sparse epifauna consisting of mainly anemones and hydrozoans. Due to the lack of conspicuous bedrock reef formations, the bedrock was classified as Annex I (1170) – Potential Bedrock Reefs.

ANNEX I (1110) - SANDBANKS WHICH ARE SLIGHTLY COVERED BY SEA WATER ALL THE TIME

Two areas between approximate KP 5.122 to KP 8.841 and from KP 9.405 to KP 10.029 comprising of sand and ripples were classified as Annex I (1110) - Sandbanks which are slightly covered by sea water all the time. Grab sample sites S31 and S32 were located within these sections.

ANNEX I (1170) - SABELLARIA SPINULOSA REEFS

All grab sampling locations where *S. spinulosa* was identified are listed in Table 32, along with abundances (grab samples) and coverage (photos).

Table 32 Summary of S. spinulosa *quantities at sample locations where it occurred (Final Route, UK).*

SAMPLE LOCATION	QUANTITY OF *SABELLARIA SPINULOSA* PER m²		AVERAGE NUMBER OF INDIVIDUALS PER SAMPLE LOCATION PER m²	AVERAGE PERCENTAGE COVERAGE IN SITE PHOTOS
	REPL. 1	REPL. 2		
S20	2330	1110	1720	24%
S21	540	170	355	10%
S22	10	0	5	-
S23	250	320	285	10%
S24	1120	360	740	-
S25	1460	1530	1495	12%
S26	40	170	105	1%
S27	40	0	20	-
S29	0	10	5	2%
S30	180	560	370	-

S. spinulosa was identified from both grab samples at S30, with an average abundance of 350 specimens per m^2. The images from the site does not indicate any presence of reef formations, and no conspicuous elevated formations of possible *S. spinulosa* aggregations was identified in the geophysical data.

A few specimen of *S. spinulosa* was identified in one of the grab samples at S29. The grab sample site was located within an area of coarse sediment. Minor aggregations of *S. spinulosa* was identified in the images from the site, showing an average coverage of 2%. This was also reflected in the geophysical data, that showed a homogenous seabed with coarse sediment. Grab site S27 showed similar characteristics, but no aggregations of *S. spinulosa* were identified in the images. The areas were not considered meeting the criteria to qualify as a *S. spinulosa* reef.

Grab sample site S26 was located in an area with sand and gravel at KP 35.997. Specimens of *S. spinulosa* were identified from both samples at this site, with an average abundance of 105 specimens per m^2. Small, low aggregations of *S. spinulosa* was scattered across the seabed, amounting to an average coverage of 1 %. The area was not considered meeting the criteria to qualify as a *S. spinulosa* reef.

Grab sample site S25, located further west at KP 40.990, showed a higher presence of *S. spinulosa.* An average abundance of 1495 specimens per m^2. The *S. spinulosa* aggregations visible in the images from the site showed a coverage between 7% and 17%, with an average coverage of 12% (Figure 40). The elevation of the tube aggregations was assessed to vary between flat seabed and 5 cm. The reef meets the criteria of an Annex I (1170) – Low Grade Biogenic reef according to the *S. spinulosa* reef assessment by Gubbay (2007) (Table 33).

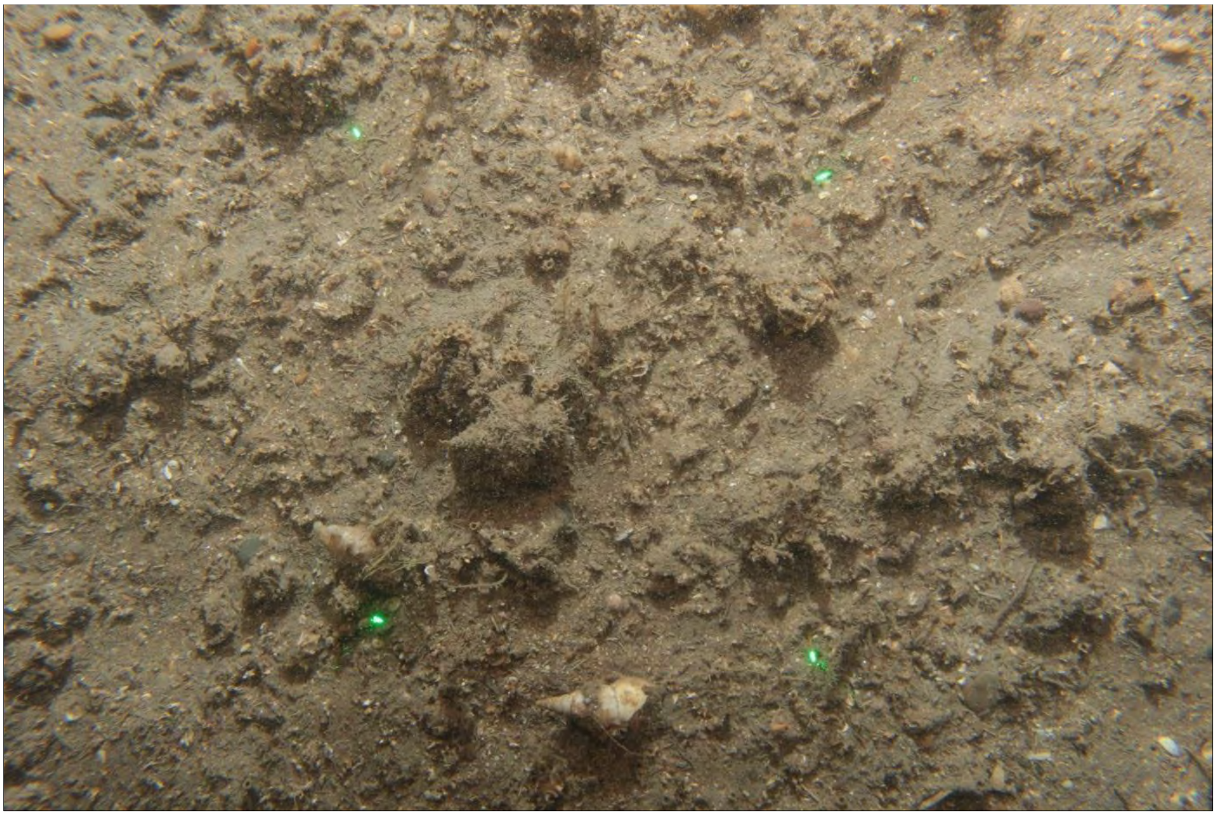


Figure 40 Image S25_003 of Annex I (1170) – Low Grade Biogenic reef with the habitat A5.611 – Sabellaria spinulosa *on stable circalittoral mixed sediment.*

Table 33 Assessment of S. spinulosa at sample location S25 (Gubbay, 2007).

CHARACTERISTIC	NOT A REEF	"REEFINESS"		
		LOW	MEDIUM	HIGH
Elevation (cm) (average tube height)	-	0-5	-	-
Extent (m^2)		-	Approx. 75 000	-
Patchiness (% cover)	-	7 % to 17 % (Average 12 %)	-	-

Specimens of *S. spinulosa* were found in both grab samples from site S24, with an average abundance of 740 individuals per m^2. No *S. spinulosa* aggregations were identified in the grab sample site photos (Figure 41), but tubes of the species is scattered across the seabed. A homogenous seabed with coarse sediment was identified from the geophysical data in the area, with no indication of any elevated reef formations. Thus, the area is not considered meeting the criteria to qualify as a *S. spinulosa* reef.

S. spinulosa was also identified from both grab samples at S23 (average abundance 285 ind/m^2), and was located within the same habitat as S24 (A5.611).

No *S. spinulosa* was identified in the site images, but the visibility was poor in the area. It was noted that *S. spinulosa* tubes were present in the gravel on the seabed, but no erect tubes were visible. As the geophysical data showed a rippled coarse sediment, with no indications of reef formations, the area was not considered meeting the criteria to qualify as a *S. spinulosa* reef.

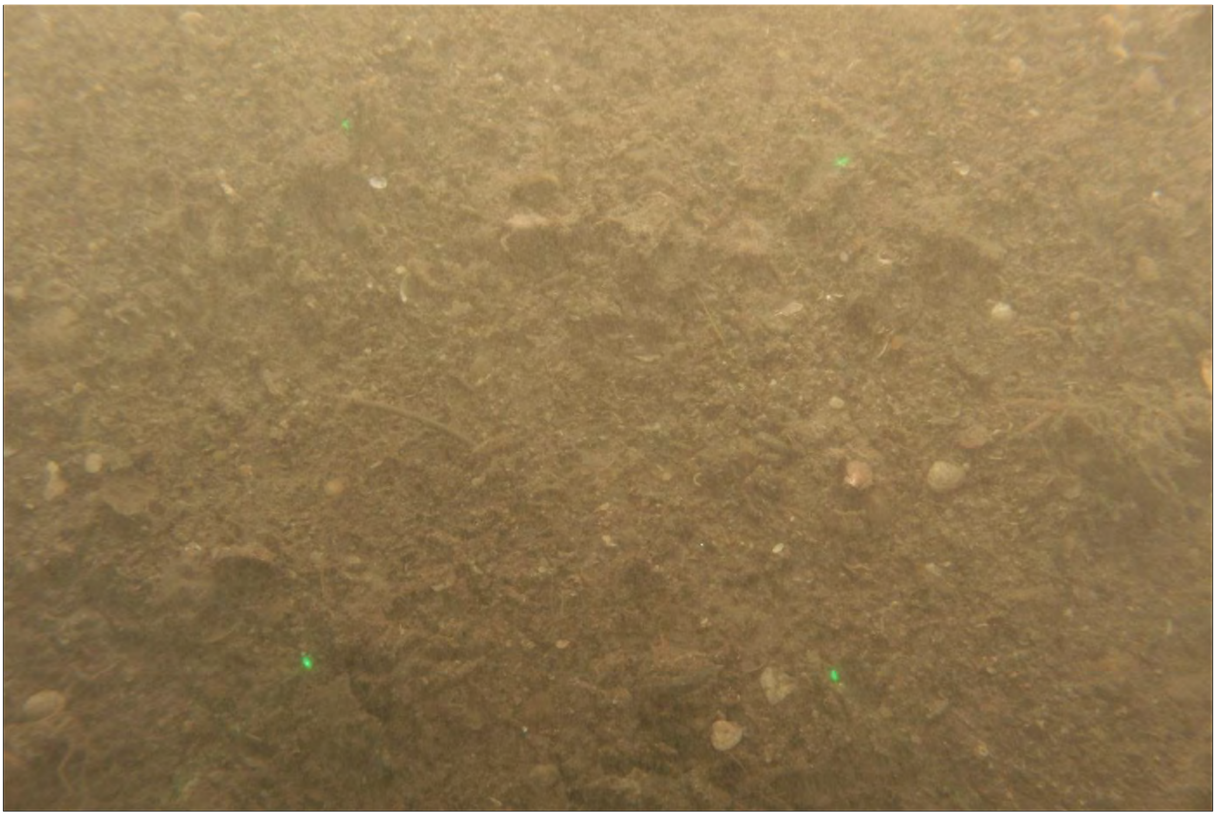


Figure 41 Image S24_001 of the habitat A5.611 – Sabellaria spinulosa *on stable circalittoral mixed sediment.*

An average abundance of 325 individuals per m^2 of *S. spinulosa* was recorded at grab sample site S21. The *S. spinulosa* aggregations were visible in the site photos, with an average percentage cover of 10 %. The average elevation of the tubes was assessed to be below 2 cm. Therefore, the area was not considered meeting the criteria to qualify as a *S. spinulosa* reef.

Specimens of *S. spinulosa* were identified from both samples at site S20, located at KP 58.035. S20 had an average abundance of 1720 specimens per m^2. The *S. spinulosa* aggregations visible in the images from the site showed a coverage between 12 % and 35 %, with an average coverage of 24 % (Figure 42). The elevation of the tube aggregations was assessed to vary between flat seabed and 5 cm. Although the patchiness matched a Medium Graded *S. spinulosa* reef, the generally low elevation of the aggregations caused the reef to be assessed to meet the criteria of an Annex I (1170) – Low Grade Biogenic reef (Table 34).

Figure 42 Image S20_005 of Annex I (1170) – Low Grade Biogenic reef with the habitat A5.611 – Sabellaria spinulosa *on stable circalittoral mixed sediment.*

Table 34 Assessment of S. spinulosa at sample location S20 (Gubbay, 2007).

CHARACTERISTIC	NOT A REEF	"REEFINESS"		
		LOW	MEDIUM	HIGH
Elevation (cm) (average tube height)	-	0-5	-	-
Extent (m^2)	-	-	Approx. 375 000	-
Patchiness (% cover)	-	-	12 % to 35 % (Average 24 %)	-

All transects where *S. spinulosa* was identified are listed in Table 35, along with abundances (grab samples) and coverage (photos).

Table 35 Average coverage and standard deviation of S. spinulosa in transects where it occurred in ascending KP (Final Route, UK).

TRAN-SECT	DDV_001	DDV_002	DDV_003	DDV_004	DDV_005	DDV_006	DDV_007	DDV_008	DDV_009	DDV_010	DDV_011	DDV_012	DDV_013	DDV_014	DDV_015	DDV_016	AVERAGE	SD
T06	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	<1%	0%	<1%	0%	0%	0.2% (Total 18 photos)	0%
T07	7%	0%	0%	0%	0%	5%	0%	0%	-	-	-	-	-	-	-	-	0.9%	2%
RR_T01	1%	0%	<1%	4%	7%	7%	0%	<1%	-	-	-	-	-	-	-	-	2.5%	3%
RR_T04	3%	0%	0%	0%	<1%	0%	0%	-	-	-	-	-	-	-	-	-	0.5%	1%
RR_T05	<1%	0%	<1%	0%	<1%	0%	0%	0%	-	-	-	-	-	-	-	-	0.2%	0%
RR_T06	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.2% (Total 19 photos)	1%
RR_T07	0%	0%	0%	<1%	0%	7%	0%	0%	-	-	-	-	-	-	-	-	0.9%	2%
A_T10	0%	0%	0%	0%	0%	<1%	0%	-	-	-	-	-	-	-	-	-	0.1%	0%
T05	0%	1%	0%	0%	0%	0%	0%	16%	0%	0%	0%	0%	-	-	-	-	1.4%	4%
T04	<1%	0%	<1%	<1%	0%	0%	0%	<1%	0%	0%	0%	0%	0%	-	-	-	0.2%	0.2%
T04_X	0%	<1%	<1%	15%	0%	<1%	-	-	-	-	-	-	-	-	-	-	3%	5%

Scattered aggregations of S. spinulosa were recorded on bedrock at transect T07 and T06. It was interpreted to have a limited spatial distribution. As bedrock was the prevalent reef forming substrate in the area, the *S. spinulosa* aggregations was not considered representing a reef.

S. spinulosa was also identified along transect RR_T01, RR_T04 and RR_T05, all located within a large area of cobbles and pebbles. All recordings showed scattered small aggregations of *S. spinulosa* with low percentage coverage and elevation. The area was not considered meeting the definition of a *S. spinulosa* reef (Gubbay, 2007).

Small aggregations of *S. spinulosa* was recorded in transect RR_T06. The aggregations with the highest percentage coverage (2%) was observed on bedrock. A few small aggregations were recorded on the gravelly seabed. The occurrences of *S. spinulosa* was not considered being a reef.

S. spinulosa was recorded in transect RR_T07, which crossed a coarse gravelly seabed. The elevation of the aggregations visible in the transect photos was <2 cm. Areas of solidified sandy aggregations, possibly abraded remnants of an *S. spinulosa* reef, was observed along the transect. Due to the low elevation of the few newly formed tubes in the area, the area was not considered to meet the definition of a *S. spinulosa* reef.

A single record of *S. spinulosa* was done in shellgravel at transect A_T10.

S. spinulosa was identified on bedrock along the transect T05, located at KP 42.055. No reef characteristics were identified in the photos analysed. The aggregations were low (<2 cm) and the coverage was patchy and spatially limited.

When reviewing all raw photo data from the transect, areas of *S. spinulosa* aggregations with considerably higher elevation and coverage were visible (Figure 43). The transect traversed bedrock, that was identified in the geophysical data. It is difficult to assess to what extent outcropping bedrock underneath the *S. spinulosa* aggregations added to the perceived elevation of the reef, as no bedrock were possible to identify due to the dense aggregations of *S. spinulosa*.

As the bedrock was not the prevalent reef forming substrate in the area, the *S. spinulosa* aggregations was considered representing a reef. Due to the elevation, extent, and percentage cover of the *S. spinulosa* when assessing all raw photo material from the transect, the area was considered to meet the definition of a Annex I (1170) - *S. spinulosa* reef (Table 36).

Table 36 Assessment of S. spinulosa at transect T05 (Gubbay, 2007).

CHARACTERISTIC	NOT A REEF	"REEFINESS"		
		LOW	MEDIUM	HIGH
Elevation (cm) (average tube height)	-	-	0-10	-
Extent (m^2)		-	10 000	-
Patchiness (% cover)	-	-	20 % - 30 %	-

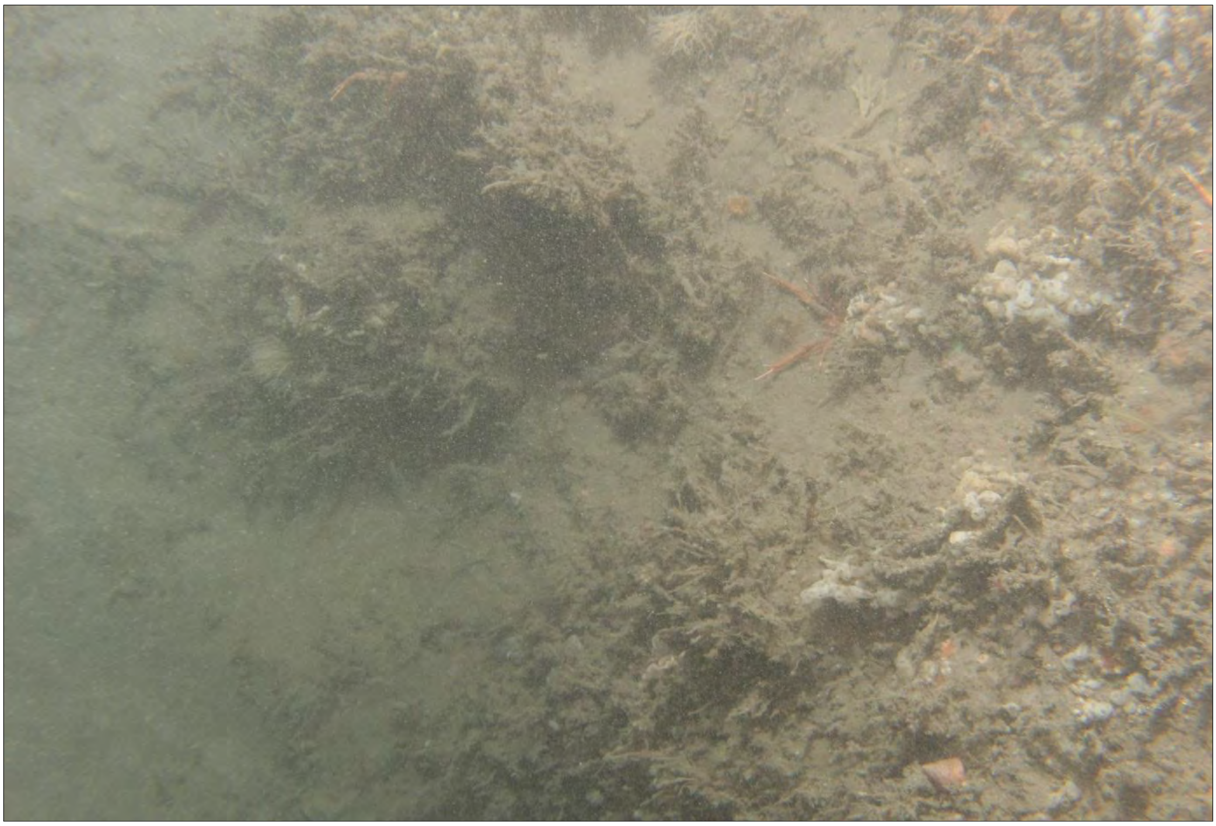


Figure 43 Raw image T05_013 of Annex I (1170) – Medium Graded Biogenic Reef on the habitat A4.2212 – Sabellaria spinulosa *didemnid and small ascidians on tide-swept moderately wave-exposed circalittoral rock.*

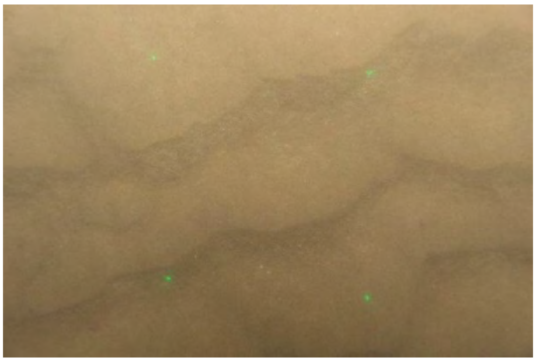
Transect T04 with the cross transect T04_X was located in an area with boulders and mixed sediment. The seabed substrate was heterogeneous, with areas of sand mixed with patches of cobbles and boulders, and shell gravel.

Polychaeta *S. spinulosa* was occurring along both transects, with a coverage ranging between 0 % to 15 %, predominantly on sand. The average coverage of *S. spinulosa* was 3 % in T04_X, and 0.2 % in T04. The area was not considered to meet the definition of a *S. spinulosa* reef.

5.5.2| ROUTE A

Annex I habitats identified within Route A survey corridor are presented in Table 37.

Table 37 Annex I habitats identified within the survey corridor.

HABITAT IMAGE	ANNEX I	OSPAR/MPA	SITE ID
	Annex I (1170) - Bedrock reef		A_T01, A_T02, A_T03, AT04, A_T06, A_T07, A_T08, A_T09
	Annex I (1170) - Potential Bedrock Reefs		A_T05, A_T06, A_T07
	Annex I (1110) - Sandbanks which are slightly covered by sea water all the time	Pembrokeshire Marine/Sir Benfro Forol SAC area	S31

ANNEX (1170) - STONY REEFS

Large areas of bedrock were present along the route A. The bedrock was primarily identified from the geophysical data. The DDV imagery showed that the bedrock was partly covered by sand and gravel, which limited the coverage of epifauna.

A_T01 was characterised by *S. spinulosa* encrusted bedrock, that was partly covered by sand, gravel and pebbles. Bedrock Reefs were identified at A_T01.

The seabed substrate along A_T02 was dominated by coarse gravel, pebbles and cobbles, with a relatively high number of epifaunal species such as ascidians, and different species pf bryozoans and cnidarians. The habitat was classified as A5.141 and the area was evaluated according to Irvings (2008) reef assessment for stony reefs. The characteristics of the seabed along A_T02 are presented in Table 38. The habitat had a low resemblance of being a stony reef. Bedrock was surrounding the A5.141 and was classified as Annex I (1170) - Bedrock Reef.

Table 38 Reef assessment for assessed stony reef in A_T02.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	<10%	-	-	-
Elevation	-	≤0.064 m	-	-
Extent	-	>25 m^2		

Transect A_T05 was performed across an area of bedrock on the route A. The bedrock was almost entirely covered by sediment in the beginning of the transect, then gradually transcended to bedrock only partly covered by sediment, with a high coverage by epifauna (Figure 44). Epifauna, such as anemones and hydrozoans, were also scattered in the beginning of the transect in areas with no visible protruding bedrock. Therefore, the bedrock in the beginning of the transect, including the adjacent areas with a similar appearance in the geophysical data, was classified as Annex I (1170) – Potential Bedrock Reefs. The remainder of the transect was classified as Annex I (1170) –Bedrock Reefs.

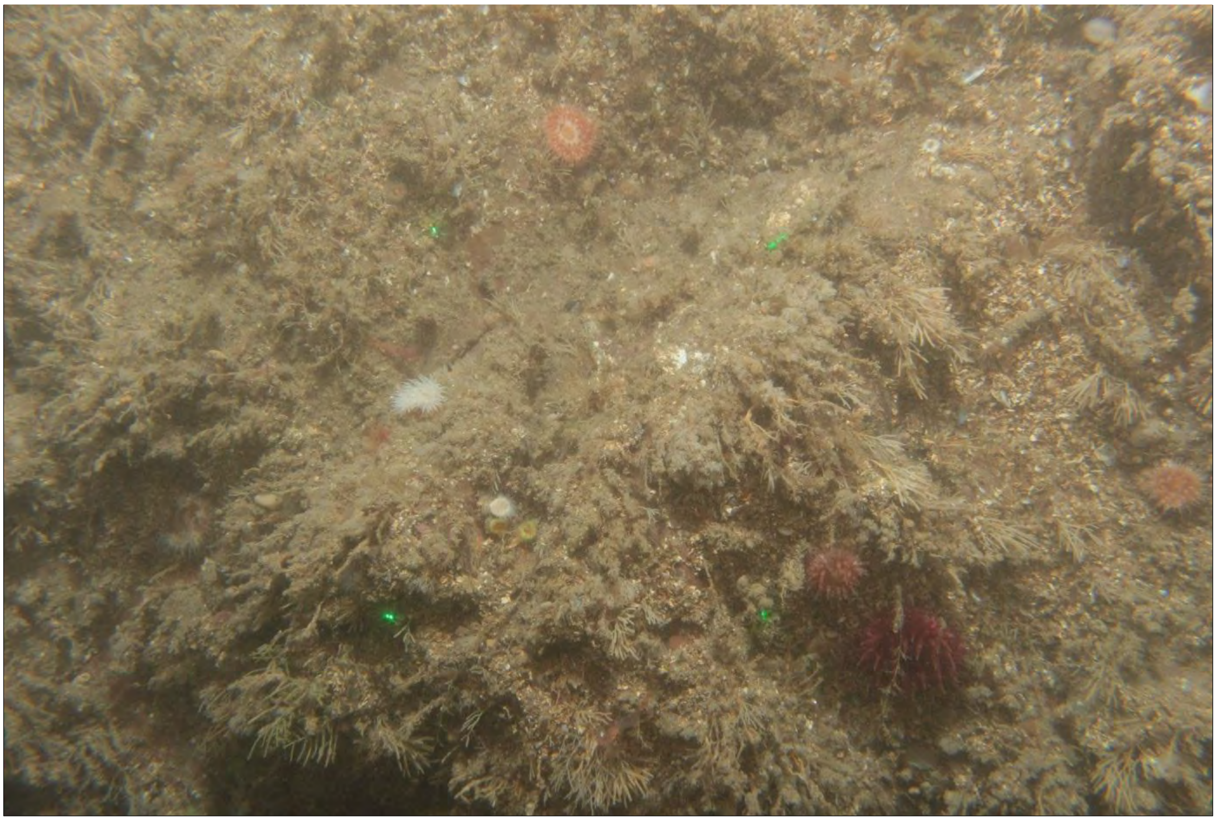


Figure 44 Annex I (1170) – Bedrock Reef at A_T05_009.

The transect A_T06 moved across the bedrock area further west along the Route A. The bedrock was partly covered by sand and gravel, and showed similar characteristics to that of A_T05.

An area of coarse sediment with pebbles and cobbles was located in the middle of the transect, in between bedrock outcrops. The area of pebbles and cobbles were evaluated against the stony reef criteria's (Table 39), and was not considered being a stony reef.

Table 39 Reef assessment for assessed stony reef in A_T06.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	<10 %	-	-	-
Elevation	-	≤0.064 m	-	-
Extent	-	>25 m^2		

The transect A_T08 moved across bedrock, that had minor intrusions of mixed sediments. The bedrock had a high epifaunal coverage with *S. spinulosa,* and turfs of different species of hydrozoans and bryozoans. Crustaceans like *Ebalia* sp. and pagurids were also common, along with different mollusc species.

ANNEX I (1110) - SANDBANKS WHICH ARE SLIGHTLY COVERED BY SEA WATER ALL THE TIME

Two areas between approximate KP 8.885 to KP 9.150 and from KP 9.818 to KP 10.340 comprising of sand and ripples were classified as Annex I (1110) - Sandbanks which are slightly covered by sea water all the time. Grab sample sites S31 was located within this section.

ANNEX I (1170) - SABELLARIA SPINULOSA REEFS

The transects where *S. spinulosa* occurred are listed in Table 40 with average coverage and standarad deviations to illustrate distribution and density.

Table 40 Average coverage and standard deviation of S. spinulosa *in transects where it occurred (Route A, UK).*

TRAN-SECT	DDV_001	DDV_002	DDV_003	DDV_004	DDV_005	DDV_006	DDV_007	DDV_008	DDV_009	DDV_010	DDV_011	DDV_012	DDV_013	DDV_014	DDV_015	DDV_016	AVERAGE	SD
A_T01	0%	0%	0%	0%	0%	15%	0%	20%	0%	0%	0%	<1%	0%	0%	-	-	2.5%	6%
A_T02	0%	0%	2%	0%	0%	0%	0%	0%	-	-	-	-	-	-	-	-	0.3%	1%
A_T03	0%	3%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0.3%	1%
A_T04	<1%	<1%	0%	0%	<1%	0%	<1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.1% (Total 21 photos)	0%
A_T06	<1%	0%	0%	0%	0%	0%	0%	-	-	-	-	-	-	-	-	-	0.1%	0%
A_T07	12%	3%	2%	0%	80%	0%	0%	0%	<1%	41%	-	-	-	-	-	-	13.9%	25%

TRAN-SECT	DDV_001	DDV_002	DDV_003	DDV_004	DDV_005	DDV_006	DDV_007	DDV_008	DDV_009	DDV_010	DDV_011	DDV_012	DDV_013	DDV_014	DDV_015	DDV_016	AVERAGE	SD
A_T08	<1%	0%	35%	0%	0%	0%	0%	<1%	0%	2%	0%	29%	0%	0%	0%	27%	5.5% (Total 17 photos)	12%
A_T09	69%	28%	0%	0%	35%	0%	0%	10%	-	-	-	-	-	-	-	-	17.8%	23%

Potential biogenic reef was classified at T07 but it was mixed with boulders and cobbles and is thus classified as a mix potential stony reef/biogenic reef.

The transect A_T01 had a relatively high coverage of *S. spinulosa,* ranging from <1 % to 20 % coverage. The colonies were abraded with only minor patches of newly formed tubes. The *S. spinulosa* was in general found encrusting bedrock (Figure 45). The area was classified to A4.221 – *Sabellaria spinulosa* encrusted circalittoral rock, and was not considered being a biogenic reef, as the bedrock was the feature that dominated and characterised this area. Minor patches of *S. spinulosa* on bedrock was also present at transect A_T03 and A_T04.

Figure 45 Image A_T01_008 of S. spinulosa encrusted circalittoral rock.

Similar occurrences of *S. spinulosa* on bedrock was also noted in transect A_T06 and A_T07, both classified as Annex I (1170) – Bedrock Reefs due to the predominance of rocky outcrops (Figure 46). Transect A_T07 had a higher coverage than A_T06, that varied from 0 % up to 80 %.

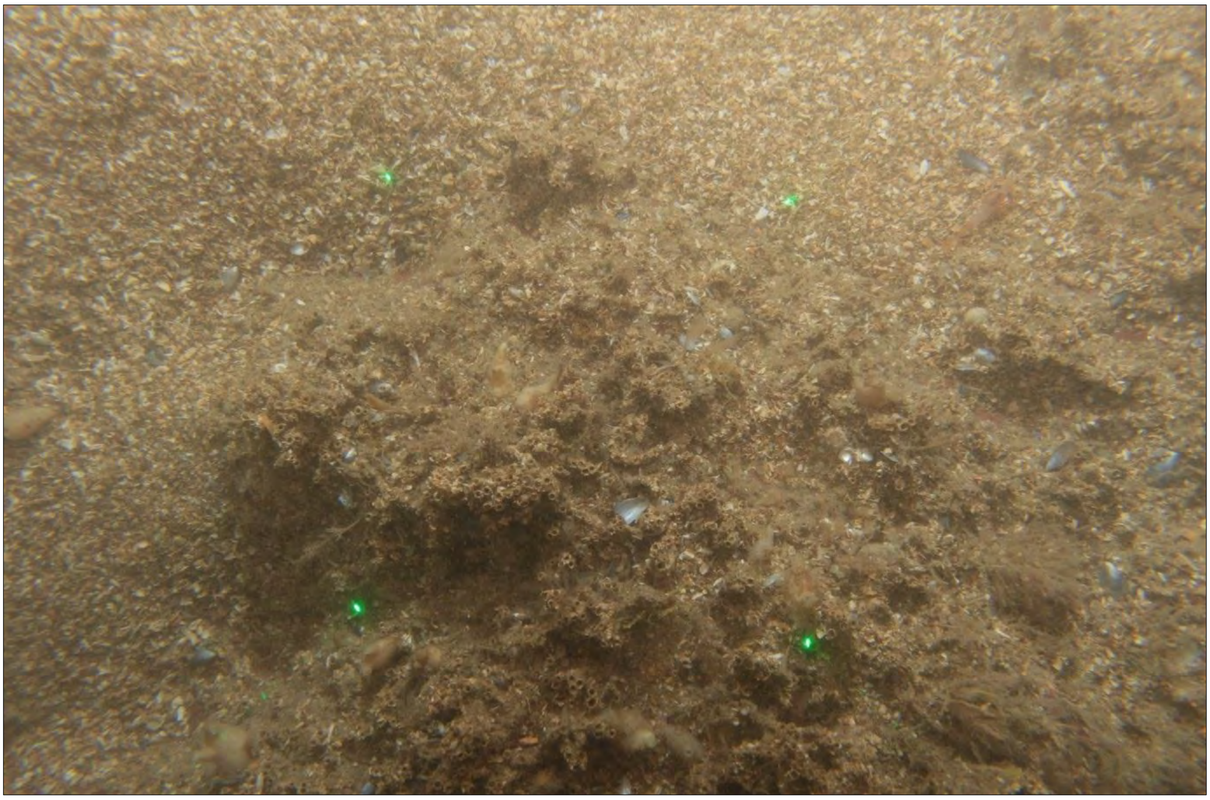


Figure 46 Image A_T07_010 of S. spinulosa *on the habitat A4.21 – Echinoderms and crustose communities on circalittoral rock on Annex I (1170) – Bedrock reefs.*

Transect A_T08 and A_T09 showed areas of relatively high coverage by S. spinulosa on bedrock outcrops, varying from 0 % coverage to 35 % coverage (A_T08) and 0 % coverage to 69 % coverage (A_T09). The conditions of the aggregations varied from abraded to newly formed classified as Annex I (1170) – Bedrock Reefs due to the predominance of rocky outcrops.

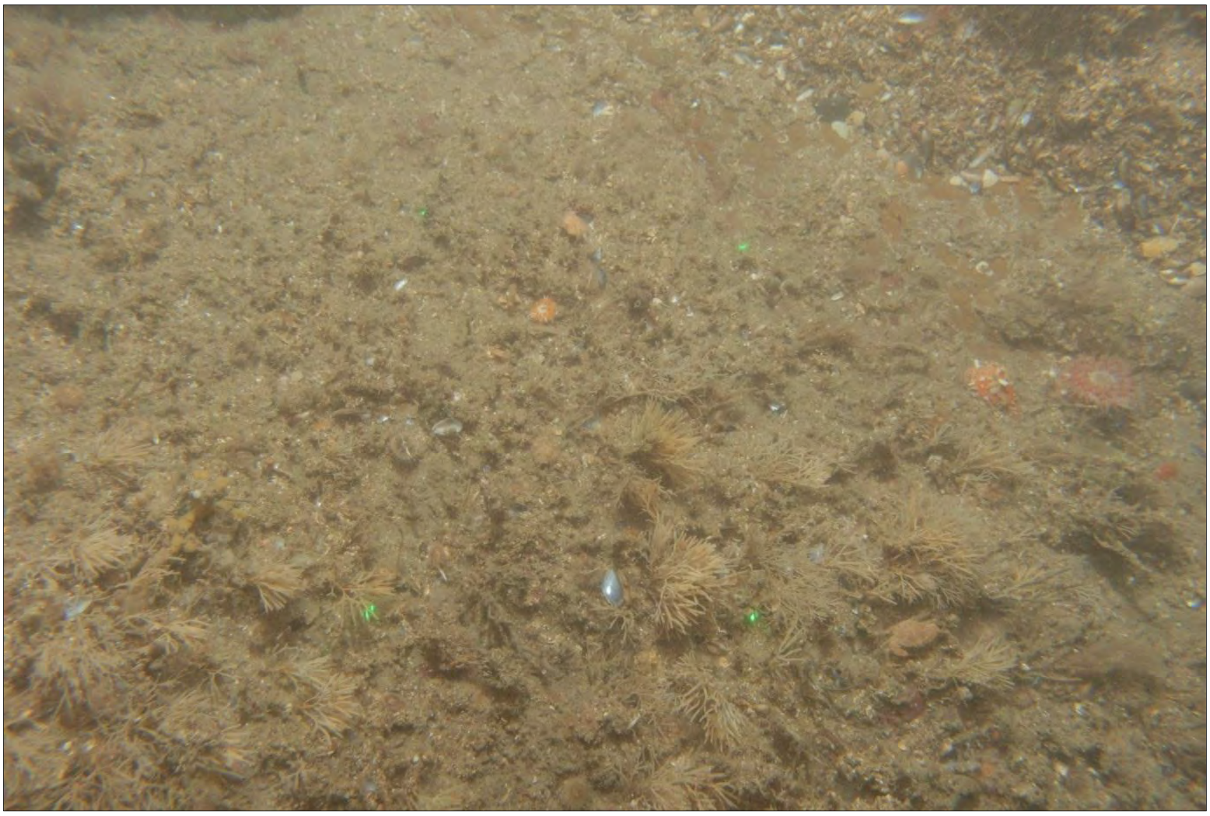


Figure 47 Image A_T09_001 of S. spinulosa *on the habitat A4.13 – Mixed faunal turf communities on circalittoral rock, on Annex I (1170) – Bedrock reefs.*

ANNEX I (1170) - MYTILUS BIOGENIC REEF

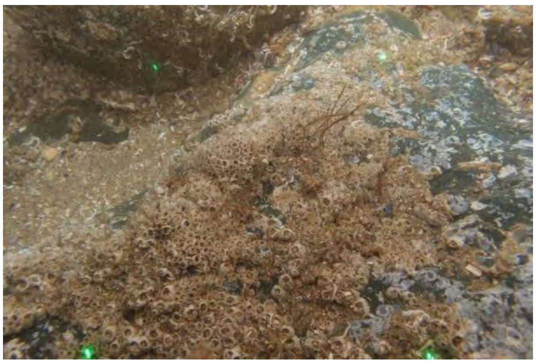
The imagery from A_T02 showed large patches of dense beds of *Mytilus edulis* on bedrock (Figure 48). The area around the transect A_T02 was classified as a bedrock reef, as the bedrock was the major epifauna supporting habitat. Transects T03 and T04 showed an average percentage coverage of 30 % and 12 %.

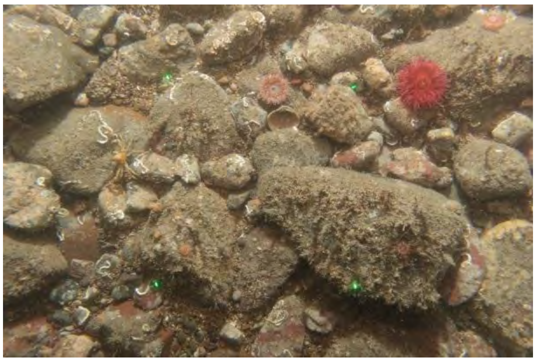
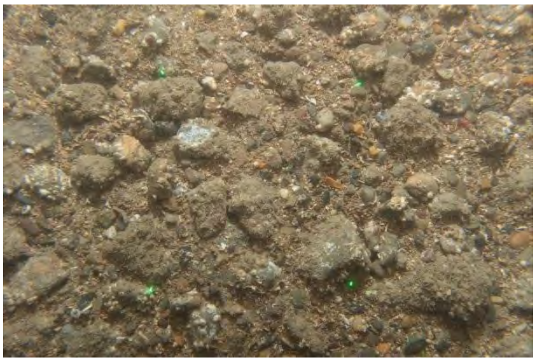
Figure 48 Image A_T02_008 of M. edulis on the habitat A4.13 – Mixed faunal turf communities on circalittoral rock, on Annex I (1170) – Bedrock reefs.

5.5.3| ALTERNATIVE E

Annex I habitats identified within Alternative E survey corridor are presented in Table 41.

Table 41 Annex I habitats identified within the survey corridor.

HABITAT IMAGE	ANNEX I	OSPAR/MPA	SITE ID
	Annex I (1170) - Bedrock Reefs		E_T05, E_T07

HABITAT IMAGE	ANNEX I	OSPAR/MPA	SITE ID
	Annex I (1170) – Potential Biogenic Reefs		E_T03
	Annex I (1170) – Medium Grade Stony Reefs		E_T04, E_T05, E_T09, E_T10
	Annex I (1170) – Low Grade Stony Reefs		E_T10

STONY REEFS

The seabed along E_T04 and E_T05 was dominated by pebbles, cobbles, and boulders with a high number of epifaunal species such as ascidians, and different species of bryozoans, poriferans and cnidarians (Figure 49). The habitat was classified as A4.132 and the area was evaluated according to Irvings (2008) reef assessment for stony reefs. The characteristics of the seabed along A_T02 are presented in Table 42. The seabed in this area meets the criteria of a medium grade stony reef.

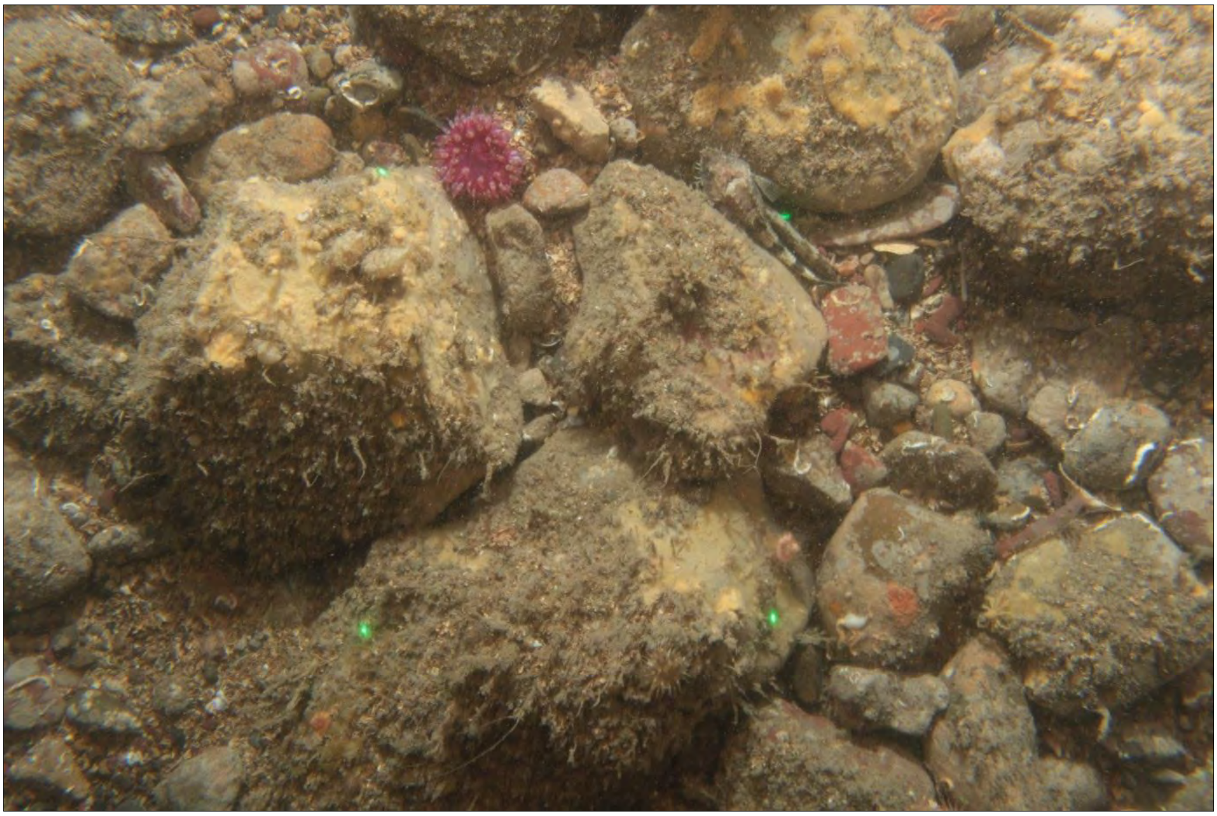


*Figure 49 Image E_T04_004 of the habitat A4.132 –*Corynactis viridis *and a mixed turf of crisiids,* Bugula, Scrupocellaria*, and* Cellaria *on moderately tide-swept exposed circalittoral rock, on Annex I (1170) – Medium Grade Stony Reefs.*

Table 42 Reef assessment for assessed stony reef in E_T04 and E_T05.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	-	-	40-95 %	-
Elevation	-	-	0.064 m-2 m	-
Extent	-	>25 m^2		

The recorded substrate and fauna along transect E_T09 matched the findings described in Table 42, and were classified to medium grade stony reef.

The seabed along E_T10 was characterised by matrix supported pebbles and cobbles, with an average elevation of approximately 0.064 m, and a maximum elevation of around 0.1 m. The area matched the assessment for an Annex I (1170) – Low Graded Stony Reef (Table 43).

Table 43 Reef assessment for assessed stony reef in E_T10.

MEASURE OF 'REEFINESS'	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	-	10-30%	-	-
Elevation	-	0.064 m	-	-
Extent	-	>25 m^2		

ANNEX I (1170) - SABELLARIA SPINULOSA REEFS

The transects where *S. spinulosa* occurred are listed in Table 40.

Table 44 Average coverage and standard deviation of S. spinulosa *in transects where it occurred (Alternative E, UK).*

TRAN-SECT	DDV_001	DDV_002	DDV_003	DDV_004	DDV_005	DDV_006	DDV_007	DDV_008	DDV_009	DDV_010	DDV_011	DDV_012	DDV_013	DDV_014	DDV_015	DDV_016	AVERAGE	SD
E_T03	0%	0%	0%	0%	0%	0%	9%	4%	9%	0%	0%	-	-	-	-	-	2.0%	3%
E_T07	20%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	-	-	-	-	-	2.0%	6%
E_T08	0%	0%	3%	0%	0%	0%	0%	0%	-	-	-	-	-	-	-	-	0.4%	1%
E_T10	0%	0%	0%	0%	1%	2%	0%	-	-	-	-	-	-	-	-	-	0.4%	1%

Small aggregations of *S. spinulosa* was recorded in transect E_T03 (Figure 50). The elevation of the aggregations visible in the transect photos was <2 cm, and the coverage varied between 0 % and 9 %, with an average coverage of 2 %. Due to the low elevation and the patchiness of the aggregations visible in the photos, the area was not considered to meet the definition of a *S. spinulosa* reef. However, the geophysical data showed that the area was characterised by a coarse seabed, and it cannot be ruled out that areas of *S. spinulosa* aggregations meeting the reef definition is present within this section.

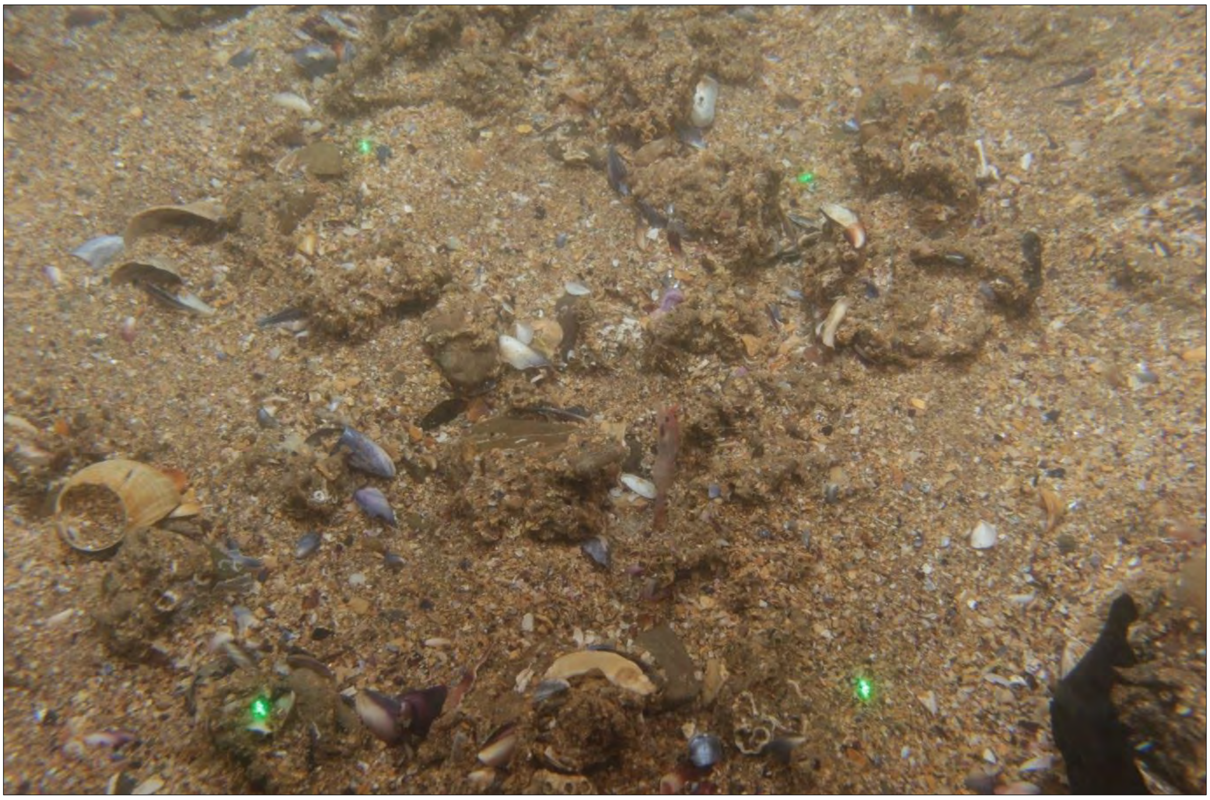


Figure 50 Image E_T03_009 of S. spinulosa *on the habitat A5.611 –* Sabellaria spinulosa *on stable circalittoral mixed sediment.*

The transect E_T07 had a coverage of *S. spinulosa* ranging from 0 % to 20 % coverage. The *S. spinulosa* was encrusting bedrock, and had in general a low elevation (<2 cm) and had very patchy distribution in (Figure 45). The area was not considered being a biogenic reef, as the bedrock was the feature that dominated and characterised this area.

S. spinulosa was recorded in transect E_T08 and E_T10. The coverage was low (<3 %). The area was not considered to meet the definition of a *S. spinulosa* reef.

5.5.4| PROTECTED AREAS

CASTLEMARTIN COAST SPA

The route run inside the Castlemartin Coast SPA between landfall in Freshwater West, KP 0, and KP 0.325. The SPA was designated to protect a population of Red-billed Chough *Pyrrhocorax pyrrhocorax* (JNCC, 2015).

PEMBROKESHIRE MARINE/ SIR BENFRO FOROL SAC

The route crosses the Pembrokeshire Marine/ Sir Benfro Forol SAC from the landfall in Freshwater West, KP 0, and KP 49.592.

The SAC include the following Annex I habitats: 1110 - Sandbanks which are slightly covered by sea water all the time, 1130 - Estuaries, 1140 - Mudflats and sandflats not covered by seawater at low tide, 1150 - Coastal lagoons, 1160 - Large shallow inlets and bays, 1170 - Reefs, 1330 - Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*), and 8330 - Submerged or partially submerged sea caves (JNCC, 2015).

The section of the survey corridor that crosses the SAC includes sections classified as 1170, both stony, bedrock, and biogenic reefs. It is possible that the habitat 1140 occurs in the intertidal zone close to landfall around KP 0.

From KP 5.122 to KP 8.841 and from KP 9.405 to KP 10.029, two areas with sand and coarse sediment could potentially be classified as 1110 - Sandbanks which are slightly covered by sea water all the time. The area is situated at a depth of about 28 m for the shallowest parts, which is generally too deep for 1110, and the geophysical data acquired does not support the interpretation of a distinct sand bank as present. However, there is a high confidence of this area to comprise of 1110, according to JNCC and NRW assessments for the Pembrokeshire Marine/ Sir Benfro Forol SAC, and therefore the area is classified as 1110.

The areas classified as 1170 - Bedrock Reefs are mainly located between KP 1.333 and KP 4.997 and along route alternative A, whereas areas classified as 1170 - Low Grade Stony Reefs are found between KP 15.003 and KP 22.071, and along route alternative E where also areas classified as 1170 - Medium Grade Stony Reef are found. Between KP 40.961 and KP 42.433 are areas classified as 1170 – Biogenic Reefs found, both Low Grade and Medium Grade, and areas classified as Potential Biogenic Reefs are found between KP 42.106 and KP 46.595.

SKOMER, SKOKHOLM AND THE SEAS OFF PEMBROKESHIRE / SGOMER, SGOGWM A MOROEDD PENFRO SPA

The route crosses the Skomer, Skokholm and the Seas off Pembrokeshire/Sgomer, Sgogwm a Moroedd Penfro SPA between KP 12.850 and KP 20.475.

The SPA was designated to protect the large populations of birds breeding on the islands Skomer, Skokholm and Middleholm, which are located North of the route. They are important breeding locations for Storm petrel *Hydrobates pelagicus*, Red-billed Chough *Pyrrhocorax pyrrhocorax,* Short-eared owl *Asio flammeus,* Manx shearwater *Puffinus puffinus*, Puffin *Fratercula arctica*, and Lesser Black-backed gull *Larus fuscus* (JNCC, 2017).

6| IRELAND

Reported KP for the Ireland EEZ Environmental survey are KP 73.906 to KP 159.070. A total of three transect were performed within the Irish EEZ, distributed between route A, and the route Final Route. Transect T01 and T02 were located within the Final Route corridor in the Irish EEZ. Transect T03 was located within the route A corridor.

Grab sample site S00 to S16 was located within the Irish EEZ. All grab sample sites were located within the Final Route corridor (Figure 51). See Appendix A| for a full list of positions of grab sample sites and transects. Field protocols are available in Appendix B| and Appendix C|. Grab identification protocols and Transect identification protocols are found in Appendix D| and Appendix E|.

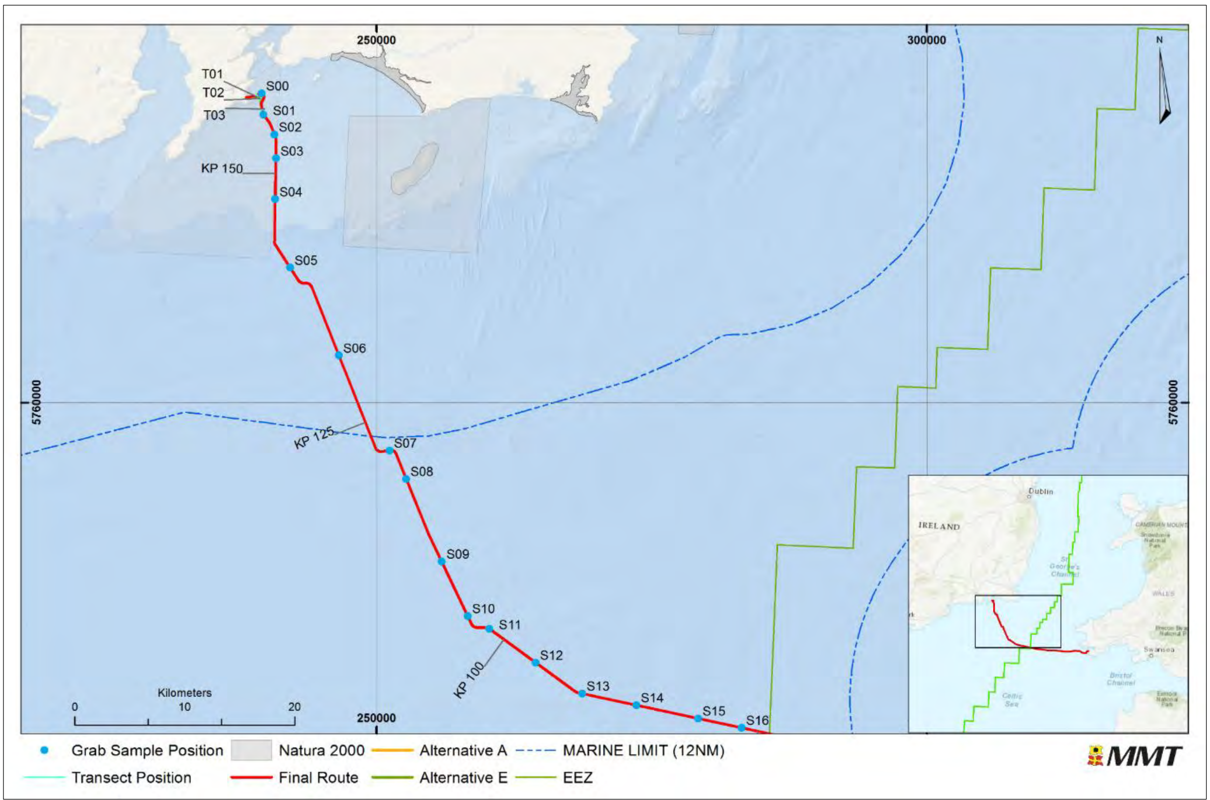


Figure 51 Overview of sampling and transect locations in the Irish EEZ.

See Table 45 for the number of sample sites and Table 46 and Table 47 for details regarding planned location coordinates and geophysical features overview.

Table 45 Number of sample sites.

NUMBER OF SAMPLE SITES	PHOTO TRANSECT SITES	GRAB SAMPLE SITES	PSA/CHEM SAMPLE SITES
	3	17	17

Table 46 List of proposed transects along Final Route in Ireland waters.

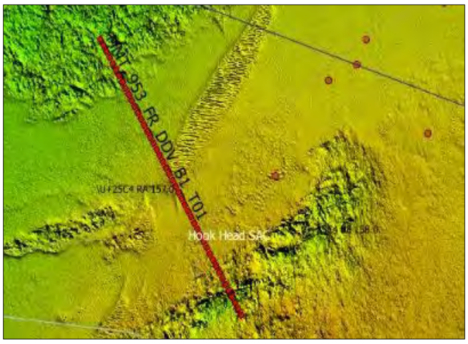
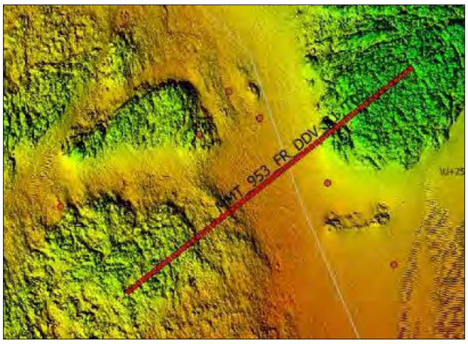
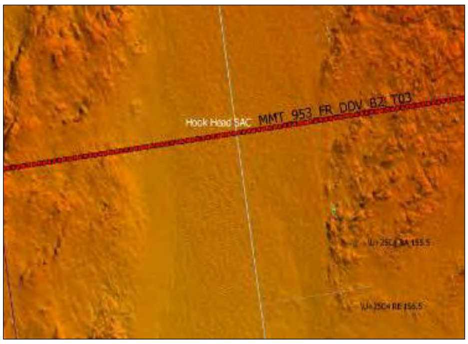
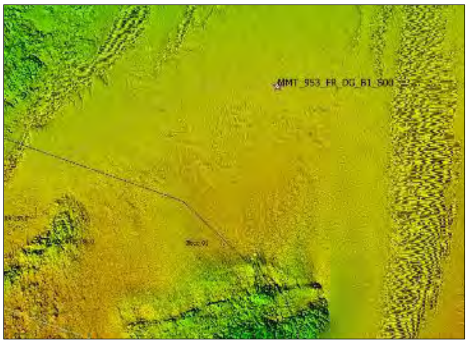
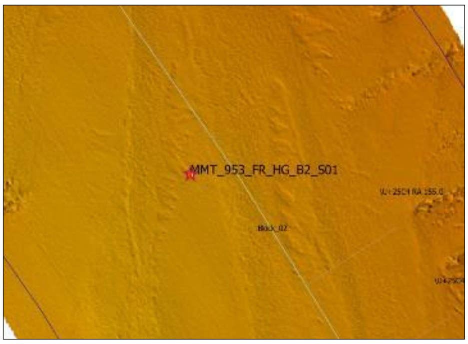
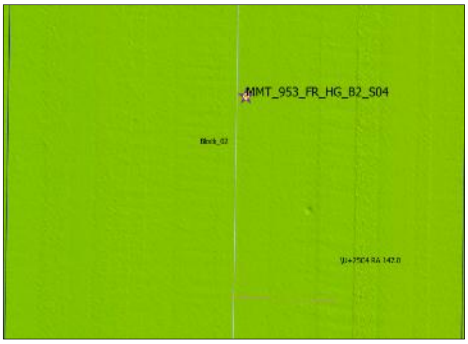
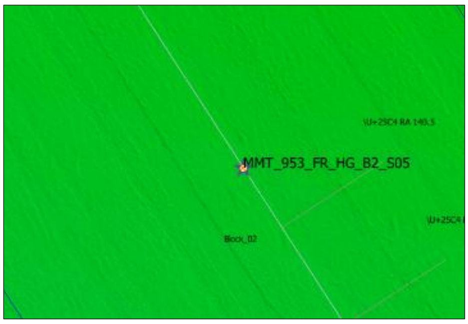
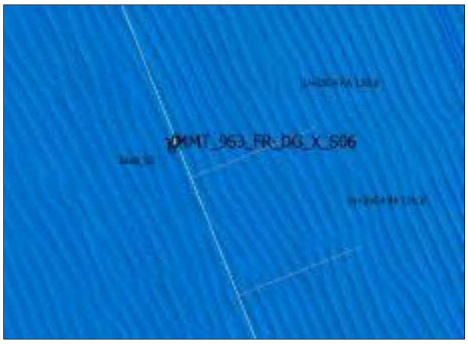
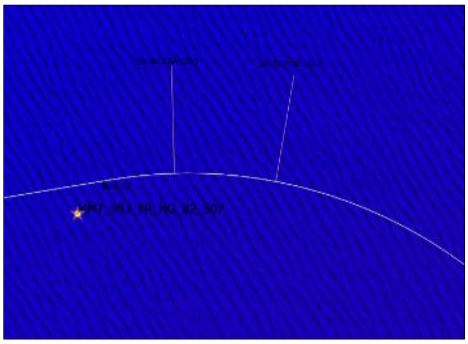
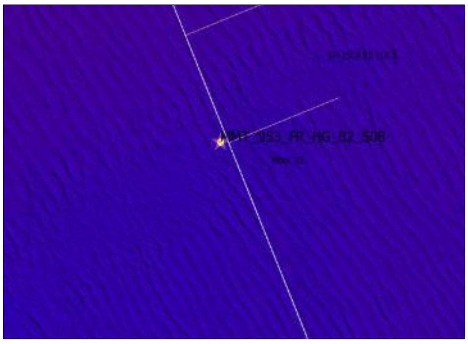
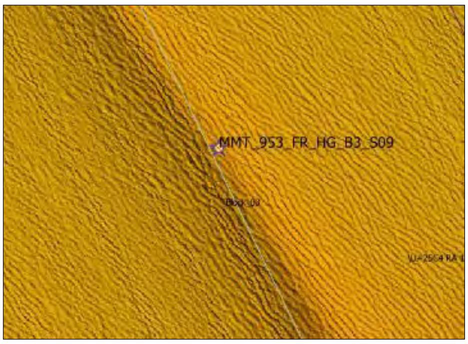
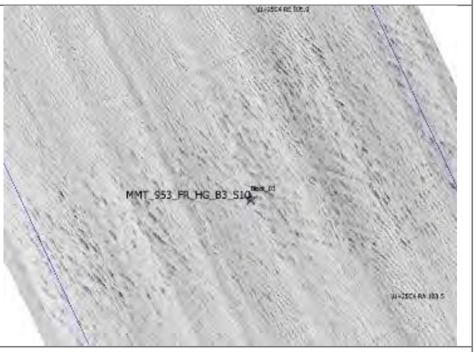
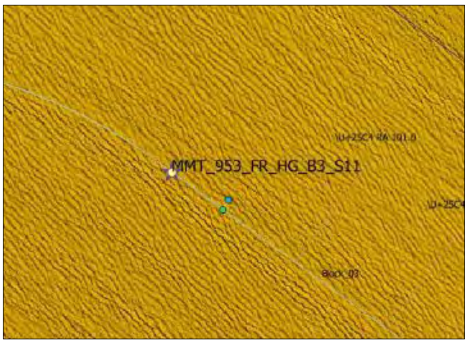
TRANSECT ID	START EASTING	START NORTHING	END EASTING	END NORTHING	GEOPHYSICAL OVERIEW
DDV_T01	239016	5787998	239133	5787788	
DDV_T02	239238	5787430	239473	5787617	
DDV_T03	239320	5786591	239814	5786661	

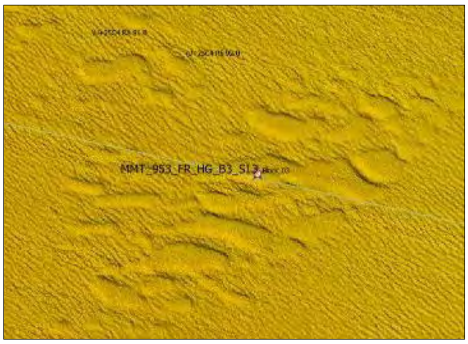
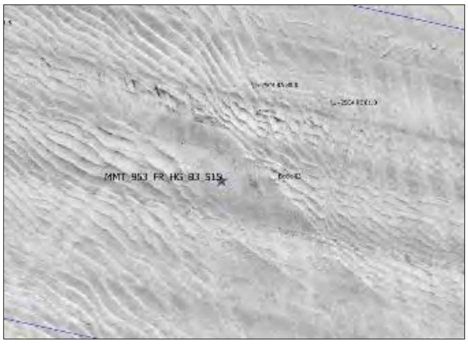
Table 47 List of proposed sampling sites performed in Irish waters.

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERIEW
S00	239542	5788098	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERIEW
S01	239719	5786155	
S02	240705	5784364	
S03	240850	5779049	
S04	240767	5778486	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERIEW
S05	242135	5772259	
S06	246562	5764282	
S07	251155	5755631	
S08	252670	2753045	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERIEW
S09	255916	5745527	
S10	258279	5740584	
S11	260245	5739415	
S12	264443	5736344	

SITE ID	EASTING	NORTHING	GEOPHYSICAL OVERIEW
S13	268685	5733542	
S14	273604	5732472	
S15	279212	5731266	
S16	283177	5730430	

6.1| DETAILED AREA DESCRIPTIONS

6.1.1| FINAL ROUTE

From KP 73.906 to KP 74.557 the seabed comprised rippled sands and was classified as A5.251 - *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand (Figure 52). Between KP 74.557 and KP 98.689 the seabed was predominantly classified as A5.252 - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand. A few gravelly areas classified as A5.272 - Owenia fusiformis and Amphiura filiformis in deep circalittoral sand or muddy sand were identified between KP 88.715 and KP 92.655, occasionally crossing the final route.

Grab sample site S16 at approximate KP 76.476, S15 at approximate KP 80.529, S14 at approximate KP 86.263, S12 at approximate KP 96.422 were located within habitat A5.252. The infaunal composition at these locations was characterised by molluscs *Abra prismatica, A. alba, Phaxas pellucidus, cumaceans Eudorellopsis deformis,* numerous polychaetes, *B. elegans* and echinoderms *A. filiformis* and *E. pusillus*.

Grab sample site S13 at approximate KP 91.300 (Figure 52) , was located within habitat A5.272. the infaunal composition was characterised polychaetes *Spiophanes kroyeri*, *Owenia* sp., *Goniada maculata,* echinoderms *A. filiformis* and molluscs *Corbula gibba* and *Nucula hanleyi*.

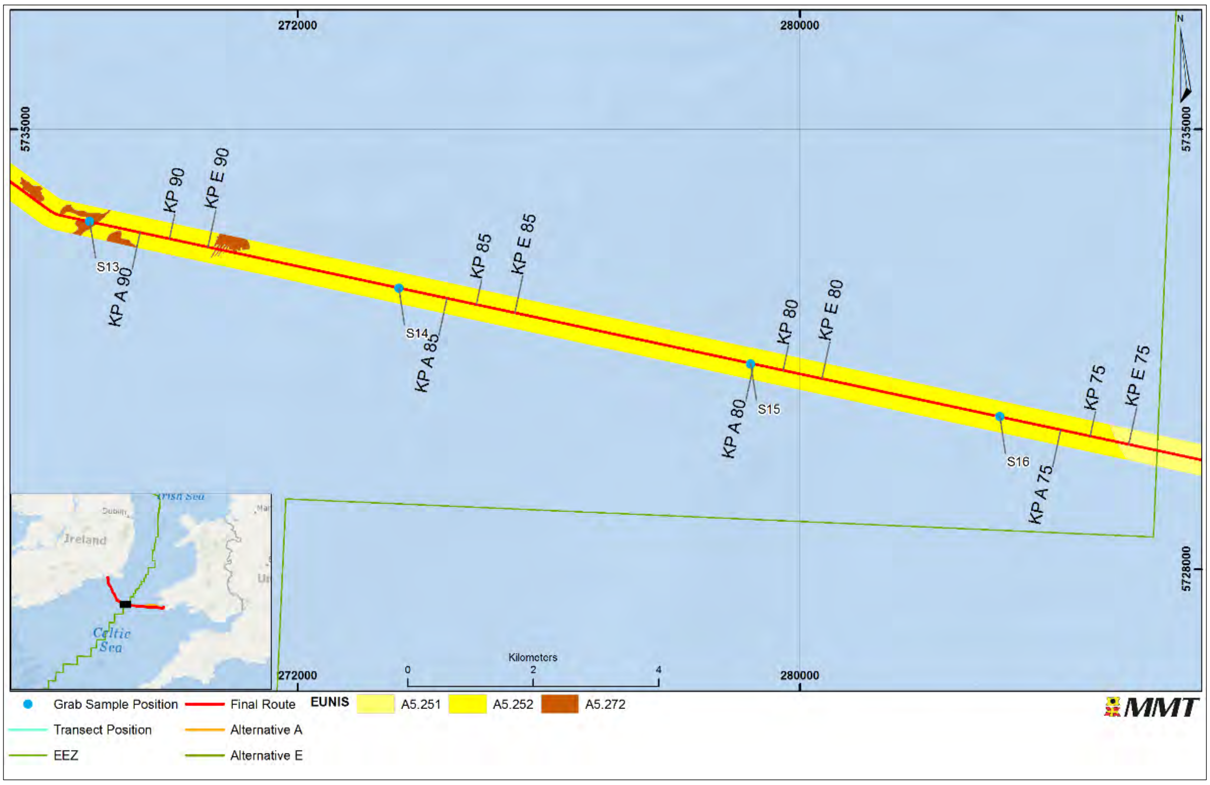


Figure 52 Overview of Irish EEZ KP 74 to KP 91.

From KP 98.689 to KP 104.107 the seabed comprised rippled sands and was classified as A5.272 (Figure 53). Grab sample site S11, at approximate KP 101.624 was located within habitat A5.272 and the infaunal composition was characterised by polychaetes *Owenia sp., O. borealis, Lagis koreni,* molluscs *Nucula nitidosa, C. gibba, Thyasira flexuosa,* echinoderms *A. filiformis* and *E. pusillus.*

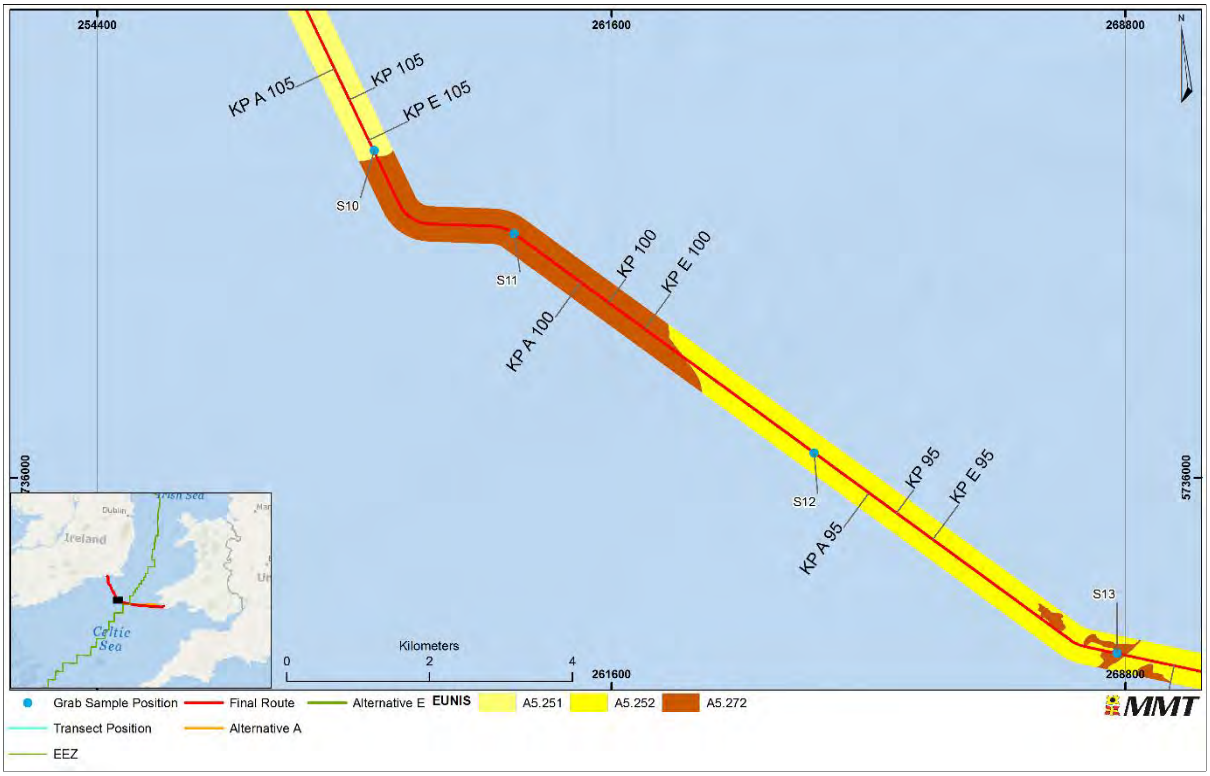


Figure 53 Overview of Irish EEZ KP 90 to KP 106.

From KP 104.107 to KP 117.805 the seabed comprised rippled sands and was classified as A5.251 (Figure 54).

Grab sample site S10, at approximate KP 104.203, and S09, at approximate KP 109.684, were located within habitat A5.251. The infaunal composition was similar at both locations, although less diverse and abundant at S09 than compared to S10, and was characterised by echinoderm *E. pusillus,* polychaetes *O. borealis,* and *Spiophanes bombyx, amphipod B. elegans and molluscs A. prismatica, T. flexuosa* and *K. bidentata.*

A small section classified as A5.25 - Circalittoral fine sand was located between KP 117.806 and KP 117.948. Grab sample site S08, at approximate KP 117.873, was located within habitat A5.25. No residue was acquired for analysis of infauna.

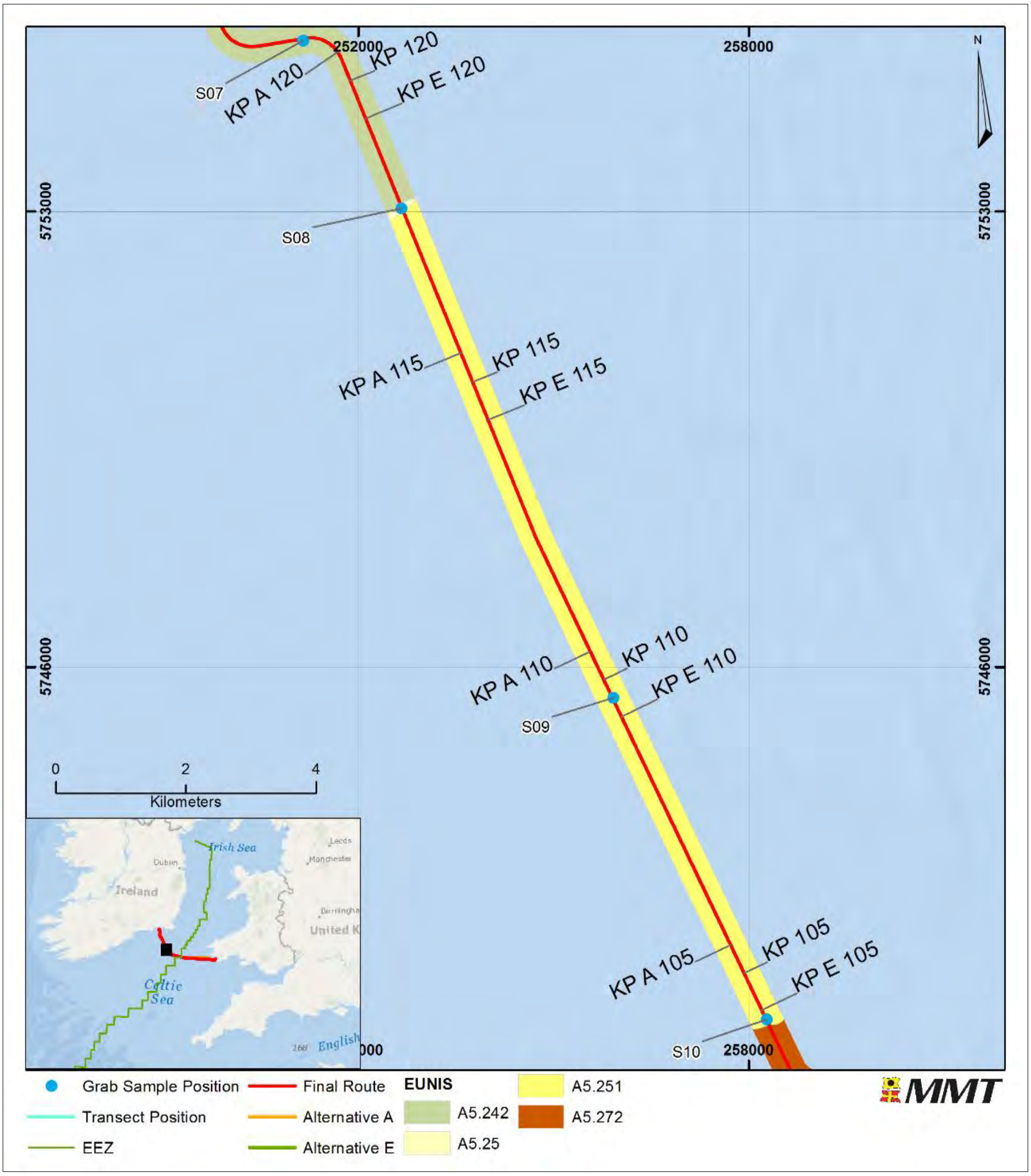


Figure 54 Overview of Irish EEZ KP 105 to KP 120.

From KP 117.948 to KP 148.306 the seabed was classified as A5.242 - *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand. Grab sample site S07, at approximate KP 121.090, S06 at approximate KP 131.546, S05 at approximate KP 141.046 and S04 at approximate KP 147.691 were all located within habitat A5.242 (Figure 55).

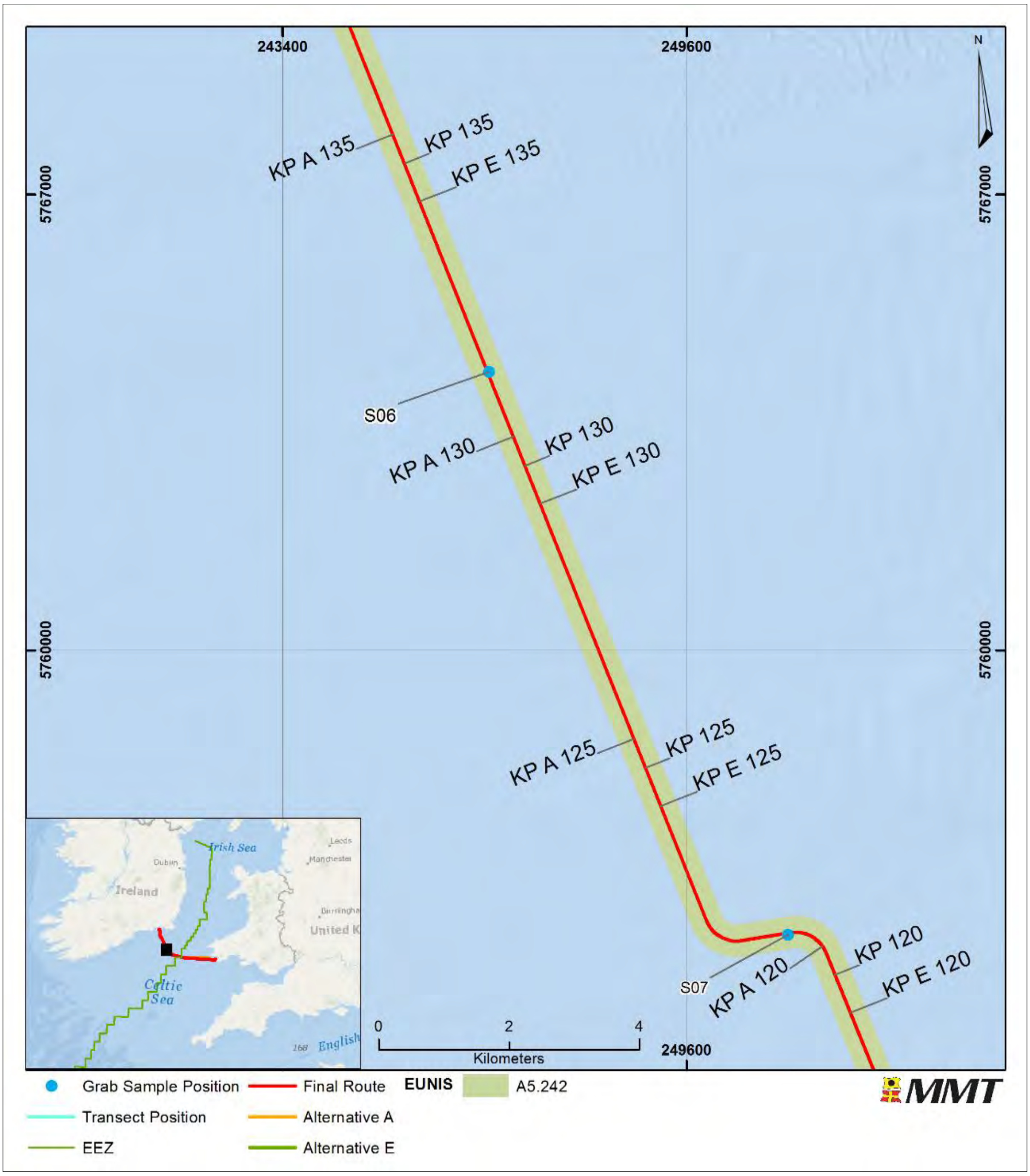


Figure 55 Overview of Irish EEZ KP 120 to KP 135.

The infaunal composition at sites S07 to S04 was similar and characterised by molluscs *Fabulina fabula, A. prismatica, N. nitidosa, Gari fervensis,* polychaetes *Magelona johnstoni*, *Magelona filiformis*, *N. cirrosa,* amphipods *Bathyporeia tenuipes, B. elegans* and echinoderms *E. pusillus and A. filiformis.*

From KP 148.306 to KP 152.363 the seabed comprised of coarse sediments and dominating habitat was classified as A5.14 - Circalittoral coarse sediment with frequent bands across the route corridor composed of finer sediments classified as A5.252 (Figure 56).

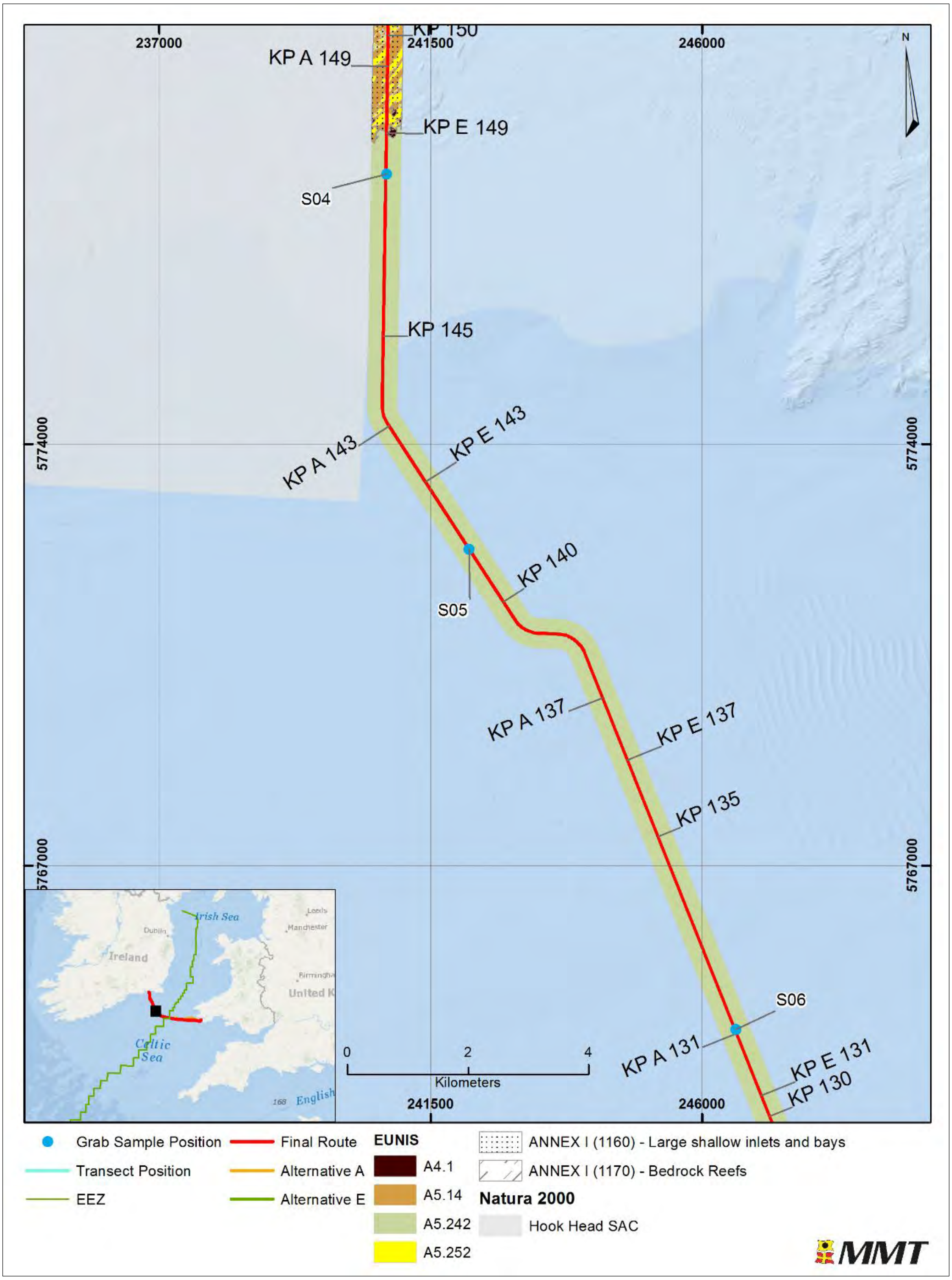


Figure 56 Overview of Irish EEZ KP 131 to KP 150.

Between KP 148.306 and KP 148.797 several areas of outcrops were classified as A4.1 - Atlantic and Mediterranean high energy circalittoral rock. These areas were predominantly located in the outer edges of the route corridor and further asses to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009). The assessment of these areas was predominately based on the interpretations of the geophysical data.

Between KP 150.442 and KP 150.726 a few scattered areas in the outer edges of the corridor were classified as A4.1 and as Annex I (1170) – Bedrock Reefs (Irving, 2009) with a few patches of A5.44 - Circalittoral mixed sediments (Figure 57). These interpretations were predominantly based on the interpretations of the geophysical data.

Grab sample site S03, at approximate KP 151.395, was located within habitat A5.252. The infaunal was characterised by polychaetes *O. borealis,* and *Spiophanes bombyx, L. cingulate, amphipods B. elegans, Urothoe elegans and molluscs A. prismatica* and *T. ovata.*

From KP 152.363 to KP 154.505 habitat A5.14 continued to dominate with intrusions of A5.25, KP 153.284 to KP 154.505. A few rocky areas interpreted from the geophysical data, between KP 153.118 and KP 154.484 were classified as A4.1 and as Annex I (1170) – Bedrock Reefs (Irving, 2009). These were predominantly located in the outer edges of the route corridor.

Grab sample site S02, at approximate KP 153.593, was located within habitat A5.14. the infaunal composition at S02 was characterised by polychaetes *Pista mediterranea, Psamathe fusca, echinoderms Amphipholis squamata, holothurian Thyone fusus,* molluscs *Gari telinella* and *Clausinella fasciata*.

From KP 154.505 to KP 157.712 the seabed along the final route was classified as A5.44. Between KP 154.505 and KP 155.966 a few rocky areas along the outer edges of the corridor were classified as A4.1 and as Annex I (1170) – Bedrock Reefs (Irving, 2009). These interpretations were predominantly based on the interpretations of the geophysical data. Intrusions of A5.14 and A525 were classified between KP 154.505 and KP 155.966.

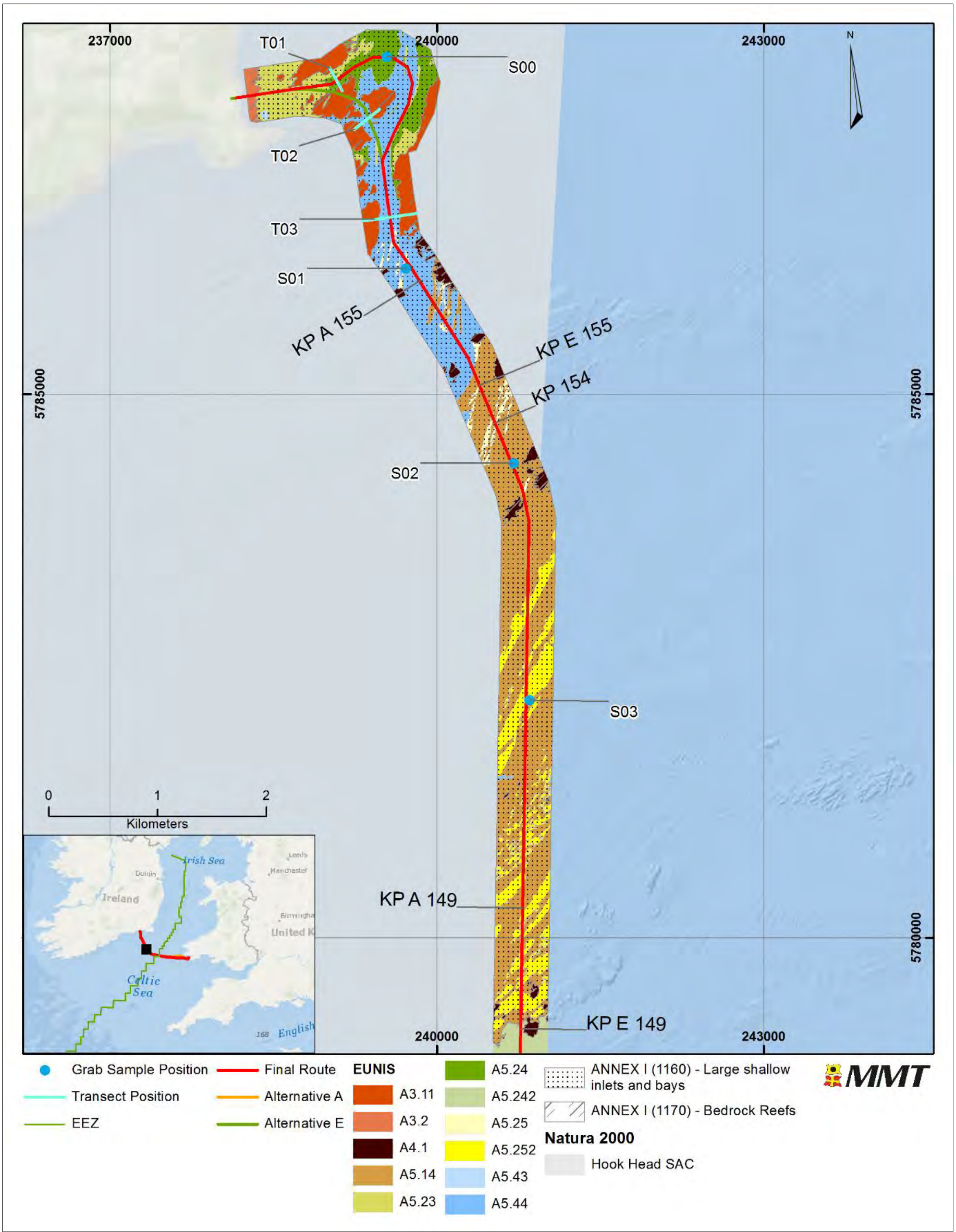


Figure 57 Overview of Irish EEZ KP 105 to KP 159.

Grab sample site S01, at approximate KP 155.639, was located at the boundary between A5.44 and A5.25. The infaunal analysis showed a small sample with regards to abundance and diversity, which was primarily characterised by crustaceans and polychaetes.

Transect DDV_T03, crossing the final route at approximate KP 156.149, had poor visibility.

From KP 155.966 to KP 157.712 areas of bedrock were interpreted along the edges of the route corridor. These were classified as A3.11 - Kelp with cushion fauna and/or foliose red seaweeds and assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009).

In the channel between the bedrock, KP 156.541 to KP 157.711 areas of A5.23 - Infralittoral fine sand and A5.24 - Infralittoral muddy sand were classified.

From KP 157.711 to KP 158.424 the seabed was classified as A5.24 with bands of A5.23. Grab sample site S00, at approximate KP, was located within habitat A5.24. The infaunal composition was characterised by molluscs *A. alba*, *F. fabula, Spisula subtruncata* and polychaetes *M. johnstoni* and *Nephtys hombergii.*

Transect DDV_T01 at approximate KP 158.266 had poor visibility in the imagery acquired.

From KP 158.424 to KP 159.070 the seabed along the route was classified as A5.23 with surrounding areas of bedrock classified as A3.11 which were assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009). From KP 159.070 to KP 159.267 the seabed was classified as A3.2 - Atlantic and Mediterranean moderate energy infralittoral rock and assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009). The assessment of the bedrock areas was predominatly based on the findings at T01 aswell as the interpretations of the geophysical data.

6.1.2| ALTERNATIVE E

Route Alternative E diverges from the final route at approximate KP 156.190 (Final Route KP 156.667) and converges with the final route at approximate KP 157.412 (Final Route KP 158.759) (Figure 57).

From KP 156.190 to KP 156.817 the seabed along Alternative E was classified as A5.44 - Circalittoral mixed sediments.

An area of bedrock was classified as A3.11 - Kelp with cushion fauna and/or foliose red seaweeds and assessed to meet the criteria of Annex I (1170) – Bedrock Reefs (Irving, 2009). The bedrock areas extended from KP 156.817 to KP 157.049. Transect DDV_T02 at approximate KP 157.168 had poor visibility but kelp and red foliose red seaweeds were visible in the imagery acquired.

From KP 157.049 to KP 157.412 the seabed was dominated by A5.23 - Infralittoral fine sand with intrusions of A5.24 - Infralittoral muddy sand.

6.2| SEDIMENT PARTICLE SIZE DISTRIBUTION

Samples for sediment particle distribution were acquired along the Final Route only. The full laboratory analyses results are presented in Appendix F|.

The results of the particle size analysis show that the sediment at the sites consisted mainly of sand, but for the three shallowest sites. Out of the three most shallow sites, site S00 mainly consisted of mud (clay and silt; 70 %), site S01 consisted mainly of sand (60 %) and site S02 consisted mainly of gravel (75 %) (Figure 58; Table 48). The sediment at the rest of the sites mainly consisted of sand (91 ± 6 %) tighter with smaller fractions of gravel (3 ± 2 %) and mud (6 ± 6 %).

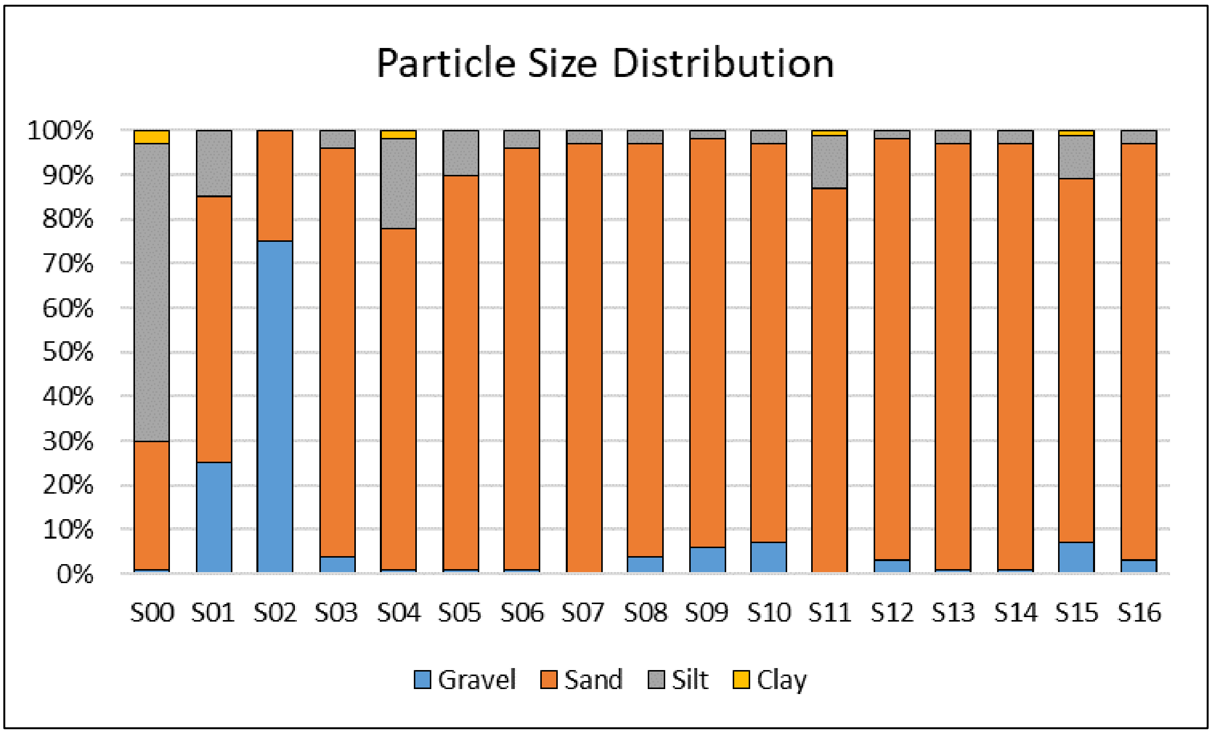


Figure 58 Bar chart displaying sediment fraction distribution across all grab sample sites.

Table 48 Summary of sediment distribution across all grab sample sites for Ireland.

GRAB SAMPLE ID	AREA	DEPTH	SEDIMENT FRACTION					FOLK DESCRIPTION
			GRAVEL	SAND	SILT	CLAY	MUD (CLAY & SILT)	
S00	IRL	13	1	29	67	3	70	Sandy mud
S01	IRL	21	25	60	15	0	15	Gravelly muddy sand
S02	IRL	27	75	25	0	0	0	Sandy gravel
S03	IRL	43	4	92	4	0	4	Sand
S04	IRL	31	1	77	20	2	22	Gravelly muddy sand
S05	IRL	43	1	89	10	0	10	Muddy sand
S06	IRL	57	1	95	4	0	4	Sand
S07	IRL	67	0	97	3	0	3	Sand
S08	IRL	70	4	93	3	0	3	Sand
S09	IRL	68	6	92	2	0	2	Gravelly sand
S10	IRL	66	7	90	3	0	3	Gravelly sand
S11	IRL	68	0	87	12	1	13	Muddy sand
S12	IRL	73	3	95	2	0	2	Sand
S13	IRL	71	1	96	3	0	3	Sand
S14	IRL	86	1	96	3	0	3	Sand
S15	IRL	104	7	82	10	1	11	Gravelly muddy sand

GRAB SAMPLE ID	AREA	DEPTH	SEDIMENT FRACTION					FOLK DESCRIPTION
			GRAVEL	SAND	SILT	CLAY	MUD (CLAY & SILT)	
S16	IRL	104	3	94	3	0	3	Sand
Mean			**8**	**82**	**10**	**0**	**10**	-
SD			**18**	**23**	**16**	**1**	**17**	-
Min			**0**	**25**	**0**	**0**	**0**	-
Max			**75**	**97**	**67**	**3**	**70**	-
Median			**3**	**92**	**3**	**0**	**3**	-

6.2.1 | MULTIVARIATE ANALYSES FOR SEDIMENT

Multivariate analyses were undertaken on the PSA data set, to identify spatial patterns in the sediment distribution. Analyses included hierarchical clustering employing the Euclidean distance resemblance matrix and the PCA. The dataset was normalised prior to analysis being undertaken.

The results from the hierarchical clustering analysis are presented in Figure 59 and Figure 60.

The SIMPROF analysis for the PSD output identified eight groups (black lines) separating the 18 grab sample sites within the survey area. Of these eight groups, three sub-groups were identified with similar characteristics.

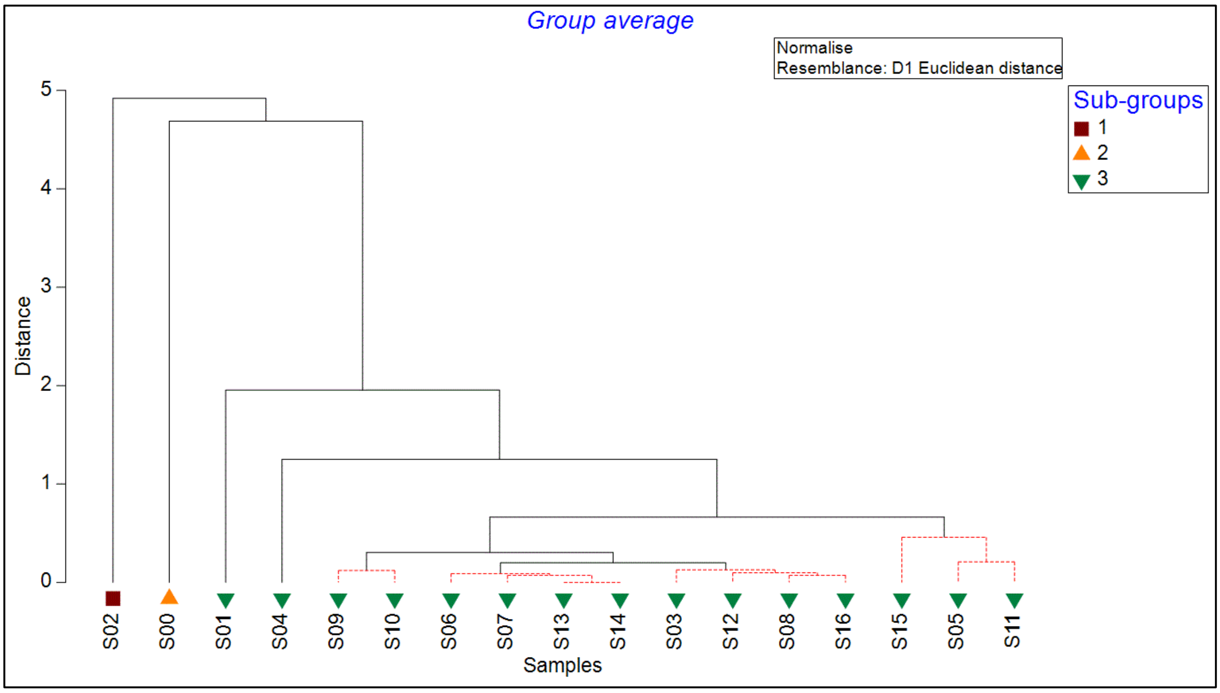


Figure 59 SIMPROF dendrogram based on sediment composition for each grab sample site.

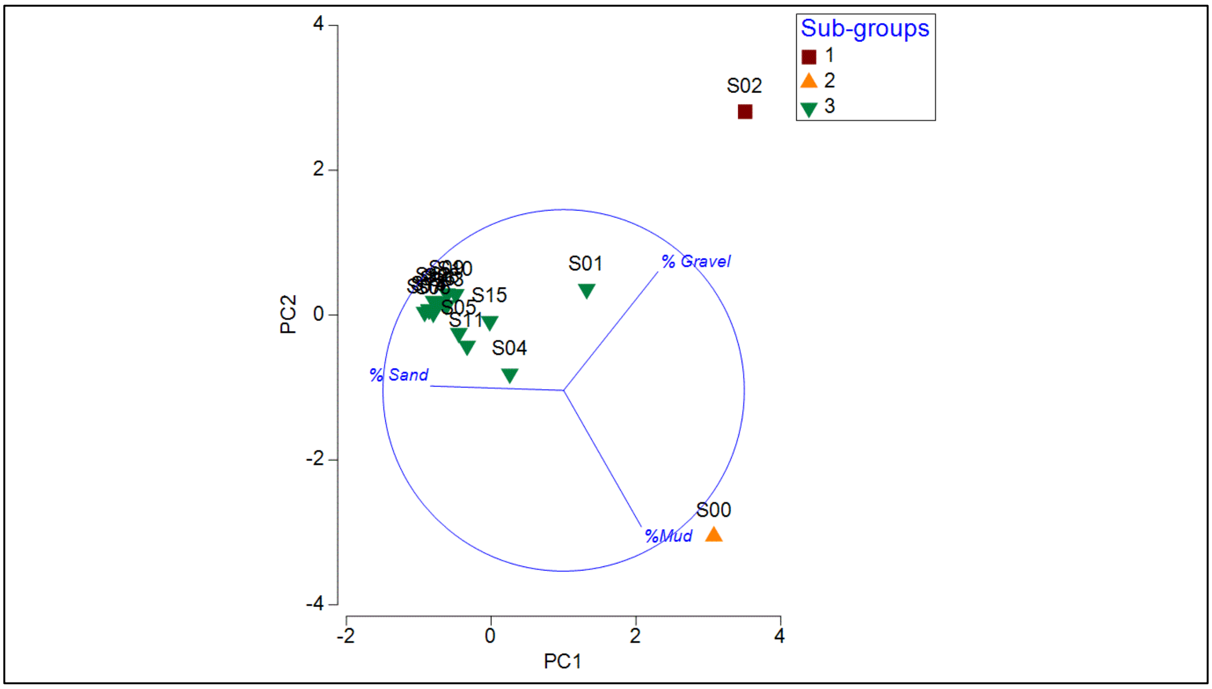


Figure 60 PCA plot of sediment data for each grab sample site, groups based on SIMPROF.

6.3 | CHEMICAL ANALYSES

All grab sample sites were selected for analyses of concentration of metals, organics and PAHs. Detailed results from the chemical analyses are stated in Appendix G|.

Grab samples for chemical analyses were not received from site S01, S02, S08 and S09 due to insufficient sample volume.

6.3.1 | METALS

Metal concentrations were low across all grab sample sites and rarely exceeded any threshold values with the exception of Arsenic (As) at grab sample sites S07, S10 and S12, where concentrations exceeded the CCME ISQG (Figure 61 and Table 49).

Table 49 Summary of metal concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.
Highlighted cells indicate where threshold values have been exceeded.

ANALYTE	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	TIN
Limit of Detection	1	0.1	0.5	2	2	0.01	0.5	0.5
OSPAR ERL		1.2	81	34	47	0.15	-	-
CEFAS AL2	100	5	400	400	500	3	200	-
CEFAS AL1	20	0.4	40	40	50	0.3	20	-
CCME PEL	41.6	4.2	160	108	112	0.7	-	-
CCME ISQG	7.24	0.7	52.3	18.7	30.2	0.13	-	-
Dutch RIVM	85	14	380	240	580	10	210	-
Units	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
S00	5	0.2	28.2	6.8	12.9	0.01	11.3	1.1
S03	5.8	0.1	8.7	4.7	11.8	<0.01	4.6	<0.5
S04	2.8	<0.1	15.2	4.5	10.4	<0.01	5.6	<0.5
S05	2.8	<0.1	11	6.6	7.3	0.02	5.4	<0.5
S06	3	<0.1	13.5	5.3	7.3	0.01	5.5	<0.5
S07	9.3	<0.1	14	4.7	11.6	<0.01	6.2	<0.5
S10	8	<0.1	12.7	5.7	9.8	0.01	5.7	<0.5
S11	5.1	<0.1	11.9	7.5	9.5	<0.01	5.3	<0.5
S12	16.2	<0.1	15.8	6.2	10.1	<0.01	8.8	0.6
S13	5	<0.1	10.2	5.1	10	<0.01	4.9	0.5
S14	4	<0.1	14	6.3	8.4	<0.01	7.8	1
S15	5.1	<0.1	11	5.6	8	<0.01	5.4	0.4
S16	6.4	<0.1	16.2	7.6	10.9	<0.01	6.8	0.6
Mean	**6.0**	**0.0**	**14.0**	**5.9**	**9.8**	**0.00**	**6.4**	**0.3**
SD	**3.6**	**0.1**	**4.8**	**1.0**	**1.7**	**0.01**	**1.9**	**0.3**
Min	**2.8**	**0.1**	**8.7**	**4.5**	**7.3**	**0.01**	**4.6**	**0.4**
Max	**16.2**	**0.2**	**28.2**	**7.6**	**12.9**	**0.02**	**11.3**	**1.1**
Median	**5.1**	**0.2**	**13.5**	**5.7**	**10.0**	**0.01**	**5.6**	**0.6**

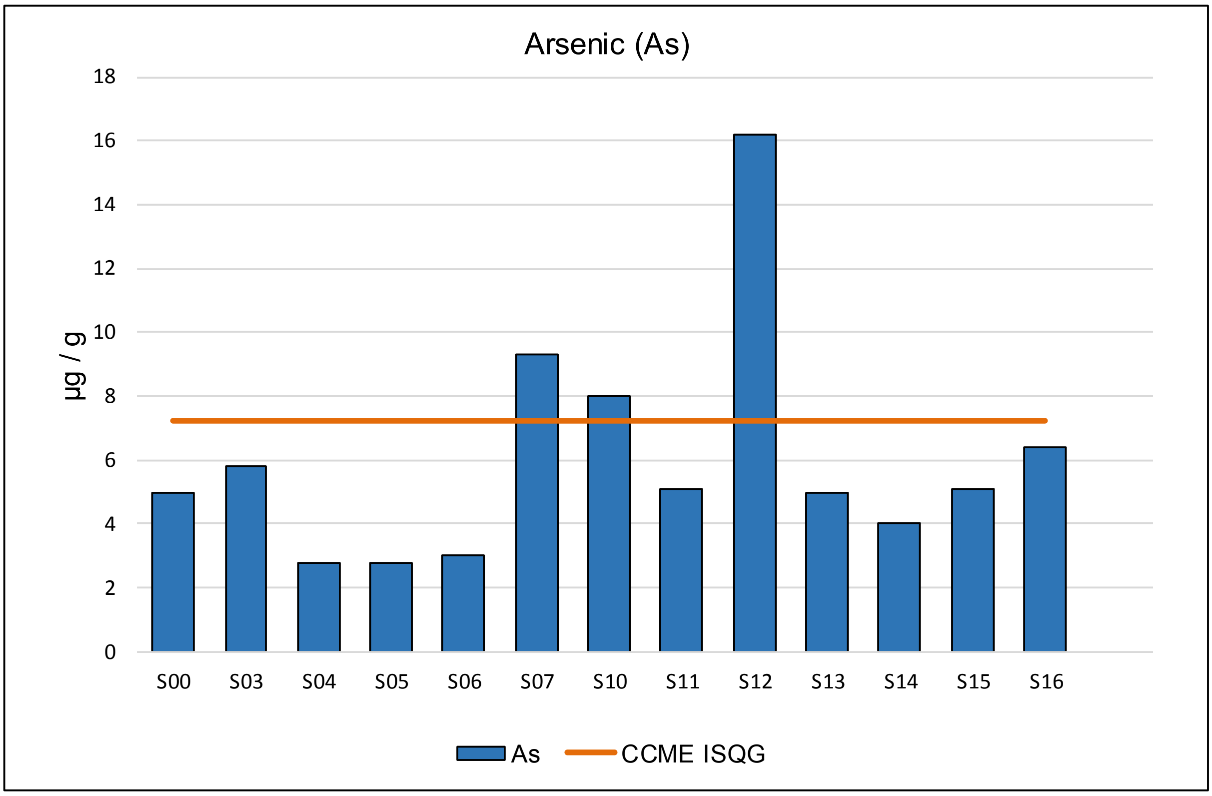


Figure 61 Arsenic (As) concentrations (µg/g dry weight) in sediment across sample sites together with threshold values for CCME ISQG.

6.3.2| ORGANICS AND MOISTURE

Concentrations of organics showed great variations between grab sample sites, whereas moisture content showed limited variation (Table 50).

Table 50 Summary of organics and moisture concentrations in sediment across grab sample sites.

ANALYTE	TOC	LOI	MOISTURE
Limits of detection	0.02	0.2	0.2
Units	%	%	%
S00	0.32	1.7	32.2
S03	0.16	1.5	26.2
S04	0.11	0.8	28.0
S05	0.12	0.8	24.0
S06	0.09	0.7	26.8
S07	0.08	0.6	27.7
S10	0.12	1.0	26.4
S11	0.08	5.4	25.3
S12	0.12	1.0	26.7
S13	0.11	1.0	16.0
S14	0.09	0.9	27.0
S15	0.25	1.6	23.0
S16	0.13	1.2	27.7
Mean	**0.14**	**1.4**	**25.9**
SD	**0.07**	**1.2**	**3.6**
Min	**0.08**	**0.6**	**16.0**
Max	**0.32**	**5.4**	**32.2**
Median	**0.12**	**1.0**	**26.7**

6.3.3| PAH

Concentrations of PAHs varied greatly between grab samples sites (Table 51). Grab sample sites S00 and S15 had markedly higher concentrations of PAHs, whereas grab sample sites S03 and S11 had markedly low concentrations. Threshold values were not exceeded at any of the grab sample sites.

Table 51 Summary of PAH concentrations (µg/Kg dry weight) across grab sample sites.

ANALYTE	NAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	DIBENZOTHIOPHENE	ANTHRACENE	FLUORANTHENE	PYRENE	BENZO[A]ANTHRACENE	CHRYSENE	BENZO[B]FLUORANTHENE	BENZO[K]FLUORANTHENE	BENZO[E]PYRENE	BENZO[A]PYRENE	INDENO[123,CD]PYRENE	DIBENZO[A,H]ANTHRACENE	BENZO[GHI]PERYLENE	SUM OF ALL
LIMIT OF DETECTION	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
OSPAR ERL	160	-	-	-	240	190	85	600	665	-	384	-	-	-	430	240	-	85	-
CEFAS AL1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-
CCME PEL	391	128	88.9	144	544	-	245	1494	1398	693	846	-	-	-	763	-	135	-	-
CCME ISQG	34.6	5.87	6.71	21.2	86.7	-	46.9	113	153	74.8	108	-	-	-	88.8	-	6.22	-	-
UNITS	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg
S00	1.78	<1	<1	1.17	4.03	<1	<1	7.47	5.74	3.48	4.71	5.94	3.67	3.94	3.88	4.84	<1	4.59	55.24
S03	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
S04	<1	<1	<1	<1	<1	<1	<1	1.34	<1	<1	<1	1.60	<1	1.09	<1	1.61	<1	1.61	7.25
S05	<1	<1	<1	<1	<1	<1	<1	1.03	<1	<1	<1	1.29	<1	<1	<1	1.36	<1	1.29	4.97
S06	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.11	<1	<1	<1	1.22	<1	1.26	3.59
S07	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.11	<1	<1	<1	1.15	<1	1.20	3.46
S10	<1	<1	<1	<1	1.14	<1	<1	1.34	<1	<1	1.02	1.66	<1	1.23	<1	1.62	<1	1.63	9.64
S11	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
S12	3.65	<1	<1	1.25	4.03	<1	<1	3.71	2.58	1.52	3.02	3.63	1.51	2.97	1.59	3.86	<1	3.78	37.10

ANALYTE	NAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	DIBENZOTHIOPHENE	ANTHRACENE	FLUORANTHENE	PYRENE	BENZO[A]ANTHRACENE	CHRYSENE	BENZO[B]FLUORANTHENE	BENZO[K]FLUORANTHENE	BENZO[E]PYRENE	BENZO[A]PYRENE	INDENO[123,CD]PYRENE	DIBENZO[A,H]ANTHRACENE	BENZO[GHI]PERYLENE	SUM OF ALL
LIMIT OF DETECTION	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
OSPAR ERL	160	-	-	-	240	190	85	600	665	-	384	-	-	-	430	240	-	85	-
CEFAS AL1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-
CCME PEL	391	128	88.9	144	544	-	245	1494	1398	693	846	-	-	-	763	-	135	-	-
CCME ISQG	34.6	5.87	6.71	21.2	86.7	-	46.9	113	153	74.8	108	-	-	-	88.8	-	6.22	-	-
UNITS	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg
S13	1.92	<1	<1	<1	2.81	<1	<1	2.07	1.45	<1	1.73	1.48	<1	1.58	<1	1.75	<1	1.70	16.49
S14	1.08	<1	<1	<1	1.49	<1	<1	1.76	1.18	<1	1.30	1.77	<1	1.39	<1	1.70	<1	1.70	13.37
S15	4.57	<1	<1	1.97	5.89	<1	<1	6.75	4.67	2.80	4.76	6.18	3.18	4.64	3.27	5.43	1.06	5.09	60.26
S16	2.32	<1	<1	1.23	3.84	<1	<1	4.08	2.86	1.77	3.16	3.64	1.98	2.99	2.05	3.76	<1	3.60	37.28
Mean	**1.2**	**0.0**	**0.0**	**0.4**	**1.8**	**0.0**	**0.0**	**2.3**	**1.4**	**0.7**	**1.5**	**2.3**	**0.8**	**1.5**	**0.8**	**2.2**	**0.1**	**2.1**	**19.1**
SD	**1.3**	**-**	**-**	**0.4**	**1.6**	**-**	**-**	**2.4**	**1.8**	**0.9**	**1.5**	**1.9**	**1.0**	**1.4**	**1.1**	**1.6**	**-**	**1.5**	**21.2**
Min	**1.1**	**0.0**	**0.0**	**1.2**	**1.1**	**0.0**	**0.0**	**1.0**	**1.2**	**1.5**	**1.0**	**1.1**	**1.5**	**1.1**	**1.6**	**1.2**	**1.1**	**1.2**	**3.5**
Max	**4.6**	**0.0**	**0.0**	**2.0**	**5.9**	**0.0**	**0.0**	**7.5**	**5.7**	**3.5**	**4.8**	**6.2**	**3.7**	**4.6**	**3.9**	**5.4**	**1.1**	**5.1**	**60.3**
Median	**2.1**	**-**	**-**	**1.2**	**3.8**	**-**	**-**	**2.1**	**2.7**	**2.3**	**3.0**	**1.7**	**2.6**	**2.3**	**2.7**	**1.7**	**1.1**	**1.7**	**13.4**

6.4| MULTIVARIATE ANALYSIS OF GRAB SAMPLES

Multivariate analysis was undertaken using the Plymouth Routines in PRIMER v7.0 statistical package (Clarke K. &., 2015). The statistical analyses are based on macrofaunal data derived from the taxonomic analysis of the grab samples at each location. No faunal sample was retrieved from grab sample site S08. All grab samples were located along the Final Route.

The SIMPROF analysis on faunal composition produced nine statistically distinct groups (black lines). Of these nine groups, five sub-groups were identified. The five groups were relatively far from each other, with the basal split in the dendrogram at 20 % average similarity. Both replicates from grab sample site S02 and S01_B differed from the rest of the sample sites. (Figure 62, Figure 63 and Table 52).

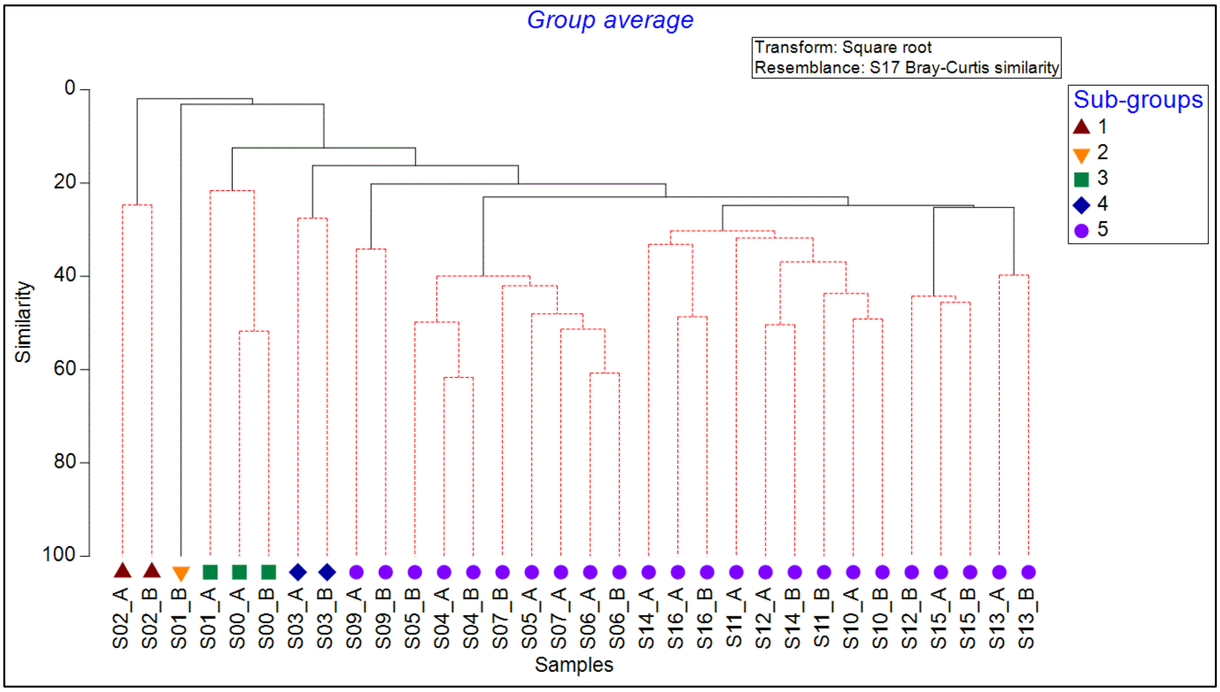


Figure 62 SIMPROF dendrogram based on faunal composition for each grab sample site and replicate.

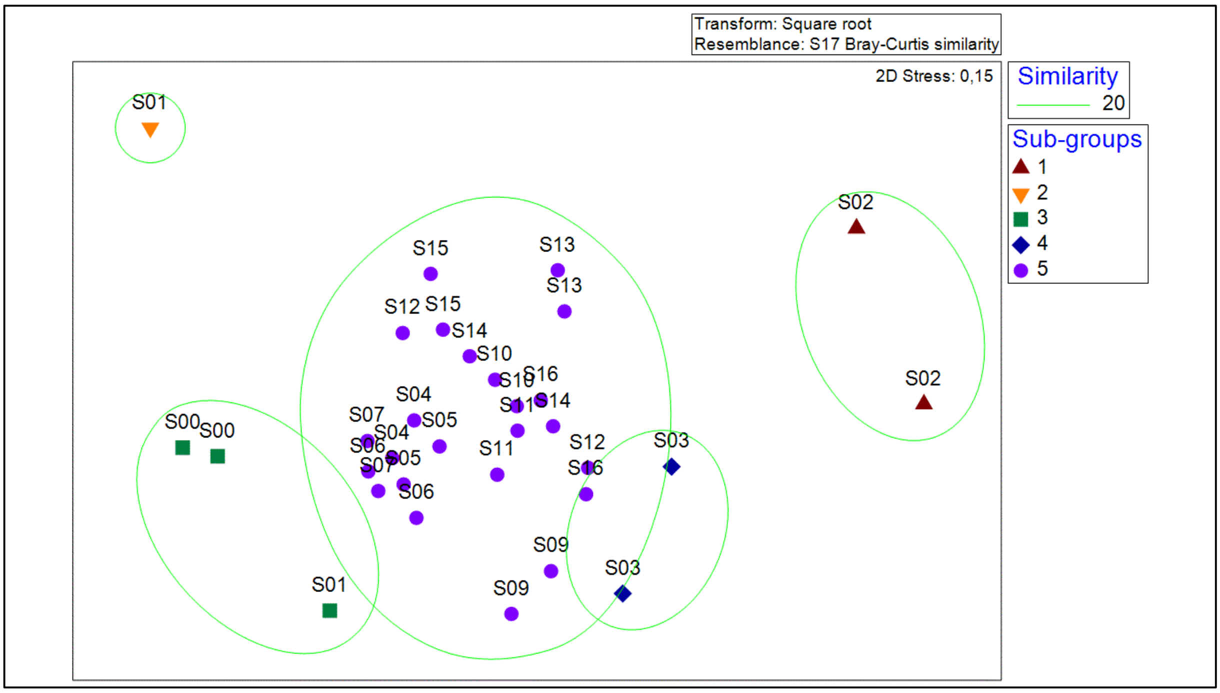


Figure 63 nMDS plot on faunal composition for each grab sample site and replicate, groups based on SIMPROF.

Group 1 consisted of both replicates from site S02 (S02_A, S02_B) and group 2 consisted of one replicate from site S01 (S01_B). Group 3 consisted of both replicates from site S00 (S00_A, S00_B) and the other replicate from site S01 (S01_A). Group 4 consisted of both replicates from site S03 (S03_A, S03_B). Group 5 was the largest group that comprised most samples and consisted of both replicates from site S04 to S16. The highest average similarity was found in group 3 (31.67 %) and the lowest in group 1 (24.73 %). This low similarity within groups suggest a difference in faunal composition in the groups.

Table 52 Characteristics of groups identified by SIMPROF analysis on abundance of non-colonial fauna.

GROUP	SAMPLES	PHYSICAL FEATURES	SPECIES	AVERAGE ABUNDANCE	CONTRIBUTION (%)
1 Average Similarity: 24.73 %	S02 (A&B)	Depth: 27 m Sediment: Sandy gravel	*Sphaerosyllis bulbosa* Nematoda *Glycera lapidum* *Trypanosyllis coeliaca*	4.0 3.0 1.5 1.0	25.73 14.85 14.85 14.85
2 Less than two samples in group	S01_B	Depth: 21 m Sediment: Gravelly muddy sand	Sclerocheilus *Scolelepis korsuni* *Parexogone hebes* *Magelona johnstoni* *Heteroclymene robusta* *Echinocyamus pusillus*	2 1 1 1 1 1	-
3 Average Similarity: 31.67 %	S00 (A&B) S01_B	Depth: 13 – 21 m Sediment: Sandy mud, Gravelly muddy sand	*Abra alba* *Nucula nitidosa* *Fabulina fabula*	17.7 3.0 2.67	28.41 26.13 19.61
4 Average Similarity: 27.54 %	S03 (A&B)	Depth: 43 m Sediment: Sand	*Urothoe elegans* *Lumbrineris cingulata* *Bathyporeia elegans*	4.5 5.5 1.5	36.94 26.12 18.47
5 Average Similarity: 26.83 %	S04 (A&B) S05 (A&B) S06 (A&B) S07 (A&B) S09 (A&B) S10 (A&B) S11 (A&B) S12 (A&B) S13 (A&B) S14 (A&B) S15 (A&B) S16 (A&B)	Depth: 31 – 104 m Sediment: Sand, Gravelly muddy sand, Muddy sand, Gravelly sand	*Abra prismatica* *Echinocyamus pusillus* *Amphiura filiformis* *Spiophanes bombyx* *Owenia sp* *Phoronis sp* *Fabulina fabula* *Scoloplos armiger* *Bathyporeia elegans* *Nucula nitidosa* *Kurtiella bidentata* *Ophelia borealis* Nemertea *Magelona johnstoni*	4.7 2.2 4.0 1.9 3.4 1.5 3.5 1.0 1.1 2.0 3.9 1.1 0.8 1.9	13.96 12.54 7.29 6.51 5.68 3.53 3.2 3.04 2.82 2.79 2.74 2.43 2.35 2.01

The resulting EUNIS habitat classification for each site is presented in Figure 64. The different habitats can in some extent be related to the sub-groups identified in the SIMPROF analysis. EUNIS habitat classification A5.14 was the only habitat found within sub-group 1 (grab sample site S02). Habitat classification A5.242, A5.251 and A5.272 was found within sub-group 5. Habitat classification A5.252 was only found within sub-group 4 (grab sample site S03). Sub-group 2, with one replicate of S01, was classified as A5.44. Sub-group 3, with one replicate of S01 and site S00, included both A5.44 and A5.24.

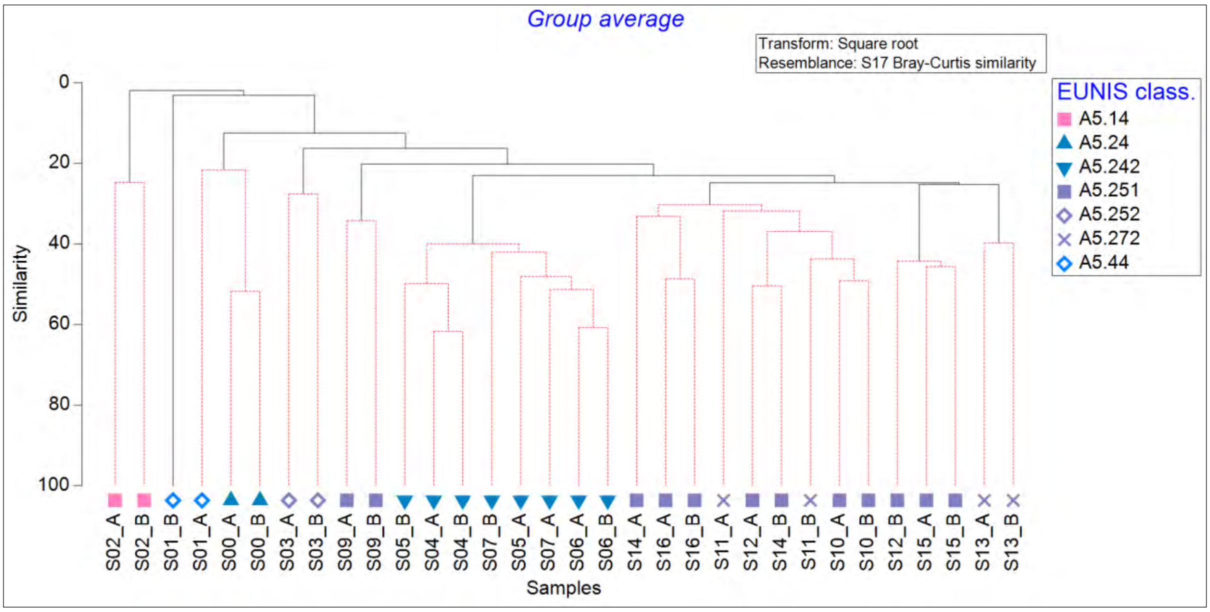


Figure 64 SIMPROF dendrogram based on faunal composition with EUNIS habitat classification overlay for each grab sample site and replicate.

6.5| POTENTIAL AREAS AND SPECIES OF CONSERVATION

The habitats in the Irish EEZ corresponding to those defined in the EC Habitats directive (EUR 27, 2007) are listed in separate sections for each route alternative.

Figures displaying detailed overview of the potential areas of conservation concern are displayed in Figure 65.

Figure 65 Overview of Annex I areas in Irish EEZ between KP 149 and KP 159.

6.5.1| FINAL ROUTE

Annex I habitats identified within the final route survey corridor are presented in Table 53.

Table 53 Annex I habitats or species of special interest identified within the survey corridor.

HABITAT IMAGE	ANNEX I	OSPAR/MPA	SITE ID
	Annex I (1170) - Bedrock reef	Hook Head SAC	T01, T02, T03

ANNEX I (1170) - STONY REEFS

Bedrock outcrops were identified in the geophysical data edging the Final Route corridor in the Irish EEZ. Photo transects were performed across the corridor at several locations (T03 at KP 156.136, T01 at KP 158.318). However, no habitats or associated fauna was recorded from the transects located along the Final Route due to very poor visibility from suspended sediment in the water column. One successful transect was performed on alternative E (Transect T02), showing kelp on bedrock. All outcropping bedrock shallower than 20 m, were classified to A3.11 and thus assessed to meet the criteria for Annex I (1170) - Bedrock reefs. No areas that could be classified as Stony Reefs were interpreted in the data acquired.

ANNEX I (1170) - SABELLARA SPINULOSA REEFS

No *S. spinulosa* was identified in any of the grab samples in the Irish EEZ.

6.5.2| ALTERNATIVE E

ANNEX I (1170) - STONY REEFS

Transect T02, crossing the alternative E at KP 156.911, showed rocky outcrops with kelp and red algae. Multiple areas of outcropping bedrock were identified in the geophysical data. All were classified to A3.11 (Figure 66). These areas were assessed to meet the criteria for Annex I (1170) - Bedrock reefs. No areas that could be classified as Stony Reefs were interpreted in the data acquired.

Figure 66 Image T02_001 of Annex I (1170) – Bedrock Reefs with the habitat A3.11 – Kelp with cushion fauna and/or foliose red seaweeds.

ANNEX I (1170) - SABELLARA SPINULOSA REEFS

No *S. spinulosa* was identified in any of the grab samples in the Irish EEZ. Due to the poor visibility, no fauna was identified.

6.5.3| HOOK HEAD SAC

The route crosses the Hook Head SCA between KP 151.258 and the landfall in Baginbun, KP 159.267.

The SAC include the following Annex I habitats: 1160 - Large shallow inlets and bays, 1170 - Reefs, and 1230 - Vegetated sea cliffs of the Atlantic and Baltic coasts (NPWS, 2018).

The section of the survey corridor that crosses the SAC is mainly classified as 1160, with areas of 1170 bedrock reef. The cliffs just inside the landfall are classified as 1230 (NPWS, 2011).

None of the invertebrate species listed in the Natura 2000 standard data form for Hook Head (NPWS, 2018) was identified in the grab samples. Areas of *Laminaria* sp. was identified on outcropping bedrock within the Irish EEZ (Figure 66).

7| DISCUSSION

In total 38 sampling locations were investigated during the benthic survey. In addition, 38 photo transects were performed over where potential areas of conservation were identified from the geophysical data.

In general, the variation was larger in the UK section of the survey corridor, than in the Irish section, this can be seen in the number of habitats identified, 25 habitats were identified in the UK section, and 12 in the Irish section, it is also reflected in the PSA, where the sites in the Irish section are more homogeneous compared to the sites in UK section.

Bedrock reefs have been hard to discriminate as much of the bedrock elevated above surrounding seabed is partly or totally covered by sand and gravel, with only small patches protruding with epifauna on them. Due to this some areas were classified as Potential Bedrock Reefs.

Two areas of low grade, and one of medium grade Biogenic Reef (1170)- *S. spinulosa* reef were identified in this survey. *S. spinulosa* habitats were identified along major parts of the UK Final Route survey corridor, but only a minority of the area were considered to meet the criteria of Annex I (1170) – Biogenic reef (Gubbay, 2007). The *S. spinulosa* that was identified in the imagery was often occurring on bedrock, and thus it fell under the Annex I (1170) - Bedrock Reefs. The elevation of the *S. spinulosa* aggregation rarely exceeded 5 cm, and was never assessed to exceed 10 cm. However, the elevation and extent of the *S. spinulosa* aggregations on bedrock are hard to evaluate outside the boundaries of the visual survey corridor, as the *S. spinulosa* structures are hard to discriminate from outcrops of bedrock with low elevation, and stony areas. Where this discrimination was arbitrary areas were classified to Potential Biogenic Reefs.

The *S. spinulosa* was often abraded, likely due to natural abrasion caused by sand drifting by the strong currents.

S. spinulosa was recorded in transect RR_T07. Areas of solidified sandy aggregations, possibly abraded remnants of an *S. spinulosa* reef, was observed along the transect. Due to the low elevation of the few newly formed tubes in the area, the area was not considered to meet the definition of a *S. spinulosa* reef. However, the area is clearly influenced by the aggregations, with a rich epifaunal community associated with the concrete sandy formation in the seabed.

The visibility was poor in the nearshore area of Irish landfall.

No *S. spinulosa* was identified in any of the grab samples acquired within the Irish EEZ. The visibility in the nearshore area of the Irish EEZ was very poor. No biogenic reefs were identified within the Irish EEZ.

The reef habitats found in Hooks Head SAC are Bedrock and Stony Reefs of three community types: Exposed to moderately exposed intertidal reef community complex, Echinoderm and sponge dominated community complex, and *Laminaria* dominated community (NPWS, 2011).

Concentrations of *Mytilus edulis* on for recorded on three transects along route alternative A, however none of these were classified as Annex I *Mytilus* reef, as the bedrock was the major epifauna supporting habitat, therefore they were classified as Bedrock Reefs.

The grab sample sites within the UK sector comprised of coarse sediment, consisting nearly exclusively of sand and gravel. However, the sand to gravel proportion differed from site to site. Whereas in the Irish sector, all grab sample sites, but the three closest to the Irish landfall, the sediment was highly homogeneous and comprised nearly exclusively of sand. The three sites closest to the Irish landfall were more heterogeneous, with site S02 comprising mainly of gravel and site S00 comprising mainly of mud.

The sediment composition of the UK and Irish areas of the route differ notably with more homogenous sandy sediment in the Irish section and more heterogeneous courser sediment in the UK section.

The change occurs somewhere between site S19 and S20, site S19 comprising of 94% sand and site S20 comprising of 49 % gravel and 26 % sand. This transition in particle size coincides with the change in peak tidal current velocity which generally decreases with increased KP and most likely drops below 0.5 m/s in-between KP 50 and KP 70 (Coscia, Robins, Porter, Malham, & Ironside, 2013; Lewis, Neill, Robins, & Hashemi, 2015). The higher current velocity on the UK side is most likely re-suspending and transporting finer sediment, leaving behind only coarser sediment such as coarse sand and gravel (Hjulstrom, 1935).

Metal concentration were low across all grab sample sites and did not exceed any threshold values but for Arsenic (As), which exceeded the CCME ISQG threshold levels for three sites in the Irish section (S07, S010 and S12), and at all sites in the UK sector except for three sites, the two sites closest to the UK landfall (S35 & S37) and S17. No correlations were found between arsenic concentration and sediment composition nor any other parametres measured.

The concentration of organics varied more across the sites in the Irish section than across the sites in the UK section, the moisture content showed limited variation across both the UK and Irish sites. In the Irish sites the TOC correlates with the sand/mud content, TOC concentrations decreasing with increased sand content and increasing with increased mud content. Such a correlation cannot be seen in the UK sites.

The concentrations of PAH’s varied greatly across all grab sample sites. The levels were overall low and did not exceed any threshold value but for site S33, where naphthalene exceeded the CCME ISQG threshold level. Any correlation between the high concentration and any other measured value was not found.

In total 38 photo transects and 38 grab sample locations were sampled, together with geophysical data, they form the basis of the assessment in this report, where a total of 33 habitats were identified within the survey corridor, 12 in the Irish section and 25 in the UK section. Further three potential Annex I habitats: 1160 Large shallow inlets and bays, 1170 Reefs, with its three subtypes “Bedrock Reef”, “Stony Reef”, and “Biogenic Reef”, as well as 1110 Sandbanks which are slightly covered by sea water all the time were identified within the corridor.

8| RESERVATIONS AND RECOMMENDATIONS

The definition of a reef is still a subject to debate within and among the member countries in the EU.

The JNCC report No. 405 "*Defining and managing Sabellaria spinulosa reefs: Report of an inter-agency workshop1-2 May*" (Gubbay, 2007) presents methods for defining *S. spinulosa* reef structures and setting different criteria to assess the quality of the reef. The report stated the following as the baseline for the definition of *S. spinulosa* reefs:

"The simplest definition of Sabellaria spinulosa reef in the context of the Habitats Directive was considered to be an area of Sabellaria spinulosa which is elevated from the seabed and has a large spatial extent. Colonies may be patchy within an area defined as reef and show a range of elevations."

A number of evaluation criteria were agreed upon in this report to be considered as "*a starting point for wider discussion rather than accepted and fully agreed thresholds for* Sabellaria spinulosa *reef identification"* (Gubbay, 2007).

9| REFERENCES

BRIG (ed. Ant Maddock). (2008 (Uppdated Dec 2011)). *UK Biodiversity Action Plan Priority Habitat Descriptions.* JNCC.

Brig, M. (2008 (Updated Dec 2011)). *UK Biodiversity Action Plan Priority Habitat Descriptions.* JNCC.

British Standard. (2010). *Methods of test for soils for civil engineering purposes 1377-2:1990.* BSI.

BS 1377-1:1990. (n.d.). *Methods of test for soils for civil engineering purposes.* BSI.

Clarke KR, G. R. (2006). PRIMER v6: User Manual/Tutorial. PRIMER-E. *Plymouth*, 192pp.

Clarke, K. &. (2015). *PRIMER v7: User Manual/Tutorial. Plymouth: PRIMER-E.*

Clarke, K. R., & Warwick, R. M. (2001). *Change in marine communities: An approach to statisctical analysis and interpretation, 2nd edition.* Plymouth: PRIMER-E.

Coscia, I., Robins, P. E., Porter, J. S., Malham, S. K., & Ironside, J. E. (2013). Modelled larval dispersal and measured gene flow: seascape genetics of the common cockle Cerastoderma edule in the southern Irish Sea. *Conservation Genetics*, 451-466.

Dickey-Collas et al. (2010). *Lessons learned from stock collapse and recovery of North Sea herring: A review.* ICES Journal of Marine Science 67(9):1875-1886.

Environment, C. C. (1995). *Protocol for the derivation of Canadian sediment quality guidelines for the protection of aquatic life.*

Environment, C. C. (2001). *Canadian sediment quality guidelines for the protection of aquatic life: Introduction. Updated.*

EUR 27. (2007). Interpretation manual of European Union Habitats. COMMISSION, EUROPEAN.

European Commission. (2007). Interpretation manual of European Union Habitats - EUR 27. European Commission.

European Commission. (2017, March 30). *Lead EQS dossier 2011.* Retrieved from CIRCABC: https://circabc.europa.eu/sd/d/be12c5a9-19b2-40eb-87ce-f62eb3b43b39/Lead%20and%20its%20compounds%20EQS%20dossier%202011.pdf

Fariñas-Franco, J. P. (2014). *Marine Strategy Framework Directive Indicators for Biogenic Reefs formed by Modiolus modiolus, Mytilus edulis and Sabellaria spinulosa.* Peterborough: JNCC.

Fey, D. P., Hiller, A., Laak, M. v., & Szymanek, L. (2014). *Herring - An analysis of spawning ground management, ecological conditions and human impacts in Greifswald Bay, Vistula Lagoon and Hanö Bight.* Malmö: CA Andersson.

Fey, D. P., Hiller, A., Margonski, P., Moll, D., Nilsson, H., Pongolini, L., . . . and Szymanek. (2014). *HERRING Impact Report Herring spawning areas.*

Gubbay, S. (2007). *Defining and managing Sabellaria spinulosa reefs: Report of an inter-agency workshop Report of an inter-agency workshop.* Joint Nature Conservation Committee.

Hin, J. A. (2010). *Guidance document for Sediment Assessment.* Ministry of Infrastructure and the Environment.

Hjulstrom, F. (1935). Studies of the morphological activity of rivers as illustrated by the River Fyris, Bulletin. *Geological Institute Upsalsa*.

Holt et al. (1998). *Biogenic Reefs (volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs.* UK Marine SACs Project.

Holt, T. R. (1998). *Biogenic Reefs (volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs.* Scottish Association for Marine Science (UK Marine SACs Project).

Irving, R. (2009). *The identification of the main characteristics of stony reef habitats under the Habitats Directive. Summary report of an inter-agency workshop 26-27 March 2008.* Peterborough: JNCC Report No.432.

J. R. Ellis, S. M. (2012). *Spawning and nursery ground of selected fish species in UK waters.* Lowestoft: Cefas.

JNCC. (2010, 12 15). *UK Priority species data collation.* Retrieved from Ammodytes marinus Ver 2: http://jncc.defra.gov.uk/_speciespages/2029.pdf

JNCC. (2015). *NATURA 2000 - Standard Data Form, UK0013116, Pembrokeshire Marine/ Sir Benfro Forol.* Natura 2000.

JNCC. (2015). *NATURA 2000 - Standard Data Form, UK9014061, Castlemartin Coast.* Natura 2000.

JNCC. (2017, January 25). Retrieved from SAC Selection: http://jncc.defra.gov.uk/protectedsites/sacselection/habitat.asp?FeatureIntCode=H1170

JNCC. (2017). *NATURA 2000 - Standard Data Form, UK9014051, Skomer, Skokholm and the Seas off Pembrokeshire / Sgomer, Sgogwm a.* Natura 2000.

Lewis, M., Neill, S. P., Robins, P. E., & Hashemi, M. R. (2015). Resource assessment for future generations of tidal-stream energy arrays. *Energy*.

Marine Scotland. (2014). *Fish and Shellfish Stocks 2014 Edition.* The Scottish Government.

Marine Scotland Science. (2016). *Fish and Shellfish Stocks 2016 Edition.* Edinburgh: Scottish Government.

MESH. (2012). *Recommended Operational Guidelines (ROG) for grab sampling and sorting and treatment of samples.* MESH Atlantic.

Offshore Energy SEA. (2017, January 18). Retrieved from https://www.gov.uk/: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/194336/OES_A3a4_Fish.pdf

OSPAR. (2011). *CEMP 2011 assessment report.*

OSPAR. (2013). *Background document on Sabellaria spinulosa reefs.* 978-1-909159-47-1.

PLA. (2017, March 30). *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*. Retrieved from Port of London Authority: https://www.pla.co.uk/Environment/Canadian-Sediment-Quality-Guidelines-for-the-Protection-of-Aquatic-Life

Project, U. M. (2017, March 30). *UKmarinesac.org*. Retrieved from Interim marine sediment quality guidelines (ISQGs) and probable effect levels (PELs; dry weight) (from CCME 1999): http://www.ukmarinesac.org.uk/activities/water-quality/wq4_3_2.htm

Saunders G., B. G. (2011). *Guidance on survey and monitoring in relation to marine renewables deployments in Scotland. Volume 5. Benthic Habitats.*

Scottish Biodiversity Forum. (2009). *Biodiversity Scotland.* Retrieved from Scottish Biodiversity List: http://www.biodiversityscotland.gov.uk/

The Council of the European Communities. (1992). *Council Directive 92/43/EEC of 21 May 1992 on the conservation of the natural habitats and of wild fauna and flora.*

Tyler-Walters, H. J. (2016, January 10). *Descriptions of Scottish Priority Marina Features (PMFs).* Scottish Natural Heritage Commissioned Report No. 406. Retrieved from http://www.snh.gov.uk/: http://www.snh.gov.uk/docs/A1327320.pdf

UK Marine SAC's Project. (2017, March 30). *Interim marine sediment quality guidelines (ISQGs) and probable effect levels (PELs; dry weight) (from CCME 1999)*. Retrieved from UK Marine SAC's Project: http://www.ukmarinesac.org.uk/activities/water-quality/wq4_3_2.htm

UN. (5 June 1992). Convention on Biological Diversity. (pp. 1-28). Rio De Janeiro: UN.

Worsfold, T., & Hall, D. (2010). *National Marine Biological Analytical Quality Control Scheme. Guidelines for processing marine macroninvertebrate samples: a Processing Requirements Protocol, s.l.* NMBAQC.

APPENDIX A | SAMPLE POSITION LIST

APPENDIX B | GRAB FIELD PROTOCOLS

APPENDIX C | TRANSECT FIELD PROTOCOLS

APPENDIX D | GRAB ID PROTOCOLS

APPENDIX E | TRANSECT ID PROTOCOLS

APPENDIX F | PARTICLE SIZE ANALYSIS RESULTS

APPENDIX G | CHEMICAL ANALYSIS

APPENDIX H | CTD DATA

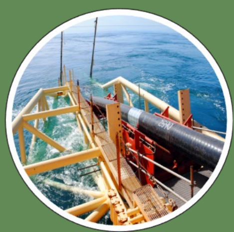
GREENLINK
MARINE ENVIRONMENTAL IMPACT ASSESSMENT REPORT- IRELAND

APPENDIX I

Intertidal Habitat Survey Report

P1975_R4500_RevF1
July 2019

Greenlink Interconnector
- connecting the power markets
in Ireland and Great Britain



Greenlink
INTERCONNECTOR

Greenlink Interconnector Cable Landfall Locations (Wales and Ireland) - Intertidal Walkover Survey Report 2018

Document Ref: J/7/67/17	Originator: OEL/MarineSpace
Date: 03/10/2018	Circulation: Closed

Greenlink Interconnector Cable Landfall Locations (Wales and Ireland) - Intertidal Walkover Survey Report 2018

Prepared by:

MarineSpace Ltd

MarineSpace Ltd
Ocean Village Innovation Centre
Ocean Way
Southampton
SO14 3JZ

Prepared for:

Intertek
Energy & Water Consultancy Services
Exchange House
Station Road
Liphook
Hampshire
GU30 7DW

Date	Originator	Version	Action	Signature
01/10/2018	Shona Guinan	v0.2	Internal Draft	Shona Guinan
03/10/2018	Jonny Lewis	v1.0	Director Sign-off / External Document	J Lewis
05/10/2018	Jonny Lewis	v1.1	Internal Draft - Addressing Client / Regulator Comments	J Lewis
			Choose an item.	

Any reproduction must include acknowledgement of the source of the material. This report should be cited as:

MarineSpace Ltd, 2018. ***Greenlink Interconnector Cable Landfall Locations (Wales and Ireland) - Intertidal Walkover Survey Report 2018.***

Executive Summary

This report presents the findings of intertidal surveys conducted at Freshwater West, Pembrokeshire, and Baginbun Beach, Wexford, aimed at establishing the main habitats present in the general vicinity of two proposed landfall locations for the Greenlink Interconnector cable. The surveys involved Phase I walkover surveying to map the habitats present accompanied by soft and hard substrate quadrat sampling to gather detailed information on the benthic communities present for biotope mapping purposes.

Freshwater West was found to be mostly characterised by impoverished sandy shores. The lack of benthic organisms in these sediments can be explained by the highly mobile nature of sediments in this area due to its exposed location and lack of shelter from prevailing southwesterly winds and Atlantic swell.

Baginbun Beach was found to be a complex mosaic of rock platforms and sand filled gullies supporting a variety of biotopes and aggregations of honeycomb worm tubes. Rockpools were highly abundant across the Baginbun site as well as across an area of rocky shore at Freshwater West. However, it was not possible to map the distribution and assess the high number of pools present without returning to the sites over multiple low tide periods.

All littoral rock biotopes encountered during both surveys correlate to Annex I reef habitat while the sandy biotopes (A2.21 and A2.23) correlate to the Annex I habitat ‘mudflats and sandflats not covered by seawater at low tide’. As such the littoral rock habitat encountered at the Freshwater West landfall site is representative of the Annex I reef habitats that are a primary reason for the selection of the Pembrokeshire Marine SAC. The sandy shore biotopes are also representative of the Annex I ‘mudflats and sandflats not covered by seawater at low tide’ habitat that qualifies as a feature but is not a primary reason for the selection of the site.

Other than the habitats described above, no rare or important species and/or habitats were recorded during the survey.

Contents

List of Figures

List of Tables

1. Introduction

The proposed Greenlink Interconnector cable will link the existing electricity grids in the UK and Ireland and will have key strategic importance providing significant additional interconnection between Ireland, the UK and onwards to mainland Europe. The 'Greenlink' project will consist of two converter stations, one close to the existing substation at Great Island in County Wexford (Ireland) and one close to the existing substation at Pembroke in Pembrokeshire (Wales).

Greenlink Interconnector Limited, trading as Greenlink, was awarded an Interconnector Licence in Great Britain, by Ofgem, on 10th February 2015 and an Initial Project Assessment (IPA) Status under Ofgem's Cap and Floor Regime, on 30th September 2015. Greenlink is designated as a European Union Project of Common Interest (PCI project number 1.9.1) under the provisions of European Union Regulation No. 347/2013 on guidelines for Trans-European Network for Energy (TEN-E Regulations) and has successfully applied for funding under the Connecting Europe Facility (CEF).

This document provides an overview of the intertidal Phase I walkover surveys of the two proposed landfalls of the Greenlink Interconnector cable, with identification of the main habitats present (in the form of biotope mapping) and features of conservation importance. The proposed landfalls are located at Freshwater West, Pembrokeshire, Wales and Baginbun Beach, Wexford, Ireland (Figure 1.1).

1.1. Area of Study

1.1.1. Freshwater West

Freshwater West is a large south-west facing sandy beach backed by an extensive system of sand dunes and forms part of the 'large shallow inlets and bays' feature of the Pembrokeshire Marine Special Area of Conservation (SAC), illustrated within Figure 1.2. Existing information available, including biotope mapping from EMODnet[1], suggests that the survey area is largely characterised by gently sloping fine sand shores lined by shingle on the upper shore and exposed rock shore grading into steep red sandstone cliffs in the north of the survey area.

1.1.2. Baginbun Beach

Baginbun Beach is located within an exposed easterly facing bay (Baginbun Bay) on the Hook Peninsula, Wexford, Ireland (Figure 1.3). Existing information available on EMODnet suggests that the survey area is mostly characterised by fucoid dominated littoral rock habitat backed by a sandy beach and steep cliffs in the south of the bay.

[1] http://www.emodnet.eu/

Figure 1.1: Survey areas for the Proposed Greenlink Interconnector Cable Landfall Locations (Wales and Ireland) intertidal walkover survey (Source: Greenlink).

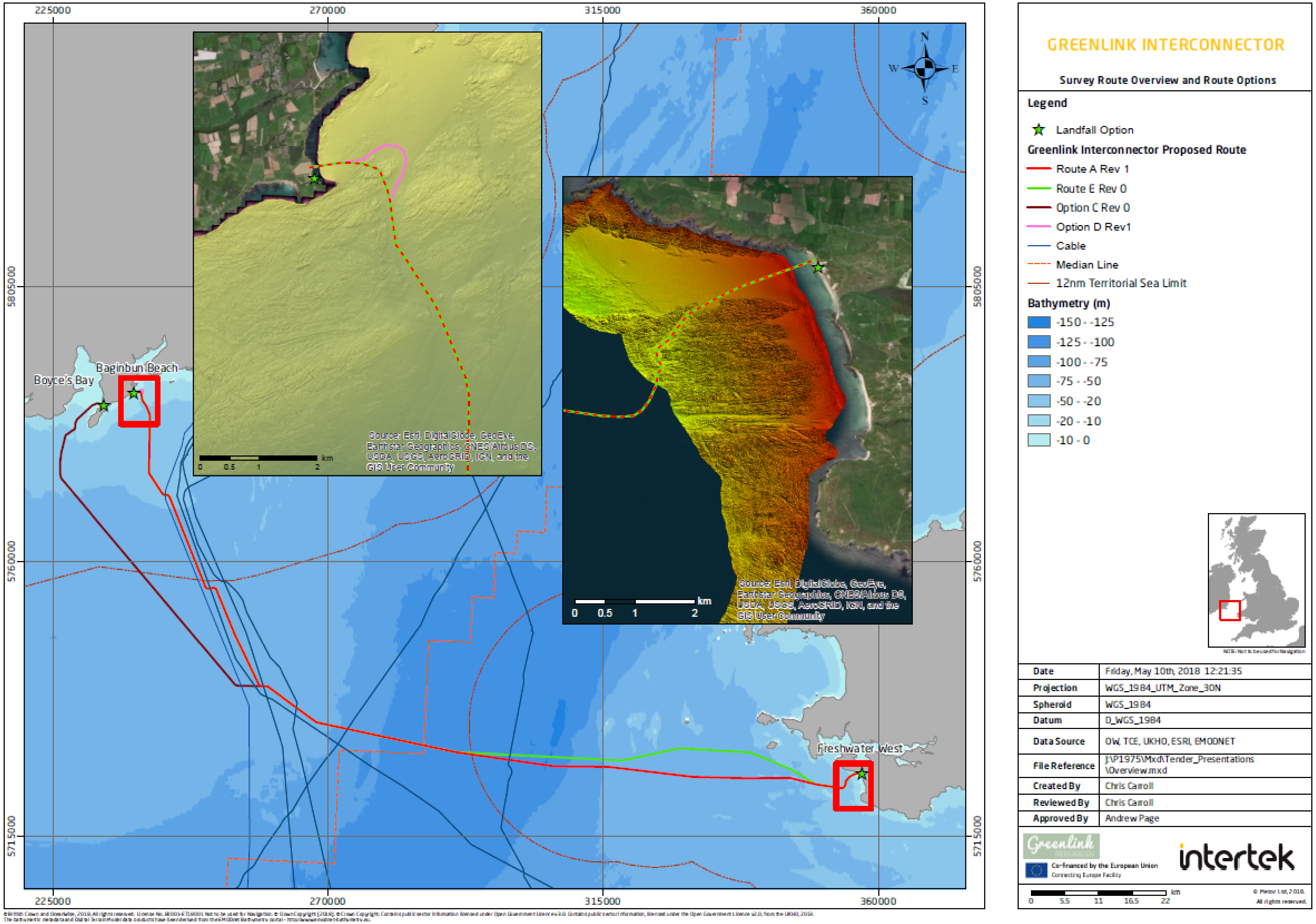
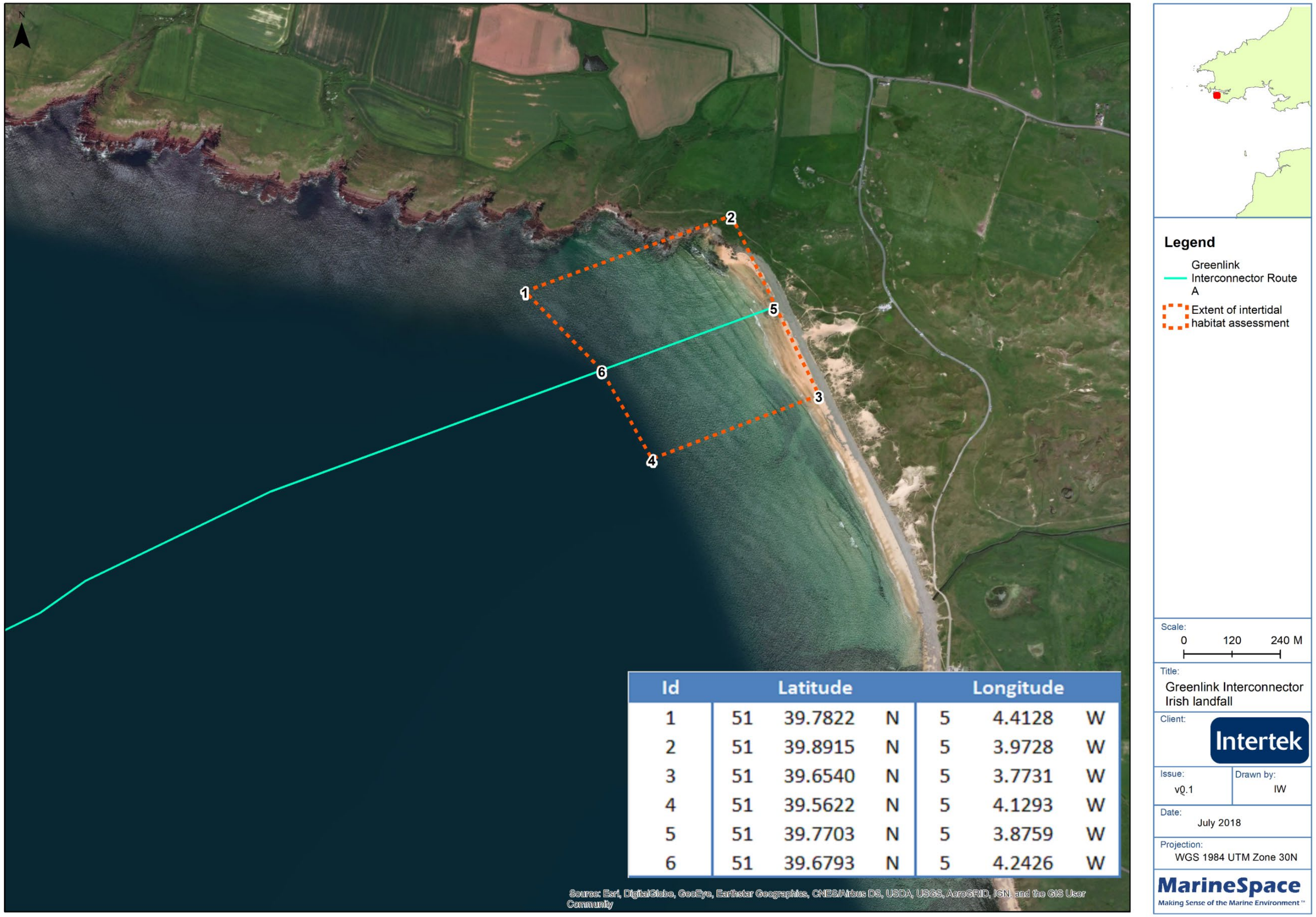
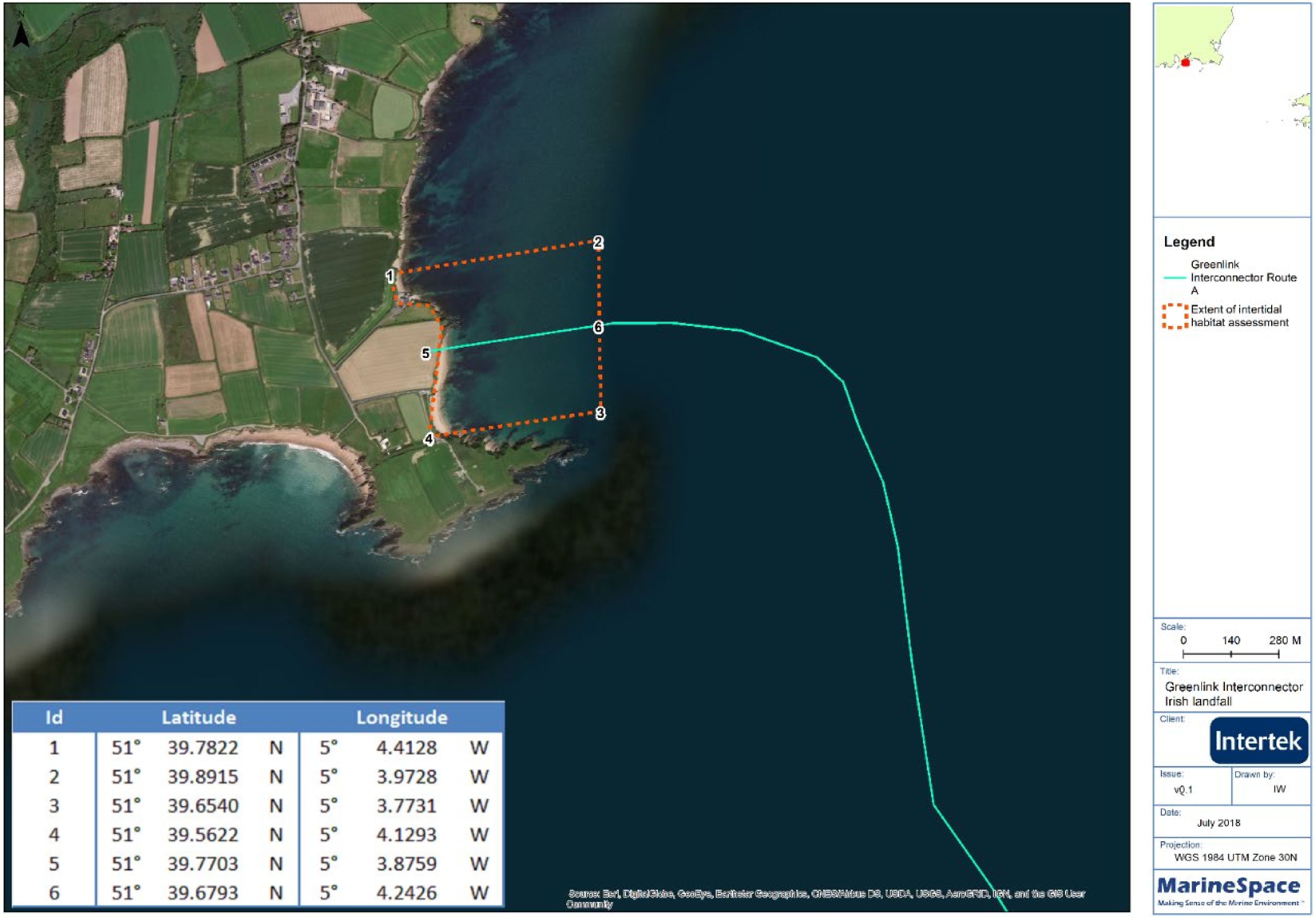


Figure 1.2: Extent of the intertidal survey area at Freshwater West, Pembrokeshire, Wales (Source: MarineSpace).



Id	Latitude			Longitude		
1	51	39.7822	N	5	4.4128	W
2	51	39.8915	N	5	3.9728	W
3	51	39.6540	N	5	3.7731	W
4	51	39.5622	N	5	4.1293	W
5	51	39.7703	N	5	3.8759	W
6	51	39.6793	N	5	4.2426	W

Figure 1.3: Extent of the intertidal survey area at Baginbun Beach, Wexford, Ireland (Source: MarineSpace)



Id	Latitude			Longitude		
1	51°	39.7822	N	5°	4.4128	W
2	51°	39.8915	N	5°	3.9728	W
3	51°	39.6540	N	5°	3.7731	W
4	51°	39.5622	N	5°	4.1293	W
5	51°	39.7703	N	5°	3.8759	W
6	51°	39.6793	N	5°	4.2426	W

2. Methodology

2.1. Survey Design

The Phase I survey was carried out across 500 m wide cable landfall corridors extending across intertidal areas at Freshwater West and Baginbun Beach. A series of locations were also sampled in areas of both soft sediment and hard substrates to further inform detailed biotope mapping.

2.2. Survey Methods

2.2.1. Phase I Walkover Survey

The intertidal surveys were undertaken during spring tides in line with guidance in the Marine Monitoring Handbook (Davies *et al*., 2001) and Countryside Council for Wales (CCW) Handbook for Marine Intertidal Phase I Survey and Mapping (Wyn *et al*., 2006). During the walkover survey, biotopes were identified according to the European Nature Information System (EUNIS) classification in line with relevant guidance (Parry, 2015) (and correlated to the Marine Nature Conservation Recorder (MNCR) biotopes). Where possible, boundaries of biotopes were tracked using handheld Garmin E-Trex 10 GPS devices and the Phase One Habitat Survey Tool Kit application (v1.4.0).

The distribution of any features of conservation interest were recorded using photographs and GPS fixes where encountered. Other information recorded included general site conditions, sediment surface features, sediment type and characteristics, topography and anthropogenic pressures.

2.2.2. Quadrat Sampling

Areas representative of each key soft sediment habitat at different tidal heights were assessed by sampling the upper 10 cm of a 0.04 m^2 (0.2 m x 0.2 m) quadrat using a spade and screened on a 0.5 mm sieve. Any macrobenthos retained on the sieve was identified to species level where possible in the field. The quadrats were then dug to ~ 30 cm depth to check for the presence of larger, burrowing species.

Any soft sediment samples were subject to a visual inspection and observations of colour, smell, Redox Potential Discontinuity (RDP) depth layer, texture and presence of surface features (accretions, algae, fauna, etc.) recorded.

Two high-resolution photographs were taken of the sediment for future reference. The first was taken from a ‘cross section’ looking across the substrate and the second taken directly above the quadrat (in plan view). A further four photographs were also taken in a north, east, south and west orientation. The location of all samples were recorded using a Garmin E-Trex 10 GPS device.

Areas representative of each key hard substrate habitat at different tidal heights were assessed by recording the epibiotal taxa present in randomly placed 0.04 m^2 (0.2 m x 0.2 m) quadrats. Identification was taken to species level where possible and undertaken in the field.

2.2.3. Target Notes

Target notes were taken when notable features were encountered, e.g. *Sabellaria alveolata* aggregations. These were accompanied by GPS fixes and close up photographs of each feature along with general site photographs (Figure 2.1).

Figure 2.1: Top left: Hard substrate 0.5 m^2 quadrat sampling. Top right: 0.25 m^2 quadrat soft substrate sampling. Bottom left: Sieving sediment sample through 0.5 mm mesh sieve on the lower shore. Bottom right: sieved sediment sample residue.

2.3. Analysis

2.3.1. Biotope Monitoring

EUNIS biotopes were identified in line with Joint Nature Conservancy Council (JNCC) guidance on assigning benthic biotopes (Parry, 2015) to allow the communities to be mapped and allow comparison with existing data. All biotope determination was undertaken through consideration of each of the following information:

- Existing biotope mapping (EMODnet);
- Quadrat sediment/substrate descriptions for determination of Broad Scale Habitat (BSH); and
- Species information from quadrat sampling for assigning EUNIS Level 4 biotopes and above.

3. Results

3.1. Survey Progress

The intertidal surveys were undertaken during spring tides on 11th September (Freshwater West) and 12th September (Baginbun Beach) 2018. Table 1 provides a summary of the sampling undertaken and information collected during the two surveys. Figure 3.1 provides an overview of the shore at both survey locations.

Table 1. Summary of sampling undertaken, and information collected during the intertidal surveys at Freshwater West and Baginbun Beach.

	Freshwater West	Baginbun Beach
Soft-Sediment Quadrats	12	16
Hard Substrate Quadrats	7	14
Target Notes	11	54
Photographs	185	375

Figure 3.1: Top: View looking north west across the survey area at Freshwater West. Bottom: View looking south-east across the southern portion of the survey area at Baginbun Beach.

3.2. Freshwater West

3.2.1. Biotopes

The majority of the survey area at the proposed Freshwater West landfall site was characterised by barren littoral coarse sand (EUNIS biotope A2.111), as illustrated within Table 2. This dominant biotope was fringed by barren littoral shingle (A2.111) along the upper shore overlain by a narrow strandline biotope constituted by decomposing seaweed supporting sandhopper (Talitrid amphipods) communities (A2.211). The lower extent of the dominant A2.111 biotope was fringed by littoral medium-fine sand supporting amphipods and the polychaete worms *Scolelepis* spp. (A2.223). The north of the survey area extended across a complex mosaic of littoral rock biotopes spanning the full range of the typical zonation expected on an exposed rocky coastline. This included lichen and barnacle dominated biotopes in the supralittoral (B3.111 and B3.1132) and upper shore zones (A1.112, A1.1121, A1.1122) and the typical fucoid dominated biotopes in mid-lower shore areas (A1.212, A1.213 and A1.3141) interspersed with coralline crust-dominated (A1.411) and green and red seaweed dominated (A1.421 and A1.452) rock pools. A summary of these biotopes is presented within Table 2, and illustrated within Figure 3.3.

Table 2. Key biotopes recorded during the intertidal survey of the proposed landfall location at Freshwater West.

Habitat	EUNIS Code	EUNIS Description
A1 - Littoral Rock and other hard substrata	A1.112	*Chthamalus* spp. on exposed upper eulittoral rock
	A1.1121	*Chthamalus montagui* and *Chthamalus stellatus* on exposed upper eulittoral rock
	A1.1122	*Chthamalus* spp. and *Lichina pygmaea* on steep exposed upper eulittoral rock
	A1.211	*Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock
	A1.212	*Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock
	A1.213	*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock
	A1.3141	*Ascophyllum nodosum* on full salinity mid eulittoral rock
	A1.411	Coralline crust-dominated shallow eulittoral rockpools
	A1.421	Green seaweeds *Enteromorpha* spp. and *Cladophora* spp. in shallow upper shore rockpools

	A1.452	*Porphyra purpurea* or *Enteromorpha* spp. on sand-scoured mid or lower eulittoral rock
A2 - Littoral sediment	A2.111	Barren littoral shingle
	A2.211	Talitrids on the upper shore and strandline
	A2.223	Amphipods and *Scolelepis* spp. in littoral medium-fine sand
	A2.23	Polychaete/amphipod-dominated fine sand shores
B3 - Rock cliffs, ledges and shores, including the supralittoral	B3.111	Yellow and grey lichens on supralittoral rock
	B3.1132	*Verrucaria maura* on very exposed to very sheltered upper littoral fringe rock

3.2.2. Features of Interest

A large number of littoral rock pools were noted across the rocky shore in the north of the survey area. Due to their ubiquitous nature and the limited time available during a single low tide period, it was only possible to map and assess a small number of rock pools within the survey area. In general, the pools were deemed to be representative of the biotopes A1.411 and A1.421.

3.3. Baginbun Beach

3.3.1. Biotopes

Baginbun Beach was found to be a complex mosaic of littoral rock platforms and sand filled gullies representative of a variety of littoral rock and soft sediment EUNIS biotopes (Table 3). To the south, the upper shore was dominated by barren littoral coarse sand (A2.221) with a narrow overlying strandline biotope constituted by decomposing seaweed supporting sandhopper (Talitrid amphipods) communities (A2.211). Fingers of sandy sediment extended down the shore filling tide swept gullies formed by fucoid dominated rocky outcrops (A1.214) from the mid to the lower shore along which aggregations of *Sabellaria alveolata* tubes were noted.

To the north of the survey area, the band of barren upper shore sand was narrower and was fringed by barnacle dominated littoral rock (A1.112 / A1.113) quickly grading into fucoid dominated mid-shore rocky outcrops (A1.313 / A1.3141) that extended into a rocky platform dominated by *Fucus serratus* (A1.214) and *Laminaria digitata* along the sublittoral fringe. Details of these biotopes are presented within Table 3, and illustrated within Figure 3.4.

Table 3. Key biotopes recorded during the intertidal survey of the proposed landfall location at Baginbun Beach.

Habitat	EUNIS Code	EUNIS Description
A1 - Littoral Rock and other hard substrata	A1.113	*Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock
	A1.214	*Fucus serratus* on moderately exposed lower eulittoral rock
	A1.2141	*Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock
	A1.311	*Pelvetia canaliculata* on sheltered littoral fringe rock
	A1.312	*Fucus spiralis* on sheltered upper eulittoral rock
	A1.313	*Fucus vesiculosus* on moderately exposed to sheltered mid eulittoral rock
	A1.3141	*Ascophyllum nodosum* on full salinity mid eulittoral rock
	A1.421	Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools
	A1.412	Fucoids and kelp in deep eulittoral rockpools
	A1.413	Seaweeds in sediment-floored eulittoral rockpools
A2 - Littoral sediment	A2.111	Barren littoral shingle
	A2.211	Talitrids on the upper shore and strandline
	A2.221	Barren littoral coarse sand
	A2.23	Polychaete/amphipod-dominated fine sand shores

3.3.2. Features of Interest

A large number of littoral rock pools were noted to be interspersed across the entire mid-lower rocky shore area. Due to the sheer number and limited time available during a single low tide period, it was only possible to map and assess a small number of rock pools within the survey area. In general, the pools were deemed to be representative of the biotope A1.421 (Figure 3.2) in the upper shore areas and A1.412 and A1.413 further down the shore.

Significant portions of the lower shore fucoid dominated rock found in the southern end of the survey area was colonised by low lying veneers of *S. alveolata* tube aggregations (Figure 3.2).

Discrete clumps were also noted on the vertical faces of the sand-filled gullies formed by the rocky outcrops along the majority of the survey area. Given their low-lying nature (< 2 cm) and limited extent, these aggregations were not thought to be representative of the larger reef structures that are afforded protection as Annex I biogenic reef habitats under the European Union Habitats Directive.

Figure 3.2: Left: Shallow upper shore rock pool feature. Right: *S. alveolata* tube aggregation in a gully on the mid-shore.

Figure 3.3: EUNIS biotope mapping and sampling locations visited during the intertidal survey of the proposed landfall at Freshwater West, Pembrokeshire.

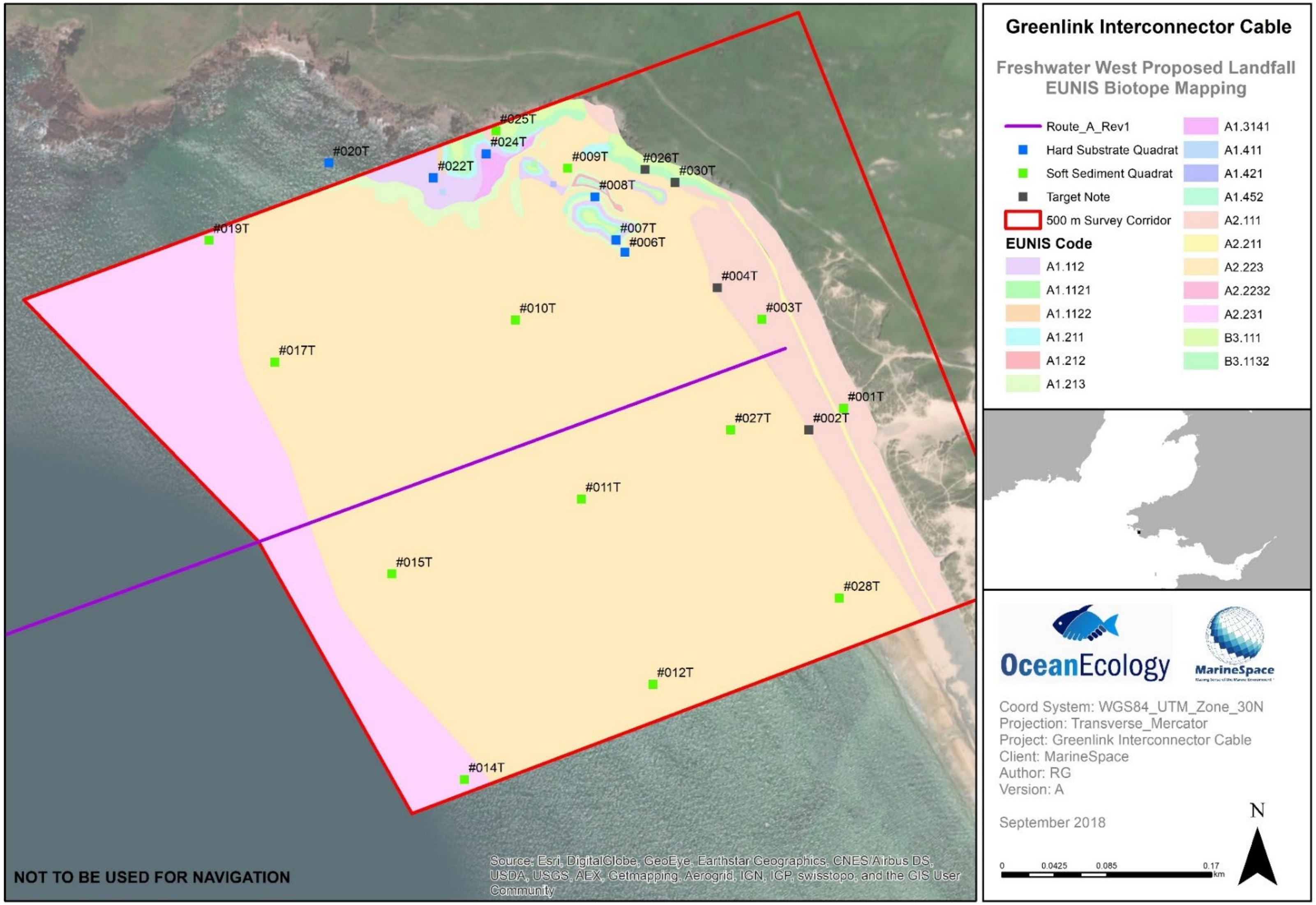
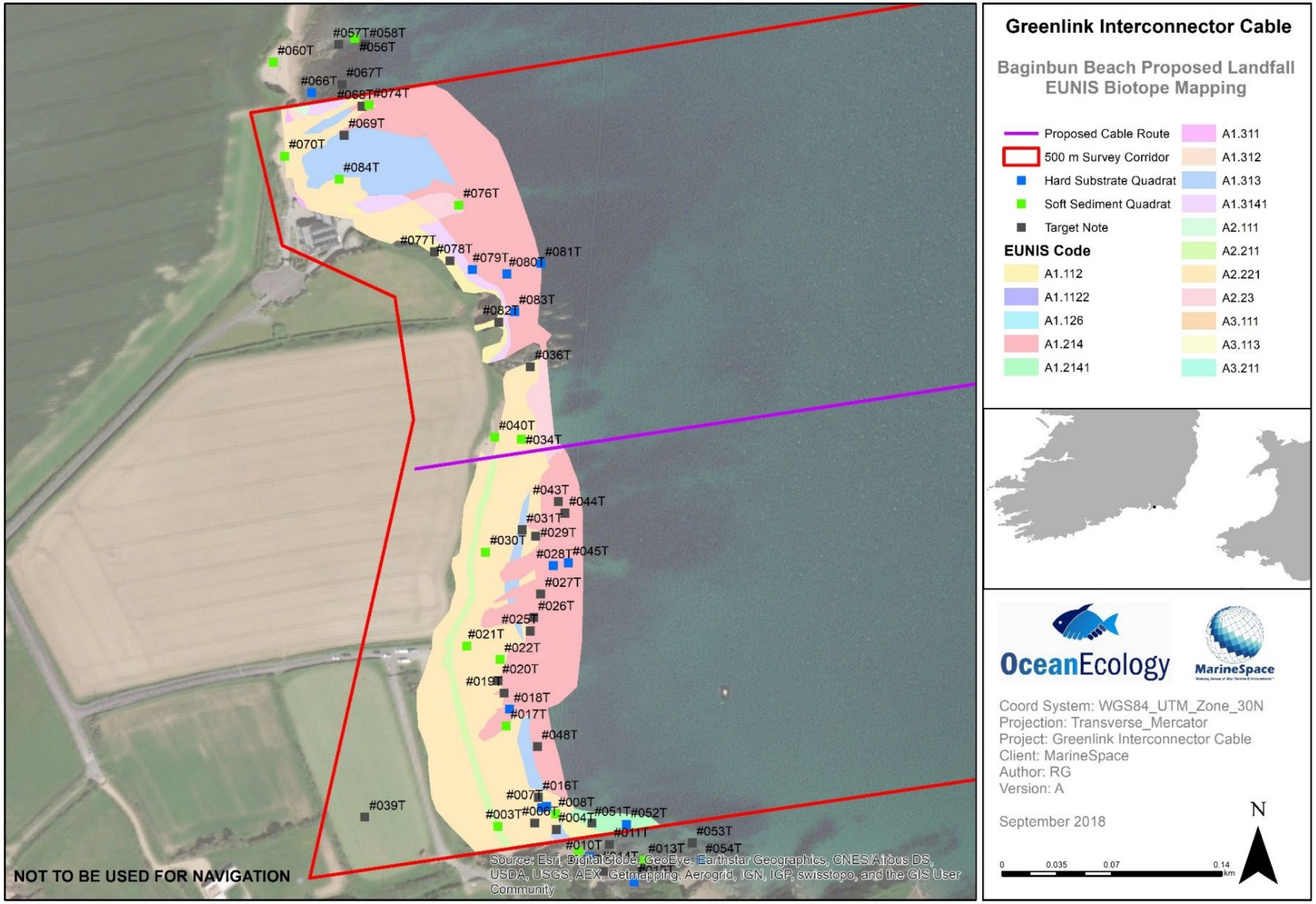


Figure 3.4: EUNIS biotope mapping and sampling locations visited during the intertidal survey of the proposed landfall at Baginbun Beach, Wexford.



4. Discussion

This report presents the findings of intertidal surveys conducted at Freshwater West, Pembrokeshire, and Baginbun Beach, Wexford, aimed at establishing the main habitats present in the general vicinity of two proposed landfall locations for the Greenlink Interconnector cable. The surveys involved Phase I walkover surveying to map the habitats present accompanied by soft and hard substrate quadrat sampling to gather more detailed information on the benthic communities present for biotope mapping purposes.

Freshwater West was found to be mostly characterised by impoverished sandy shores. The paucity of benthic organisms in these sediments can be explained by the highly mobile nature of sediments in this area due to its exposed location and lack of shelter from prevailing southwesterly winds and swell. Baginbun Beach was found to be a complex mosaic of littoral rock platforms and sand filled gullies supporting a variety of biotopes and aggregations of honeycomb worm (*S. alveolata*) tubes. Rockpools were ubiquitous across the site as well as across an area of rocky shore at Freshwater West however it was not possible to map the distribution and assess the high number of pools present without returning to the sites over multiple low tide periods.

It should be noted that all littoral rock biotopes encountered during both surveys correlate to Annex I reef habitat while the sandy biotopes (A2.21 and A2.23) correlate to the Annex I habitat 'mudflats and sandflats not covered by seawater at low tide'. As such the littoral rock habitat encountered at the Freshwater West landfall site is representative of the Annex I reef habitats that are a primary reason for the selection of the Pembrokeshire Marine SAC. The sandy shore biotopes are also representative of the Annex I 'mudflats and sandflats not covered by seawater at low tide' habitat that qualifies as a feature but is not a primary reason for the selection of the site.

Other than the habitats described above, no rare or important species and/or habitats were recorded during the survey.

It should be noted that the collection of aerial imagery through the use of Unmanned Aerial Vehicles (UAV) is now becoming standard practice for intertidal habitat mapping surveys facilitating higher accuracy biotope and feature mapping than can be achieved by walkover surveying. Given the minimal additional cost and reduced health and safety risks, it is recommended that any future intertidal surveys at these sites are supported by UAV mapping methodologies.

5. References

Davies J, Baxter J, Bradley M, Connor D, Khan J, Murray E, Sanderson W, Turnbull C, Vincent M (2001) Marine Monitoring Handbook March 2001.

Great Britain. Parliament (1974) Health and Safety at Work etc. Act 1974. London: HSMO.

Parry ME V (2015) Guidance on Assigning Benthic Biotopes using EUNIS or the Marine Habitat Classification of Britain and Ireland.

Wyn G, Brazier P, Birch K., Bunker A, Cooke A, Jones M, Lough N (2006) CCW Handbook for Marine Intertidal Phase 1 Biotope Mapping Survey.

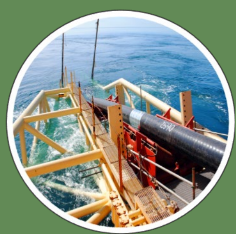
GREENLINK
MARINE ENVIRONMENTAL IMPACT ASSESSMENT REPORT- IRELAND

APPENDIX J

Marine Detailed UXO Risk Assessment

P1975_R4500_RevF1
July 2019

Greenlink Interconnector
- connecting the power markets in Ireland and Great Britain



Greenlink
INTERCONNECTOR

Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	Greenlink
Client	Intertek
Site Address	Pembrokeshire, Wales to County Wexford, Ireland
Report Reference	DA2985-01
Date	15th April 2019
Originator	MN

Find us on Twitter and Facebook

Company No: 7717863 VAT No: 128 8833 79
www.1stlinedefence.co.uk

1st Line Defence Limited
Unit 3, Maple Park, Essex Road, Hoddesdon, Herts. EN11 0EX
Tel: +44 (0)1992 245 020 info@1stlinedefence.co.uk

Executive Summary

Description and Location of Study Area

The Greenlink project is a proposed subsea and underground cable interconnector, with associated convertor stations, between existing electricity grids in Wales and Ireland.

The project is designed to provide significant additional energy interconnection between Ireland, the UK and continental Europe with the aim of delivering increased security of supply, fuel diversity and greater competition. It is also designed to provide additional transmission network capacities, reinforcing the existing electricity grids in south-east Ireland and south Wales.

The study area is approximately 160km in length and spans the St George's Channel, including areas of landfall in Ireland and Wales. Its westernmost section intercepts the Hook Peninsula in County Wexford and the easternmost section incorporates an area of land surrounding Freshwater West Beach in Pembrokeshire. The western half of the study area branches and re-joins the main route line at several points, while the eastern half comprises one singular route line.

It is situated between the approximate OS grid references: **SL 6524661908** (at its westernmost point) and **SM 8871100290** (at its easternmost point) but does not connect between these points in a straight course.

Proposed Works

The proposed works comprise a pre-construction marine survey campaign and the subsequent subsea cable installation.

The pre-construction marine survey campaign is proposed for a suitable period between summer 2018 and summer 2019. It is understood that the primary purpose of the campaign is to acquire appropriate data for the confirmation of the location of the offshore route; as well as to determine the appropriate installation and protection methods to be adopted. This will include a range of geophysical, geotechnical and environmental surveys. Designed to create detailed mapping of nearshore shallow geological and seabed character; reconnaissance level mapping of seabed relief and features along offshore sections; and baseline environmental mapping along the route corridor.

Intrusive activities during the subsequent cable installation are believed to include:

- Use of anchors – set potentially up to 1km distant from the route's centre line.
- Cable trenching equipment e.g. ploughs, jet trenchers, rock trenchers to install the cable into the seabed.
- Pre-lay grapnel run. Equipment dragged along seabed to hook any debris.
- Boulder removal plough to pushes boulders along the route's centre line to one side.
- Mass flow excavator to transport sand, in order to bury the cable in sand sediments.
- Dredging
- Placement of rock and/or concrete mattresses on the seabed.

It should be noted that the width of the initial survey is understood to be 500m in total. Though the width of the survey corridor is 1km in total to allow for the manoeuvre of the route's centreline, where necessary. A 1km buffer zone either side of this survey corridor has also been included for the purpose of this report.

Seabed Geology

The British Geological Survey (BGS) map, the Geological Survey Ireland (GSI) map and the European Marine Observation and Data Network (EMODnet) were consulted for the purpose of this report. These sources show the bedrock geology of the westernmost section of the study area, on the Irish mainland, to be underlain by the Ballysteen Formation – dark muddy limestone, shale.

The bedrock geology of the easternmost section of the study area, on the Welsh mainland, is underlain by the Millford Haven Group – conglomerate with superficial deposits of blown sand - sand. The bedrock geology of the coastline was underlain by the Aber Mawr Shale Formation – mudstone and contains Marine Beach Deposits – sand of the Quaternary Period.

The offshore bedrock geology varies considerably over the length of the study area and includes areas underlain by:

- Sandstone
- Limestone
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated) and limestone
- Mudstone and sandstone (undifferentiated) and limestone

UXO Risk Assessment
1st Line Defence has assessed a potential risk within the location of the study area from UXO contamination. This assessment is based on the following factors:

- The Castlemartin training area, a 6,000 acre former and current military range, with a danger area extending up to 14 miles, is situated within the immediate surroundings of the easternmost section of the proposed Greenlink route. Predominantly used by the RAC (Royal Armoured Corps) as a tank range, the Castlemartin area has been used extensively by both British and West German armed forces since its requisition in 1938. Its usage is also recorded to include infantry training, such as small arms training and naval aerial bombing, which is indicated to have taken place within an area immediately bordering Freshwater West Beach.
- The presence of Castlemartin range significantly increases the likelihood that items of Allied ordnance could have been expended, through training exercises, or discarded, through poor housekeeping within the easternmost section of the study area. This includes any part of the study area within Freshwater West Beach and the surrounding offshore danger area. Such items will include LSA (Land Service Ammunition) and SAA (Small Arms Ammunition) but may also include larger, aerially delivered bombs, due to the presence of an air to land training. Explosive Ordnance Clearance tasks undertaken within Castlemartin ranger in the 1980's and 1990's are documented to have recovered thousands of expended items of ordnance and hundreds of live items.
- The island of Grassholm, approximately 7km to the north, is also recorded as a training range during WWII and was used by the USAF (Unites States Air Force) for target practice. The presence of the former Grassholm range is considered to have had less of an impact than Castlemartin though US aerially deployed ordnance, such as practice bombs, deployed in its surroundings waters could have migrated within the study area.
- An extensive British mine area, believed to comprise over 6,000 mines and several significant minefields, was laid in the St George's Channel in 1940 to protect naval and merchant shipping in the Irish Sea from German U-boat attacks. Historical mine mapping of UK waters shows the former location of this mine area to include a significant portion of the western/Irish side of the study area. References to several smaller minefields, including a WWI-era German minefield and two WWII-era German minefields have been found on and in the general proximity of the eastern/Welsh side of the study area. These appear to have been deployed to restrict British naval activity originating from important military sites at Milford Haven and Pembroke Dock.
- A precise assessment of the current risk from mines within the St Georges Channel is difficult to ascertain. Efforts were made by the Royal Navy at the end of the war to clear/make safe mined areas. However such clearance tasks are not considered to guarantee the complete removal of all mines within a danger area, especially if such items have the potential to migrate or became covered due to sediment and tidal action over a period of time. It is therefore not possible to discount the possibility of encountering surface or submarine laid sea mines across any location of the study area.
- A number of listed historic wrecks have been identified on and around the study area. The majority of these wrecks are situated within shallower waters, off the coastlines of both Ireland and Wales, and often demonstrate the presence of both sea mines and torpedoes during WWI and WWII. The majority of these wrecks are also British cargo ships, though military vessels are recorded within the area during both world wars, including an unnamed German warship in 1917, the German submarine UC-44 in 1917, the British warship HMS Arbutus in 1917 and the British warship HMS Minicoy in 1941. Such vessels are anticipated to have carried items of ordnance at the time of their loss and, if not recovered, could have contaminated their immediate surroundings.
- Torpedoes and anti-submarine weaponry were commonly deployed in the waters around Britain on account of German U-Boat activity during both world wars. The Irish Sea, including the St George's Channel was particularly affected by U-boats during WWI due to the high volume of merchant shipping travelling to and from important docks such as Liverpool and the Clyde from the south-west approaches, leading the region to be subsequently dubbed 'U-Boat alley'. Anti-submarine weapons, most commonly depth charges, were deployed by Royal Navy vessels to combat this threat, with Hedgehog and Squid spigot mortars put into operation from 1942. Although generally deployed in low numbers when compared to other types of munitions, it is not possible to discount the presence of such items at the site location, due to their recorded usage in the wider area.
- Three munitions dumps are recorded within the wider surrounding area, off the Pembrokeshire coastline. These are believed to have operated in conjunction with surrounding military sites and to have been used in the immediate post period. These dumps are not anticipated to pose a significant risk to the study area, unless its location is altered and situated on or in their immediate proximity. It is also possible that dumped munitions may have either been deposited outside the designated areas or have else migrated within the region over time.
- The likelihood of encountering historic Allied ordnance, such as Land Service Ammunition (LSA) and Small Arms Ammunition (SAA) is considered to be elevated within parts of the study area on and surrounding the former premises of RAF Angle or any coastal defences. This is because of the presence of a number of features associated with ordnance usage and disposal, such as pillboxes, ranges and ammunition stores and the potential for poor

UXO Risk Assessment

housekeeping, whereby items of ordnance were buried, burnt or otherwise disposed of unrecorded. EOC reconnaissance tasks undertaken in 2000 and 2001 also refer to 'WWII-era coastal defences (barbed wire) reappearing' on Freshwater West Beach and suggest that the area was mined during the war.

- The easternmost section of the study area was situated within an area of Wales that sustained a very low density of bombing throughout the war. Bombing within the rural areas of Pembrokeshire were generally isolated incidents and the result of Luftwaffe bombers travelling to and from more significant targets within the wider region. This infrequency of incidents, combined with the nearby presence of RAF Angle, increases the probability that any bomb strikes within the Freshwater West area would have been recorded and any signs of UXO investigated. It is not possible however to completely discount the possibility of such incidents going unnoticed because of the open, rural nature of the groundcover of Freshwater West and its surrounds.
- Likewise, it is not anticipated that a significant number of aerial bombs were deployed within the St Georges Channel, though several attacks on merchant shipping are recorded within more central areas in 1940 and 1941. Any bombs falling during such raids are not likely to have been well observed or investigated and thus the possibility that aerially delivered UXO may be present within the offshore areas also cannot be discounted, though the likelihood is not considered to be high.
- The risk from items of air delivered UXO within the westernmost section of the study area, within the Irish mainland, is considered negligible. The Republic of Ireland was never subject to a targeted bombing campaign during WWII and instead only sustained bombing by the Luftwaffe on a handful of isolated occasions, none of which are recorded within the study area.
- Based on these findings it has only been possible to confidently reduce the risk from UXO within the section of the study area situated in the Irish mainland, on the Hook Head peninsula. There is a potential risk of encountering UXO across the remainder of the study area, which is significantly elevated on and surrounding the eastern end at Freshwater West, due to the presence of the Castlemartin Training Area and the former RAF Angle.

UXO Risk Mitigation

This report has concluded that there is a potential risk from unexploded ordnance within the study area. The risk from different types of UXO is however not considered to be homogenous. Consequently the study area has been broadly split into the following four zones:

- Irish mainland – no significant risk of UXO identified.
- Western and central offshore – primary risk is from larger items of ordnance, mainly sea mines.
- Eastern offshore – larger items such as sea mines, but also risk from smaller items such as projectiles and other land service ammunition (LSA).
- Welsh mainland – risk from land service ammunition (LSA), small arms ammunition (SAA) and unexploded bombs (UXB's) identified.

Offshore Mitigation

It is recommended that the proposed cable route and areas subject to intrusive investigation techniques (any time when the seabed is being affected) are subject to a UXO survey to identify targets which might be UXO related. It is understood that various survey techniques are already proposed along the survey corridor including side scan sonar and magnetometer survey. It is recommended that these surveys be designed with sufficient resolution to allow for the detection of large items of ordnance across the entire length of the route such as sea mines, bombs and torpedoes. If there is the potential for larger items to become buried due to localised sea bed conditions/sediment, then a magnetometer survey in these areas would be especially recommended. Any anomalies detected with the potential to be UXO related should be inspected as part of an ROV video survey to identify them. If they are found to be UXO related, they can either be avoided or if necessary, moved or disposed of remotely.

Smaller items such as projectiles and other items of LSA pose a lesser risk if encountered on the seabed, and are generally too small to be detected by most survey techniques except visual. These types of items are most likely to be present in the far eastern end of the route, in the vicinity of the firing range and munitions dumps. The main concern regarding smaller items of UXO is if they come into direct contact with personnel – for example if brought on-board on equipment deployed on the seabed, or incorporated within seabed sediment samples. For this reason, it would be prudent to have a UXO Specialist present on board to check over any equipment brought on deck and to check and identify any suspect items found within sediment samples. A UXO Specialist on-board can also review any ROV video footage undertaken to identify any potential UXO on the seabed.

Onshore/Nearshore UXO Risk Mitigation

Because no significant risk has been identified at the Irish mainland, is it not recommended that any proactive risk mitigation measures are necessary on the landward side at this end beyond UXO Safety and Awareness Briefings.

For onshore/nearshore works at the eastern end of the route, it is recommended that proactive support is provided. It is recommended that trial pits are supported by a UXO Specialist and that all proposed boreholes are subject to a magnetometer survey. All operatives should receive UXO Safety and Awareness Briefings. It may be viable to undertake a non-intrusive magnetometer survey and target investigation on the beach area for the cable trench as it goes onshore.

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AAA	Anti-Aircraft Ammunition
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
AXO	Abandoned Explosive Ordnance
DA	Delay-action
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot
GM	G Mine (Parachute mine)
HAA	Heavy Anti-Aircraft
HE	High Explosive
IB	Incendiary Bomb
LAA	Light Anti-Aircraft
LRRB	Long Range Rocket Bomb (V-2)
LSA	Land Service Ammunition
MOL	Molotov (Incendiary Bomb)
OB	Oil Bomb
PAC	Pilotless Aircraft (V-1)
PB	Phosphorous Bomb
PM	Parachute Mine
POW	Prisoner Of War
RAF	Royal Air Force
RFC	Royal Flying Corps
RNAS	Royal Naval Air Service
SAA	Small Arms Ammunition
SD1000	1,000kg high explosive bomb
SD2	Anti-personnel “Butterfly Bomb”
SIP	Self-Igniting Phosphorous
U/C	Unclassified bomb
UP	Unrotated Projectile (rocket)
USAAF	United States Army Air Force
UX	Unexploded
UXAA	Unexploded Anti-Aircraft
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	Flying Bomb (Doodlebug)
V-2	Long Range Rocket
WAAF	Women’s Auxiliary Air Force
X	Exploded

Contents

Annexes

List of Report Annexes	
Annex A	Site Location Maps
Annex B	Recent Aerial Photography
Annex C	Historical Mapping
Annex D	Example of Naval Mines, Anti-Submarine Weapons and Torpedoes
Annex E	Examples of Offshore UXO Incidents
Annex F	Overlay of Wreck Sites
Annex G	Minefield Mapping of the St Georges Channel
Annex H	Overlay of U-boats lost in the Irish Sea in WWII
Annex I	Overlay of Conventional Munitions Dumpsites
Annex J	Armament Training Areas and 'Danger Area' Mapping
Annex K	RAC Castlemartin Range Documentation and Plans
Annex L	Examples of LSA and SAA
Annex M	RAF Angle Site Plan
Annex N	1942 RAF Aerial Photography
Annex O	1946 RAF Aerial Photography
Annex P	Examples of Anti-Aircraft Projectiles
Annex Q	Luftwaffe Reconnaissance Imagery
Annex R	Examples of German Air Delivered Ordnance
Annex S	LOP (Look Out Post) Logbook – Hook Head
Annex T	Decoy Site Mapping
Annex U	OSPAR Munition Encounters

Appendices

List of Report Appendices	
Appendix i	Sections of the Study Area
Appendix ii	Overlay of Significant UXO Features[1]
Appendix iii	Overlay of UXO Features on Welsh Mainland

[1] Please note that this appendix has been based on a final version of the route of the proposed study area. This route was provided following the completion of this report and for all other purposes the original study area proposed has been used.

1st Line Defence Limited
Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: Greenlink
Client: Intertek

1. Introduction

1.1. Background

1st Line Defence has been commissioned by Intertek to conduct an Offshore Detailed Unexploded Ordnance (UXO) Risk Assessment for the planned works along the proposed Greenlink interconnector route.

UXO in offshore areas of the UK can originate from three principal sources:

1. Munitions resulting from wartime activities including ship-to-ship engagements, aerial bombing, long range shelling and defensive activities in both WWI and WWII.
2. Munitions deposited as a result of military training and exercises.
3. Munitions lost, burnt, buried or otherwise discarded either deliberately, accidentally, or ineffectively.

During WWI and WWII, significant quantities of explosive ordnance was either dropped from the air or placed on and around the beaches of the UK, including both bombs and mines. There is also a legacy of military activity which has led to contamination off the UK coast – including offshore munitions dumping, firing ranges, training exercises, military related wrecks, torpedoes and depth charges. UXO which was deployed during such military activities, but failed to initiate, or else has been dumped at sea can present a significant risk to construction works and development projects. The discovery of a suspect device during works can cause considerable disruption to operations as well as cause unwanted delays and expense.

This report will assess the potential factors that may contribute to the risk of UXO contamination, by examining the history of the area, and the activities and deployment of various types of weaponry that may have led to contamination. The risk of ordnance remaining, of ordnance being encountered and the consequences of any encounter will also be examined. If an elevated risk is identified at the site, this report will suggest appropriate mitigation measures, in order to reduce the risk to as low as is reasonably practicable.

This report complies with the guidelines outlined in *CIRIA C754*, ‘Assessment and Management of Unexploded Ordnance (UXO) Risk in the Marine Environment’.

2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO during and prior to the installation of the proposed Greenlink route. The report will also suggest appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

1st Line Defence has undertaken a five-step process for assessing the risk of UXO contamination:

1. The risk that the study area was contaminated with UXO.
2. The risk that UXO remains within the study area.
3. The risk that UXO may be encountered during the proposed works.
4. The risk that UXO may be initiated.
5. The consequences of initiating or encountering UXO.

In order to address the above 1st Line Defence has taken into consideration site specific and non-site specific factors including:

- The military history of the area
- Offensive and defensive mine laying
- Firing ranges
- Naval exercise areas
- Official and unofficial munitions dumping sites
- Use of torpedoes and depth charges
- Military-related wrecks
- Records of German bombing

2.3. Sources of Information

Every reasonable effort has been made to ensure that relevant evidence has been consulted and presented in order to produce a thorough and comprehensible report for the client. To achieve this the following, which includes military records and archive material held in the public domain, have been accessed:

- The National Archives, Kew, the National Archives of Ireland, Dublin, the Irish Military Archives, County Wexford Archives and Pembrokeshire Record Office.
- The UK Hydrographic Office, OSPAR Commission and Wrecksite.eu
- The RAF Museum, Hendon.
- The Central Register of Air Photography for Wales
- Relevant information supplied by Intertek.
- Available material from 33 Engineer Regiment (EOD) Archive.
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.

- Open sources such as published books and internet resources.

Research involved a visit to The National Archives, Kew and the UK Hydrographic Office.

2.4. General Considerations of Historical Research

This desktop assessment is based largely upon analysis of historical evidence. Every reasonable effort has been made to locate and present significant and pertinent information. 1st Line Defence cannot be held accountable for any changes to the assessed risk level or risk mitigation measures, based on documentation or other data that may come to light at a later date, or which was not available to 1st Line Defence during the production of this report.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records. This is compounded offshore by the limitations of record keeping over water, where the observation and positional accuracy of incidents was difficult to maintain. As a consequence, conclusions as to the exact location and nature of a UXO risk can rarely be quantified and are to a degree subjective. To counter this, a range of sources have been consulted and analysed. The same methodology is applied to each report during the risk assessment process. 1st Line Defence cannot be held responsible for any inaccuracies or the incompleteness in available historical information.

3. UK Legislative and Regulatory Environment

3.1. General

There is no formal obligation requiring a UXO risk assessment to be undertaken for construction projects in the UK, nor is there any specific legislation stipulating the management or mitigation of UXO risk. However, it is implicit in the legislation outlined below that those responsible for intrusive works (archaeology, site investigation, drilling, piling, excavation etc.) should undertake a comprehensive and robust assessment of the potential risks to employees and that mitigation measures are implemented to address any identified hazards. Outside of the UK, other EU member states have very similar legislation to ensure high standard of health, safety and welfare during construction projects. Outside of the EU, local requirements may not correspond to the standard of EU requirements.

3.2. CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 (CDM 2015) define the responsibilities of parties involved in the design and construction of temporary or permanent structures in the UK and associated territorial waters. As well as the construction of any renewable energy structures in the renewable energy zone, defined as any area outside of UK territorial waters designated for the utilisation of energy from water or winds.

For construction projects located beyond UK territorial waters but within the UK continental shelf there is no specific health and safety legislation, but current practice is to adopt a proactive approach on construction projects by applying the principles of existing CDM legislation. The UK continental shelf is defined by the greater of the natural prolongation of land territory to the continental margin's outer edge or 200 nautical miles from the coastal state's baseline.

The CDM 2015 establishes a duty of care extending from clients, principle co-ordinators, designers, and contractors to those working on, or affected by, a project. Those responsible for construction projects may therefore be accountable for the personal or proprietary loss of third parties, if correct health and safety procedure has not been applied. Although the CDM does not specifically reference UXO, the risk presented by such items is both within the scope and purpose of the legislation. It is therefore implied that there is an obligation on parties to:

- Provide an appropriate assessment of potential UXO risks at the site (or ensure such an assessment is completed by others).
- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks presented by the project.
- Ensure the preparation of a suitably robust emergency response plan.

3.3. The 1974 Health and Safety at Work etc. Act

All employers have a responsibility under the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999, to ensure the health and safety of their employees and third parties, so far as is reasonably practicable and conduct suitable and sufficient risk assessments.

3.4. Additional Legislation

In the event of a casualty resulting from the failure of an employer/client to address the risks relating to UXO, the organisation may be criminally liable under the Corporate Manslaughter and Corporate Homicide Act 2007.

4. Role of Commercial UXO Consultants and The Authorities

4.1. Commercial UXO Consultants

The role of a commercial UXO consultant is to provide a qualified assessment of the prospective risks posed by UXO and to help develop a suitable risk management strategy during the pre-construction phases of a project. If required the UXO consultant may also identify and deliver the most appropriate risk mitigation measures and provide additional support, such as the sign-off of documentation, post appointment.

In the event that a risk of UXO contamination is detected at a proposed site or during a project, the support of a UXO specialist may be recommended. A UXO specialist may be able to avoid unnecessary call-outs to the authorities through the disposal or removal of low risk items. In addition a specialist will assist in the swift recognition of high risk items, and will thereafter co-ordinate with the local authority with the objective of causing minimal levels of disruption to site operations, whilst putting in place safe and appropriate measures. In the marine environment, a UXO consultant will be able to work with the client to advise on appropriate survey methodology, and what to do should a suspect anomaly or item of ordnance be encountered either on the seabed or on board a vessel.

For more information on the role of commercial UXO specialists, see *CIRIA C754 and C681*.

4.2. The Authorities

The police are responsible for coordinating the emergency services in the event of encountering a high-risk item of UXO above the high water mark (HWM) and HM Coastguard below. This will include establishing a cordon and evacuating people from the area. In specific circumstances operations above the high water mark will be undertaken by the Royal Logistical Corps or the Corps of Royal Engineers and operations below the HWM undertaken by the Royal Navy. Note however that the Corps of Royal Engineers remain responsible for land mines encountered below the HWM and that the RAF is responsible for Allied air delivered weaponry on RAF technical ranges, regardless of their position in relation to the HWM.

The police have a responsibility to co-ordinate the emergency services in the event of an ordnance-related incident at a construction site on land (such as works on or beyond the beach). Upon inspection they may impose a safety cordon, order an evacuation, and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. The JSEOD are responsible for tasking appropriate MoD assets to provide military EOD support where there is a perceived threat to life or unacceptable economic damage. In the absence of a UXO specialist, police officers will usually employ such precautionary safety measures, thereby causing works to cease, and possibly requiring the evacuation of neighbouring businesses and properties.

The priority given to the police request will depend on JSEOD's judgement of the nature of the UXO risk, the location, people and assets at risk, as well as the availability of resources. The speed of response varies; authorities may respond immediately or in some cases it may take several days for the item of ordnance to be dealt with. Where there is a realistic expectation of encountering munitions during works and a threat to life does not exist the JSEOD may not treat each occurrence as an emergency and will recommend the construction company puts in place alternative procedures, such as the appointment of a commercial UXO contractor to manage the situation.

Depending on the on-site risk assessment the item of ordnance may be removed from the site and/or destroyed by a controlled explosion. The latter process is lengthy and may necessitate the establishment of addition cordons and evacuations. Following the removal of an item of UXO, the military authorities will only undertake further investigations or clearances in high risk situations.

5. The Study Area

5.1. Background

The Greenlink project is a proposed subsea and underground cable interconnector, with associated convertor stations, between existing electricity grids in Wales and Ireland.

The project is designed to provide significant additional energy interconnection between Ireland, the UK and continental Europe with the aim of delivering increased security of supply, fuel diversity and greater competition. It is also designed to provide additional transmission network capacities, reinforcing the existing electricity grids in south-east Ireland and south Wales.

5.2. Location of the Study Area

The study area is approximately 160km in length and spans the St George's Channel, including areas of landfall in Ireland and Wales. Its westernmost section intercepts the Hook Peninsula in County Wexford and the easternmost section incorporates an area of land surrounding Freshwater West Beach in Pembrokeshire. The western half of the study area branches and re-joins the main route line at several points, while the eastern half comprises one singular route line.

It is situated between the approximate OS grid references: **SL 6524661908** (at its westernmost point) and **SM 8871100290** (at its easternmost point) but does not connect between these points in a straight course.

Location maps are presented in **Annex A**.

5.3. Description of the Study Area

The westernmost section of the study area, situated on the Irish mainland, typically comprises open agricultural land within the Hook Peninsula but includes the hamlets of Yoletown, Carnivan and Harrylock, as well as transport infrastructure in-between. The easternmost section of the study area, which occupies the Welsh mainland, is also predominantly occupied by open agricultural land surrounding Freshwater West Beach. This area is intersected by the B4319 and the B4320 and is situated within part of the Pembrokeshire Coast National Park.

Recent aerial imagery of the study area presented in **Annex B.**

5.4. Ordnance Survey Historical Maps

WWII-era ordnance survey maps were obtained for this report and are presented in **Annex C.** See below for a summary of the site history shown on acquired mapping.

Hook Peninsula, Ireland	
Date	**Description**
1940	This map shows the westernmost section of the site to intercept the Hook Head Peninsula, in Ireland, in two areas. This includes an area of land leading to Hook Head, which contains Lumsdins Bay, Woarwoy Bay and Sandeel Bay. The other section occupies an area centred around Baginbun Head and includes land of the periphery of the village of Fethard. Both sections appear relatively rural in nature, despite the presence of structures and roadways. The remaining visible section of the study area is occupied by the open waters of St Georges Channel.

Pembroke, Wales	
Date	**Description**
1946	This map shows the easternmost section of the site, on the Welsh mainland, to be occupied by Freshwater Beach and its surrounds. This includes *Jeffersonwalls*, *Middlehill*, *Little Furzenup*, a monument and a series of burrows. This area is intercepted by the B4319 and the B320 and appears to be largely rural in nature. The remaining visible section of the study area is occupied by the open waters of St Georges Channel.

6. Scope of the Proposed Works

6.1. General

The proposed works comprise a pre-construction marine survey campaign and the subsequent subsea cable installation.

The pre-construction marine survey campaign is proposed for a suitable period between summer 2018 and summer 2019. It is understood that the primary purpose of the campaign is to acquire appropriate data for the confirmation of the location of the offshore route; as well as to determine the appropriate installation and protection methods to be adopted.

This will include a range of geophysical, geotechnical and environmental surveys, designed to create detailed mapping of nearshore shallow geological and seabed character; reconnaissance level mapping of seabed relief and features along offshore sections; and baseline environmental mapping along the route corridor. Data acquisition and coverage requirements will be split into the following survey areas:

- The land/intertidal survey: from 50m landward of the high water mark (HWM) to the charted low water mark (LWM) of each shore landing
- The shallow water survey: from LWM seawards to the first 10m lowest astronomical tide (LAT) water depth.

- The offshore survey: Seawards of the first 10m LAT water depth to a 12 nautical mile limit and onwards to median line.

6.2. The Survey Campaign and Cable Installation

The scope of the Greenlink survey campaign is detailed in the table below:

Marine Survey		
Objective	**Method**	**Specifications**
Bathymorphology Wide area bathymetry and seabed features mapping for cable route engineering evaluation and environmental characterisation	Swath bathymetry, sidescan sonar, sub bottom profiler	Nominal 1km wide corridor
Target & Crossings Investigation Unidentified seabed anomaly characterisation and archaeological assessment Confirmation of alignment and character of existing cables / pipelines	Sidescan sonar, magnetometer, ROV	Target list graded by significance
Geotechnical Sampling	Vibrocore & cone penetrometer tests (CPT)	Spaced approximately 1500 m apart along the route. Vibrocores will penetrate up to 6m.
Seabed Sampling Environmental sampling for confirmation of biotope and seabed characterisation for environmental baseline mapping	Environmental grab	Sampling locations selected from preliminary interpretation of sidescan sonar data, nominally 5km interval
Seabed Imagery Visual confirmation of biotope and seabed characterisation	Drop-down video camera	Not specified
Landfall Survey (Nominal 3-15m Water Depth)		
Objective	**Method**	**Specifications**
Geotechnical borehole Confirmation of geology to ground truth geophysical and shallow geology for purposes of determining HDD feasibility	25m deep borehole	Four geotechnical boreholes up to 25m deep at 250m spacing from beach. Furthest core will be approx. 1km from landfall along route. Boreholes will likely be drilled from a jack-up barge.
Trial pits	Mechanical digger, hand excavated	Maximum depth will be 5m. Will be dug on beaches at Freshwater West, Boyce's Bay and Baginbun Beach.

Intrusive activities during the subsequent cable installation are believed to include:

- Use of anchors – set potentially up to 1km distant from the route's centre line.

- Cable trenching equipment e.g. ploughs, jet trenchers, rock trenchers to install the cable into the seabed. (Note this might be deeper in areas of sand waves).
- Pre-lay grapnel run. Equipment dragged along seabed to hook any debris.
- Boulder removal plough to push boulders along the route's centre line to one side. This normally clears a swathe up to 10m wide.
- Mass flow excavator to transport sand, in order to bury the cable in sand sediments.
- Dredging
- Placement of rock and/or concrete mattresses on the seabed.

It should be noted that the width of the initial survey is understood to be 500m in total. Though the width of the survey corridor is 1km in total to allow for the manoeuvre of the route's centreline, where necessary. A 1km buffer zone either side of this survey corridor has also been included for the purpose of this report.

7. Ground Conditions

7.1. General Geology

The British Geological Survey (BGS) map, the Geological Survey Ireland (GSI) map and the European Marine Observation and Data Network (EMODnet) were consulted for the purpose of this report. These sources show the bedrock geology of the westernmost section of the study area, on the Irish mainland, to be underlain by the Ballysteen Formation – dark muddy limestone, shale.

The bedrock geology of the easternmost section of the route, on the Welsh mainland, is underlain by the Millford Haven Group – conglomerate with superficial deposits of blown sand - sand. The bedrock geology of the coastline was underlain by the Aber Mawr Shale Formation – mudstone and contains Marine Beach Deposits – sand of the Quaternary Period.

The offshore bedrock geology varies considerably over the length of the proposed route and includes areas underlain by:

- Sandstone
- Limestone
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated) and limestone
- Mudstone and sandstone (undifferentiated) and limestone

7.2. Site Specific Geology

Site specific geotechnical data was not available during the production of this report.

8. Introduction to UXO and The Marine Environment

8.1. General

Many different types of UXO can be found in the marine environment, primarily as a result of historic military activity. 'Poor housekeeping' by armed forces also led to the loss or deliberate dumping of items of UXO within UK shores and waters. The United Nations distinguishes these activities into the following categories: defensive military activity, offensive military activity and AXO (Abandoned

Explosive Ordnance). Further background to these categories in relation to the site location is provided in Section 9 of this report.

The following sections will provide an introduction to the types of ordnance that might be discovered on marine sites, their failure rates and their potential for initiation; as well as an introduction to the interaction between UXO and the marine environment.

8.2. Generic Types of Ordnance found in the Marine Environment

An understanding of the principal types of ordnance encountered in the marine environment allows a more informed assessment of the hazards posed by any unexploded items that may remain in situ on a site. Items of ordnance most commonly found on maritime sites include:

- Sea mines
- Depth charges
- Torpedoes
- Air delivered iron bombs
- Artillery projectiles
- LSA (Land Service Ammunition)
- SAA (Small Arms Ammunition)

Images and brief summaries of the characteristics of the above listed types of ordnance are presented in **Annex D**. Please note that their descriptions are not exhaustive and it is possible that other forms of UXO might also be present in the marine environment.

8.3. Failure Rate of Ordnance

It has been estimated that 10% of conventional ordnance failed to function as designed and remained unexploded. Reasons for why such weapons might have failed to function as designed include:

- Malfunction of the fuze or gain mechanism (manufacturing fault, sabotage by forced labour or faulty installation).
- Many were fitted with a clockwork mechanism that could become immobilised on impact.
- Failure of vessels to arm weaponry due to human error or an equipment defect.
- Aircraft jettisoning a bomb before it was armed or from a very low altitude. This most likely occurred if bomber aircraft was under attack or crashing.

From 1940 to 1945 bomb disposal teams on land dealt with a total of 50,000 explosive items of 50kg, over, 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across the UK, see press articles in **Annex E**.

8.4. Initiation of Unexploded Ordnance

Unexploded ordnance does not spontaneously explode. All high explosive filling requires significant energy to create the conditions for detonation to occur. In the case of unexploded ordnance discovered within the marine environment, there are a number of potential initiation mechanisms.

UXO Initiation Mechanisms

UXO Initiation

Direct Impact	Unless the fuze or fuze pocket is struck, there needs to be a significant impact e.g. from piling or large and violent mechanical excavation, onto the main body of the weapon to initiate a buried iron bomb. Such violent action can cause the bomb to detonate.
Friction Impact	The most likely scenario resulting in the detonation of a UXO is friction impact initiating the shock-sensitive fuze explosive. The combined effects of the marine environment and general degradation over time can cause explosive compounds to crystallise and extrude out from the main body of the bomb. It may only require a limited amount of energy to initiate the extruded explosive which could detonate the main charge.
Sympathetic Detonation	The positioning of several items of UXO in close proximity may result in the sympathetic detonation of multiple items, following the initial detonation of just one item. This can occur within features such as munitions dumps and minefield, where large number of UXO are closely grouped together.
Natural Events	Seismological events, such as earthquakes and tsunamis, can generate sufficient kinetic energy to detonate UXO.

8.5. The Physical Marine Environment

The physical conditions that exist within the marine environment and their behaviour over time can have a significant impact on the position and condition of items of UXO. In particular, the following physical aspects are described in the table below, alongside an overview of how these physical conditions and changes can interact with UXO

	Description	**Effect on UXO**
Geology and Sediments	Much of the marine environment comprises underlying rock overlain by less consolidated sediments, such as silts, clays, sands and gravels. The extent of overlying sediment cover can vary significantly between areas of little or no sediment cover, such as areas of exposed rock, and areas of the seabed with a sediment thickness greater than hundreds of metres.	The composition of the sediment cover present and the underlying geology will determine the depth to which some items of UXO initially penetrate the seabed or shore. As well as to what extent such items may subsequently become buried by natural processes.
Bedforms	Bedforms may form depressions, such as channels, and extrusions across large areas of the seabed and typically include mobile sediments, such as mega ripples and sand waves. Subsequently many areas of the seabed are not uniformly flat. More substantial features, such as sand ridges, sand ribbons and sand or gravel banks may also be present in some cases. Bedform features are often indicative of the relationship between the physical processes and sediments present. The asymmetry of bedforms can demonstrate active processes of sediment erosion, transport and deposition.	The presence of a bedform can be used to determine the net direction of active sediment transport. Highly mobile seabed and shore areas are more likely to result in notable changes to bed levels over time and can be monitored to infer more information regarding the potential burial or exposure of items of UXO present.
Coastal Processes	The energy generated from physical processes, such as winds, water and tides have their greatest effect on the surface of a water body and reduce with the depth of a water column. These forces may be affected by the modification of both wave and tidal processes in areas near to the shore, which	The force of these coastal process is affected by the relationship between water depth and wave length. Information about these factors can be used to determine the depth of a wave influence and whether the

	can cause larger forces to be exerted on items or sediments present on the sea bed.	wave will have a significant interaction with items of UXO present on the seabed.
Sediment Transport and Morphological Change	Physical forces exerted onto the seabed or shore may also cause sediment transport, depending on the size of the sediment grains and the level of force. This movement can take the form of bedload transport, where sediment moves directly across the seabed or suspended load transport, where sediment is instead transported across the water column.	Sediment transport can take the form of a gradual, progressive trend or can occur rapidly as a result of storm or surge events. Significant sediment movement is therefore difficult to determine. The influence of this sediment transport and any resulting morphological change can affect the exposure and movement of UXO present.

8.6. Interaction between UXO and the Marine Environment

These physical marine conditions can interact with items of UXO present in the marine environment in the following three principal ways:

8.6.1. Exposure or Penetration into the Seabed or Shore

Some types of UXO will be initially deployed directly on the seabed or the shore, such as sea and land mines. Whilst other types of UXO, including artillery projectiles, depth charges, air delivered bombs, LSA and SAA may only reach these surfaces after travelling through air and water. The initial resting place and penetration of UXO depends on a large number of factors, including the geology of the seabed or shore, the presence and thickness of any overlying sediment layers, the residual kinetic energy of the item of UXO and its angle of entry.

The initial position of an item of UXO within the seabed or shore surface can be classified as unburied, partially buried or fully buried. In addition, it should be noted that some items, such as buoyant sea mines, are not initially deployed directly on the seabed but will sink over time and come to rest of the seabed's surface.

8.6.2. The Subsequent Burial or Uncovering of UXO

After its initial position within the marine environment an item of UXO may experience burial, due to the vertical deposition of sediments or uncovering, due to the vertical erosion of sediments. Consequently, some items will experience cycles of burial, uncovering and re-burial due to regular trends of erosion deposition. These sediment movements can be the result of both near-field and far-field process and can be formed by gradual ongoing erosion trends or cycles of change dominated by temporal effects, such as seasonal cycles.

8.6.3. Migration of UXO

UXO in the marine environment has the potential to migrate if subject to sufficient force from metocean processes. Due to the weight and density of most large types of UXO, migration distances are likely to be small for such items, but can be greater during storm events or surges, or within areas where the seabed slopes significantly. Smaller types of UXO, such as LSA and SAA, are much more likely to migrate within the marine environment.

An exception to this description of migration are buoyant sea mines. These items should be considered separately because they have the potential for much greater distances of migration, driven by tidal currents, if they become loose from their moorings. Theoretically migration distances in this scenario could be as far as the distance of the tidal excursion each day and could extend up to several kilometres. However, such items will lose buoyancy over time and will come to rest upon the seabed, following which the normal rules of migration will apply.

Studies of UXO migration in the marine environment are still relatively limited today and require detailed information about the type of UXO and the metocean conditions present, as well as data regarding the composition of seabed sediments, bedforms and the underlying geology. It is therefore rarely possible to determine the initial location of an item of UXO in the marine environment or its potential migration distance with a great deal of accuracy.

9. The Risk from UXO

The presence of UXO in the marine environment can broadly be classified as the legacy of three activities: defensive military activity, offensive military activity and AXO (abandoned explosive ordnance.) These categories are however not definitive, as some UXO items may be multi-category.

9.1. Defensive Military Activity

Defensive military activity incorporates defensive munitions employed not only during periods of major conflict, such as WWI and WWII, but also the intervening years. Defensive munitions are most likely to be found within areas used to guard maritime zones, such as designated sea minefields and coastal armament areas, as well as areas associated with military training, such as ranges and camps. Consequently, defensive munitions can include sea mines, land mines, artillery projectiles and LSA.

Defensive naval activity played a significant role in both WWI and WWII, as each side attempted to defend their territories from invasion and to hold and reinforce certain key points and areas overseas. Such activity also played a significant part in the economic survival of each nation during these periods, with large number of munitions and vessels regularly deployed to defend merchant shipping from attack. Defensive sea mines were first used by the UK in WWI and in WWII a major defensive minefield was laid in the southern section of the St Georges Channel, between Ireland and Wales, to close the approach to shipping routes to Liverpool and the Clyde from German vessels. Post-war mine laying continued in UK waters, until its recorded cessation in 1992.

9.2. Offensive Military Activity

UXO associated with offensive military activity is more likely to originate from periods of major conflict, particularly during WWI and WWII in Europe. Offensive munitions may consist of any item used to attack or engage a target in combat and can result from such activities as aerial bombing, sea mining and vessel to vessel engagements. Offensive munitions therefore cover a broad variety of items and can include aerial bombs, sea mines, land mines, torpedoes, artillery projectiles, LSA and depth charges.

Offensive naval military activity during WWI and WWII included the blockade of ports, attacks on merchant shipping, the transport of military forces and large scale naval conflicts, such as the Battle of Jutland. No major naval engagements are recorded to have taken place within the St George's Channel during either period due to its location in relation to the continent, but it was identified as an area of strategic value by German U-Boats during WWI. This was due to the volume of naval and merchant shipping that travelled between the major ports of Ireland and Great Britain in the region to destinations across the Atlantic. The regular success of U-Boat attacks on merchant and naval ships led to the region to be dubbed as 'U- Boat Alley' and contributed to the 1,763 shipwrecks recorded in the Irish Channel during the four years of WWI.

9.3. Abandoned Explosive Ordnance (AXO)

Items of AXO are more likely to be found on or near areas where the deliberate dumping of munitions is recorded to have taken place, or else in close proximity to the wrecks of munition carrying aircraft and naval vessels. One well documented case study in Britain is the wreck of the SS Richard Montgomery, an American liberty ship, which ran aground on a sandbank in the Medway in August

1944. This vessel is recorded to have been carrying 6,127 tons of munitions and is still designated as dangerous under the Protection of Wrecks Act today.

Large numbers of AXO present today result from the practice of sea dumping, which was the internationally accepted method of disposal of surplus munitions at the end of WWII. During this time the British Army designated over 1.2 million tons of ordnance to be disposed of, with Beaufort's Dyke, situated off Stranraer, designated as the principal offshore disposal point. Beauforts Dyke remains Europe's biggest underwater dump for surplus ammunition today, with more than one millions ton of ordnance, including bombs, projectiles and explosive material deposited between 1920 and 1976.

10. Wrecks

10.1. General

Many military and civilian vessels were sunk in British waters during WWI and WWII, predominantly as a result of U-boat activity and the presence of offensive and defensive mining. Often, research into the location of wrecks and the reason for their loss can indicate the types of weapon which were deployed in an area – whether they were bombed, torpedoed or mined for example – and therefore the nature of the threat which might still exist.

Some wrecks can pose a direct threat due to their particular cargo – those in use by the military or responsible for the transportation of weapons and explosives can still pose a threat today. Sea-bed contamination from military-related wrecks tends to be fairly localised since the munitions are generally enclosed within the hull of the vessel, or will often collect in scours around the wreck. Furthermore, weapons in transit were typically unfuzed so pose less of a direct threat than weaponry which has fired but failed to detonate.

10.2. Shipwrecks in the St Georges Channel

Records of shipwrecks in the St Georges Channel were obtained from Wrecksite.eu and the UKHO. An overlay showing the location of recorded wrecks on aerial imagery presented in **Annex F**. Shipwrecks recorded within the study area and in the immediate surroundings have been included and are discussed in the table below.

Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
SS Hermione	British cargo	Armed merchant ship	14/04/1917	Struck by a mine laid by the German submarine UC-33	Within 150m NW
Name unknown	German warship	Not specified	05/08/1917	Blown up by own mines	Within 1km NW
HMT Loch Eye	British trawler	Not specified	20/04/1917	Sunk by a mine from the German submarine UC-33	**On study area, NW**
HMT George Milburn	British minesweeper	Armed trawler	12/07/1917	Sunk by a mine from the German submarine UC-42	**On study area, NW**
UC-44	German submarine	Not specified	04/08/1917	Sunk by own mines.	**On study area, NW**

Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
SS Trafford	British cargo	Not specified	16/06/1915	Scuttled (gunfire – shelled) by the German submarine U-22	**On study area, NW**
SS Fingal	British cargo	Not specified	01/09/1917	Foundered	**On study area, NW**
SS Etal Manor	British cargo	Not specified	19/09/1917	Torpedoed by German submarine UC-48	Within 100m NW
SS Carlo	British cargo	Defensively armed	13/11/1917	Torpedoed by U-95	**On study area, NW**
FV Guard	British fishing	Not specified	17/03/1917	Sunk by the German submarine UC-48	Within 1km NW
SS Rhodesia	British cargo	Defensively armed	11/10/1917	Torpedoed by German submarine U-61	Within 1km NW
SS Candidate	British cargo	Not specified	06/05/1915	Captured then torpedoed by German submarine U20	**On study area, centre**
SS Cairo	British cargo	Not specified	13/08/1915	Sunk (gunfire – shelled) by the German submarine U-24	Within 100m, centre
SS Empire Frost	British cargo	Not specified	13/03/1941	Aerial bombing	Within 5km, centre
FV Valeria (LT156)	British trawler	Not specified	18/08/1940	Aerial bombing	Within 3.5km, centre
SS Thorold	Canadian cargo	Not specified	22/08/1940	Aerial bombing	Within 3km,c entre
HMS Arbutus	British war	2 × 4 in (100 mm) guns, 1 or 2 × 12-pounder guns, Depth charge throwers	16/12/1917	Torpedoed by German submarine UB-65	Within 300m, SE
MV Empire Beacon	British cargo	Not specified	05/04/1942	Detonated a British mine	Within 2.3km, SE
SS Drina	British ocean liner	Not specified	01/03/1917	Sunk by a mine from the German submarine UC-65	Within 300m, SE
SS Inishowen Head	British cargo	Armed merchant ship	14/02/1917	Sunk by a mine from the German submarine UC-65	**On study area, SE**
SS Gisella	British cargo	Defensively armed	18/11/1917	Torpedoed by the German submarine UC-77	**On study area, SE**
Hannah Croasdell	British sailing	Not specified	26/02/1917	Sunk by a mine from the German submarine UC-65	Within, 2km SE
SS Saint Jacques	French cargo	Not specified	15/09/1917	Sunk by a mine from the German submarine UC-51	**On study area, SE**
LCG-15 Landing Craft	British war	Not specified	25/04/1943	Sank in gale force winds	**On study area, SE**

Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
HMS Minicoy	British war	Not specified	14/05/1941	Mined while being used as a harbour defence vessel	Within 2.2km, SE
MFV Helene	Belgian trawler	Not specified	04/12/1940	Sank after hitting a German mine	Within, 2.5km SE
SS Johanna Caroline	British minesweeper	Not specified	28/04/1941	Detonated a German mine	Within 3km, SE

10.3. Aircraft Crashes in the St Georges Channel

During WWII, many hundreds of aircraft were shot down and lost over British waters. The English Channel and the North Sea were the focus of a significant proportion of air activity during this period, with many hundreds of aircraft being abandoned or crash-landed due to combat damage or technical failures. Losses by RAF Fighter Command were most significant during the four months of the Battle of Britain, during which 234 aircraft are documented to have crashed within British waters.

Given the relatively low speed of impact in many cases, aircraft which crashed at sea were often largely intact as they came to rest on the sea floor and may have remained so, though subsequent damage by shipping, corrosion and movements in the physical marine environment, such as storm surges, can have a significant impact on a crash site. The risk of encountering UXO at aircraft crash sites is determined through considerations of the aircraft's specification, its potential bomb load, the nature of the crash and the extent of any recovery operations.

No evidence could be found to suggest the presence of any aircraft crash sites directly within the study area in Wrecksite.eu or the available UKHO records. RAF Log Books for RAF Angle (see section 16.3) do however reference several aircraft crashes in the general proximity. It is anticipated that a large section of the study area would have been patrolled by RAF aircraft during WWII, which may have been undertaking reconnaissance tasks or defending merchant shipping in the Irish Channel.

10.4. Deductions

A total of 15 wrecks recorded on or near the westernmost and easternmost sections of the study area, off the Irish and Welsh coastlines, are labelled to have been 'sunk by mines from German submarines'. Eight torpedo related wrecks are recorded, with the majority also situated in the easternmost and westernmost sections of the study area, in shallower waters. Three wrecks in the central section are accounted for by WWII-era aerial bombing, two wrecks are referenced to have been sunk as a result of 'gunfire' and the two remaining wrecks were brought down by 'circumstances unrelated to explosive ordnance'.

These wrecks demonstrate the potential presence of sea mines, torpedoes, aerial bombs and projectiles within the study area, each of which will be examined in turn over the course of this report.

It should also be noted that the majority of wrecks recorded on or near the study area are British cargo ships, though military vessels are recorded within the area during both WWI and WWII. These include an unnamed German warship in 1917, the German submarine UC-44 in 1917, the British warship HMS Arbutus in 1917 and the British warship HMS Minicoy in 1941. Two British minesweeper vessels are also recorded to have sunk in 1917 and 1941, as well as the British landing craft LCG-15 in 1943. Although specific armaments are only referenced on the HMS Arbutus all of these military related vessels have the potential to have been carrying items of unexploded ordnance at the time of their loss.

11. Sea Mines

11.1. General

Sea mines are self-contained explosive devices placed in water to destroy ships, submarines and other watercraft. These weapons are laid and left until they are triggered by the approach, or contact with a vessel. Naval mines can be used offensively, to hamper enemy shipping and restrict it to a harbour, or defensively, to protect friendly shipping and create "safe zones”.

During WWI it is estimated that up to around 128,000 mines were laid in the sea around the coast of the UK, both offensively by the German Navy and defensively by the British Navy. This included minefields actively laid by German aircraft, destroyers and minelayers off British harbours. Both navies continued to deploy defensive and offensive defensive fields during WWII, with approximately 100,000 mines laid in the North Sea and Thames Estuary alone. Although attempts were made to remove or make safe sea mines deployed during WWII around the coast of the UK, it is estimated by some sources that up to 70% of sea mines were not recovered.

Mines are most frequently classified by their position in the water, delivery method and method of activation. A mine’s position in the water can include bottom mines which rest on the ground, moored mines used for deeper-water areas and drifting mines, which float freely. Delivery methods include aircraft-laid mines, surface-laid mines and submarine-laid mines. Whilst the method of activation can be divided into two categories. Contact mines are designed to explode on contact with the hull of a ship and influence mines are triggered by the ‘influence’ of a ship or submarine, rather than by direct physical contact.

Further details of these classifications, alongside examples of common types, are presented in **Annexes D1-D3**.

11.2. Mines in the St Georges Channel

Historical accounts of minelaying operations in the St Georges Channel were found in both online and written texts, including *The War at Sea* by S W Roskill and *Royal Navy Minelaying Operations* by Geoffrey B Mason. One particular text, *The History of the Great War-Naval Operations* by Sir Julian Corbett and Henry Newbolt, references a German minefield laid off the south-west coast of Wales in WWI, which is believed to have been designed to disrupt shipping travelling to and from important naval sites at Pembroke Dock and Milford Haven. No original mapping of this minefield could be obtained to illustrate its exact location, but from its description it is anticipated that this minefield intercepted the section of the study area off the Pembrokeshire coastline.

No major British minefields were laid in the St George’s Channel or the wider area, otherwise known as the ‘south-west approaches’, before 1940, because of a lack of resources and the extensive use of these areas by merchant shipping. However after the German occupation of France merchant ships using the St George's Channel were diverted and had to enter the Irish Sea from the north, through the North Channel. During this period over 6,000 mines were laid across the south-west approaches to deter U-Boat activity and as an anti-invasion measure, with the St George’s Channel declared a ‘British Mine Area’ from the 22nd July 1940. The mine area incorporated a significant portion of the channel and spanned between Devon and the coast of Ireland, with gaps to allow use by Allied and neutral coastal shipping. It remained in place for the remainder of the war and was reinforced in 1945.

11.2.1. Mine Mapping

During this report the UKHO was contacted for any resources concerning the potential presence of historic mines in the St Georges Channel. According to information provided by their Mine Warfare Team Leader no detailed minelay maps exist that specifically cover the St. George's Channel. A WWII-era sea minefield map covering the whole of the British Isles and adjacent waters was however provided, with the relevant section presented in **Annex G1**. This map, compiled in 1945, shows the western section of the study area to run through a British minefield, which forms part of a much larger mined area between the south coast of Ireland and the western coast of Great Britain. (This mined area is understood to have been laid in 1940 and is described in more detail in the section above.) A section of the east of the study area is occupied by a much smaller British minefield. Two circular 'enemy minefields' are present in the wider vicinity of the site, off the Pembrokeshire coast and a number of searched channels are also labelled within this region.

Additional mine mapping covering the St Georges Channel Mine Area was acquired from the National Archives, Kew and is presented in **Annex G2**. This mapping shows the location of the designated danger area in more detail than the aforementioned mine map and includes the location of a 'secret gap' near the Irish coastline and the 'southern gap' off Devon. It is dated between 1940-1943 and 1944, with the latter map edition showing the 'secret gap' widened to accommodate for both inward and outward shipping routes.

It should be noted that the position of the aforementioned mine danger area depicted within the St George's Channel is based on navigational practices and equipment dating to WWII. Due to the limited navigational accuracies of the units laying mines at this time their true positions may differ.

11.2.2. Parachute Mines

Home Office Statistics record a total of 10 Parachute Mines dropped over the Rural District of Pembroke during WWII. Many of these would have been sea mines that had been modified with impact fuzes to act as conventional high explosive weapons, and it is likely that those recorded were dropped over targets on land. This statistic demonstrates the potential for additional aerial mines to have been deployed within the waters surrounding Pembrokeshire, where records of aerial bombing were limited. Luftwaffe minelaying was common across parts of the UK waters with the intention of disrupting shipping.

11.3. Deductions

An extensive British mine area, believed to comprise over 6,000 mines and several significant minefields, was laid in the St George's Channel in 1940 and later reinforced in 1945. The former location of this mined area is considered to include a significant portion of the Irish side of the study area. References to several smaller minefields, including a WWI-era German minefield and two WWII-era German minefields have been found on and in the general proximity of the Welsh side of the study area, surrounding Milford Haven.

Efforts were made by the Royal Navy post-war to remove or make safe the areas mined during the war. However such clearance tasks did not guarantee the complete removal of all mines within a danger area, especially as such items have the potential to migrate or became covered due to sediment and tidal action over a long period of time. It was common practice to cut the mooring cables of buoyant mines using minesweeper vessels, and then to shoot and sink any mines which came to the surface. Inevitably, some cables will not have been cut (with the mine sinking later) many mines will not have been detonated by the shooting, and many would end up sinking but still being 'viable' weapons. Furthermore, some WWII-era mines were fitted with scuttling circuits which caused them to sink after a specified period of time, on occasion prior to the period of post-war clearance. It is therefore not possible to discount the possibility of encountering surface or submarine laid sea mines across the proposed study area.

While aerial delivered parachute mines could well have fallen within the St Georges Channel undetected, they were not dropped in any great numbers, so the likelihood of one being present within the study area is not considered to be as high as for ship laid mines.

12. Torpedoes

12.1. General

A torpedo is a self-propelled weapon with an explosive warhead, launched above or below the water surface, propelled underwater towards a target, and designed to detonate either on contact with its target or in proximity to it.

Torpedo design changed little from 1870 until the 1940s. During WWI torpedoes were widely used in to disrupt shipping and to sink submarines. Germany disrupted supply lines to Britain largely through use of submarine torpedoes, while Britain targeted U-boats with the weapon (sinking a total of 20 over in this way the course of the war). In WWII both Allied and Axis forces used torpedoes primarily against enemy warships. During this period, torpedoes were aimed to explode underneath a ship, to counter the heavy armour of these vessels and instead damaged its keel, and the other structural members in the hull.

Failed torpedoes can sink to the seabed with their warheads intact when they run out of fuel. They are sometimes encountered off the UK coastline, mainly by fishermen – for example, one was recently recovered by trawlermen off the coast of Eastbourne in March 2013. Typically, the warheads contain around 200-300kg of explosives.

Examples of WWII-era torpedoes are presented in **Annex D4**.

12.2. Torpedoes in the Saint Georges Channel

Information regarding the usage of torpedoes by any vessel is generally difficult to ascertain, as historic naval records rarely clarify the exact location and numbers of torpedoes deployed during wartime. Some information regarding the potential presence of torpedoes at a site location can however be inferred by the nature of recorded shipwrecks in the region.

Information obtained from Wrecksite.eu and the UKHO indicate that eight vessels in the general proximity of the study area were sunk by torpedo attacks from German U-boats during WWI. The majority of these vessels were cargo ships, but included one fishing ship and one naval vessel, the HMS Arbutus. The majority of these wrecks are recorded in the general vicinity of the Irish coastline and the Welsh coastline, with only one wreck recorded in a more central area of the study area, within deeper waters. No WWII-era torpedo related shipwrecks were recorded in this region.

12.3. Deductions

Torpedoes were deployed in UK waters during both WWI and WWII, although their numbers were relatively low when compared with other types of munitions. Historical records indicate that shipping within the Irish Channel (including the St Georges Channel) was subject to a large number of torpedo attacks during WWI, leading the region to be dubbed as ‘U-Boat Alley’. Torpedo attacks by U-Boat resumed in WWII but were smaller in number, owing to better defences and the presence of the St Georges Channel minefield from 1941. This is correlated by the available data concerning wreck sites, which indicates that a number of WWI-era torpedo related wrecks are situated in the vicinity of the study area, especially within areas of shallower waters.

13. Anti-Submarine Weapons

13.1. General

The most common anti-submarine weapon was a depth charge. The weapon is dropped into water (either by a ship or aircraft) near a target, detonates, and consequently subjects it to a powerful and destructive hydraulic shock. Most depth charges use high explosive charges and a fuze set to detonate the charge, typically at a specific depth.

Depth charges were developed during WWI by Britain for use against German U-boats and were subsequently utilised in both war periods. While deployed far less than torpedoes, the weapon acted as the principal anti-submarine weapon for surface ships. The first models were steel canisters filled with TNT explosives and detonated at a depth pre-set by a hydrostatic valve. The first recorded sinking of a German U-boat as a result of a depth charge occurred on 22nd March 1916, off the coast of Ireland.

Anti-submarine spigot mortars were also deployed by the navy from 1942. The most common was the Hedgehog mortar which had contact fuzing and was fired in batches of 24 (16kg charge weight). The larger Squid mortar was fired in salvoes of three and had a charge weight of 45kg. These devices accounted for more U-boat losses than depth charges and their ratio of successes to attacks was much better. However up to the middle of 1944 depth charges remained the principal anti-submarine weapon for surface ships

Examples of anti-submarine weapons are presented in **Annex D5**.

13.2. Anti-Submarine Weapons in the St Georges Channel

As with torpedoes, the exact locations and number of anti-submarine weapons deployed during wartime is often difficult to determine – generally even more so than for torpedoes. Information from Wrecksite.eu and the UKHO does not indicate that any wrecks related to anti-submarine weaponry occurred directly within the study area but does suggest that these types of incidents occurred across other parts of the Irish Channel. This corresponds with an overlay of U-boat losses presented in **Annex H,** which records four U-boat losses in the general surrounding area. Three of these U-boats are labelled as 'sunk by depth charges' from British and Canadian frigates in 1945.

13.3. Deductions

Anti-submarine weapons were commonly deployed by Allied naval vessels in the home waters of Great Britain during both WWI and WWII. Such items were not generally deployed in high numbers but were concentrated within regions subject to high volumes of German submarine activity, such as off the east and south coast of the English mainland.

Historical records indicate that depth charges were deployed to combat German U-boats in the Irish Channel during both WWI and WWII, with other anti-submarine weapons, such as the Hedgehog and Squid spigot mortars put into operation from 1942. Information concerning German U-boat losses suggest that anti-submarine weaponry was at its most effective towards the end of WWII, with a number of vessels sunk by depth charges in the Irish Channel in 1945. Although no evidence could be found to suggest that any shipwrecks related to anti-submarine weaponry are situated within the study area it is therefore not possible to discount the presence of such items at the site location due to their usage in the wider area.

14. Offshore Munitions Dumps

14.1. General

Large quantities of munitions were dumped at designated sites or randomly jettisoned into the sea following WWI and WWII. These included conventional munitions such as bombs, grenades, torpedoes and mines, as well as incendiary devices and chemical munitions.

The presence of munitions in the sea can pose a risk to fishermen, coastal users and the offshore construction industry. As recently as 2005, three fishermen were killed in the southern North Sea when a WWII bomb believed to originate from a dump site exploded on their fishing vessel after having been caught in their nets.

Information on the amounts and locations of dumped munitions is recognised to be incomplete, but the existence of dumped munitions should always be a consideration for offshore construction projects. In 2004, OSPAR began a programme to establish the extent of munitions dumping and to monitor the frequency of encounters. This has revealed that munitions were dumped at 148 sites and that 1,879 encounters with munitions have occurred since 2004. Around 58% of reported munitions were encountered by fishermen and 29% found on the shore. Following discovery, 76%, of these items were removed from the sea or neutralised; 11% were returned to the sea for safety reasons.

14.2. Munitions Dumps in the St Georges Channel

The overlay provided in **Annex I** shows the approximate location of historic munitions dumpsites recorded by OSPAR in the region of the site. Three conventional munitions dumpsites are recorded off the coast of Pembrokeshire, in the surroundings of the easternmost section of the study area. Little further information could be found concerning the age of these sites, their extent or the nature of items deposited.

The presence of munitions dumps off the coastline of West Pembrokeshire is also correlated by a series of Marine Character Reports on the region, compiled by Natural Resources Wales. Which state: 'Historically a large area in the south of the MCA (West Pembrokeshire Islands) and an area at Hats and Barrels have been used to dump disused explosives, marked as Explosives Dumping Grounds on the marine charts. Military use within the MCA continues today with part of the Aberporth firing range and military practice area located to the northeast and part of the Castlemartin firing range area located to the south[2].

14.3. Deductions

The three munitions dumps depicted are not considered to be of close enough proximity to pose a direct risk to the study area, and no evidence has been found to suggest that any other official or unofficial munition dumps were present in the vicinity. However if the location of the study area was to be altered and to be situated on or near to these munitions dumps, then a significant risk from UXO may be posed by the presence of these features.

15. Coastal Armament Training Areas

15.1. General

[2] _https://naturalresources.wales/media/674497/mca-19-west-pembrokeshire-islands-bars-and-inshore-waters_final.pdf_

There are several historic armament firing ranges located along the Welsh coastline, many of which were in operation during WWII. Such ranges will have left a legacy of UXO contamination along the coast which may pose a threat to offshore intrusive works and dredging.

15.2. Armament Training/ Danger Area Mapping

Four maps were acquired from the National Archives showing the location of historic armament training areas and designated danger areas present in the UK in relation to the study area. These maps are included in **Annexes J1-J3** and are described below.

Military Range Maps – Annexes J1-J3	
Date Range	**Comments**
Restricted Flying Areas, Defended Areas & Balloon Areas – March 1941	The majority of the study area passes through red and green areas. Its easternmost section intersects a heavy AA and inner artillery zone, which surrounds the town of Pembroke.
Restricted Flying Areas, Defended Areas & Balloon Areas – March 1943	There is little significant change across the majority of the study area between this map and the previous map edition. The easternmost section of the site, near the Pembrokeshire coastline, now intercepts a coastal armament training area.
Restricted Flying Areas, Defended Areas & Balloon Areas –July 1944	This map also shows little significant change across the majority of the study area since the previous map edition. A USA armament training area is however now labelled to the north of the eastern section, surrounding the island of Grassholm.
'Notices to Airmen' Danger Areas in the UK – Date Unknown	This map shows areas used for firing or bombing practice and for air to air firing practice, including both active and inactive locations. The easternmost section of the study area, in Pembrokeshire, intercepts two inactive firing or bombing ranges and is situated in the general proximity of an active firing or bombing range, situated further east. It should be noted that from the quality of the mapping available that it is not possible to identify the names or exact locations of firing/bombing practices in the wider area of the site and that discrepancies are present between this source and both the Armament Training Areas and Restricted Flying Areas mapping covering the region.
Armament Training Areas – May 1945	This map, presented in **Annex J3**, shows that the easternmost section of the study area to intercept three WWII-era armament training areas. N104 and N105 are both classified as Milford Haven Approaches and are documented to have included naval guns and both heavy and light anti-aircraft. Both firing ranges have a designated 'danger area' up to 20,000ft. A222 Milford Haven is labelled as a coastal artillery range and has a designated 'danger area' up to 10,000ft. A smaller range is also denoted approximately 7km the north of this section of the study area, surrounding the island of Grassholm. This range is classified as a USA live bombing range, under the jurisdiction of the RAF. It has a designated 'danger area' up to 25,000ft.

15.3. RAC Castlemartin Range

The Castlemartin training area is a 6,000 acre historic and current military range, with a danger area extending up to 14 miles out to sea. A small portion of the easternmost section of the study area, at Freshwater West Beach and Gupton Barrows, is situated within the land perimeter of this range. A more sizeable portion of the study area, in the bay of Freshwater West, is situated within the range's oversea danger area.

Castlemartin was first requisitioned by the military for use as a training range in 1938, as part of the build-up of the armed forces in the run up to WWII. During the war it was predominantly used as a tank range by the RAC (Royal Armoured Corps) and was briefly returned to agricultural use at the end of the conflict in 1945, before being requisitioned once again at the start of the Korean War in 1950. From this period onwards the range retained its predominant usage as a tank range and was frequently used by German Armoured Units of the FRG (Federal Republic of Germany) during the Cold War. In 1995 training activities were broadened to include additional infantry and small arms training and in 1999 the area was reorganised under the Defence Training Estate. Today it forms one of the twelve Army Training Estates (ATEs) in the British Isles.

War Office records from the post-war period, discussing the usage and composition of the Castlemartin Training area were obtained from the National Archives, Kew, examples of which are presented in **Annex K.** These records confirm that the majority of the training area was used as a tank and armoured car weapons range during the post-war era, with reference to training involving tank gunneries, troop battle runs and small arms. These record sets also suggest that the north-west corner of the training area, which includes part of the study area, was designated as a 'naval aviation bombing range'.

15.3.1. Types of Ordnance Employed at RAC Castlemartin

Detailed information concerning the exact specifications and types of weaponry fired within Castlemartin is difficult to obtain. Parliamentary records discussing the usage of the training area between 1959-1989 have however been found to suggest that at least the following guns were deployed during this period within the tank range:

British Tank Training	
Date Range	**Weapon Type**
1959–64	Centurion 20 pounder gun
1965–72	Centurion 105 mm gun
1970–date of record	Centurion 120 mm gun
Federal Republic of Germany Tank Training	
Date Range	**Weapon Type**
1961–67	M48 90 mm gun
1968–69	Leopard 1 105 mm gun
1970–73	M48 90 mm gun
1974–75	Leopard 1 105 mm gun
176-1979	M48 90mm gun
1980–85	Leopard 1 105 mm gun
1986–date of record	Leopard 2 120 mm gun

15.4. Grassholm

Armament training mapping, danger area mapping and local historic accounts indicate that the island of Grassholm, situated approximately 7km north of the study area was used as a bombing range by the USAF (Unites States Air Force) during the latter years of WWII. COFLEIN (the Royal Commission of Ancient and Historical Monuments of Wales) have provided the following description of its operation:

Grassholm Island was used as a target for bombing practice by the United States Air Force during the Second World War, leaving small bomb craters and shrapnel across the surface. The sites of these craters, some with metal fragments, have been recorded in the past by Douglas Hague. During a field *visit on 14th October 2016 the nose cone of a projectile was recorded still embedded in the ground surface at the NGR (National Grid Reference) of the record. The lack of small fragments around it suggested to military historian Mark Kahn that it may have been a rocket projectile but a practice round, rather than a fragmentation round. Numerous other small craters or likely craters can still be seen on the eastern side of the islet.*

This account would suggest that activity by the USAF was extensive and included a range of aerial delivered bomb types. Any further details about the usage of the range, including its date of closure, could not be obtained during the production of this report and are likely held by US based sources.

15.5. Deductions

Items or ordnance used at Castlemartin will include LSA and SAA but may also include larger, aerially delivered bombs, due to the presence of the recorded air to land range. The smallest type of LSA typically used by British forces during the WWII-era and therefore likely to have been used at Castlemartin were three pounder projectiles (such as the Hotchkiss, Vickers and Nordenfelt 47mm varieties). Which were generally used by naval guns, coastal defence guns and anti-aircraft guns. Smaller sizes of projectiles may have been utilised at the ranges, but the most common small projectile is likely to have been the aforementioned three pounder HE. Examples of LSA are presented in **Annex L.**

Based on the available War Office record covering the post-war operation of Castlemartin it is anticipated that both live and practice ammunition has been employed during its operation. In the case of the former, items of ordnance fired within the sea danger area are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the seabed.

The presence of Castlemartin range also increases the likelihood that items of Allied ordnance could have been expended, through training exercises, or discarded, through poor housekeeping within the easternmost section of the study area. This includes the section within Freshwater West Beach and the surrounding sea danger area. The presence of the former Grassholm range 7km north is anticipated to have a less direct impact on the easternmost section of the study area. It is possible however that US aerially deployed ordnance, such as practice bombs, were deployed in the surroundings waters of the Island and migrated within the proposed site area.

16. RAF Angle

16.1. General

RAF Angle was developed in 1941 as a RAF Coastal Command Operational Satellite. Its location was chosen to support its predominant function, which was to provide support to both maritime and aircraft conveys across British waters, especially over the Irish Channel. Between 1941 and 1943 the airfield was occupied by a number of fighter squadrons, flying Hurricanes, Whirlwinds and Spitfires, operating on three to four month cycles. During 1943 the airfield also saw usage by the Fleet Air Arm of the Royal Navy, with two units flying a mix of aircraft types, operating as a Naval Air Firing Unit.

Following the cessation of fighter rotations in 1943 the airfield was occupied by a Coastal Command Development Unit (CCDU) until January 1945, which was tasked with the improvement of coastal operations. Following this period the airfield was declared surplus to requirements by the RAF and was finally disposed of in the 1950's, its grounds returning to agricultural use.

16.2. RAF Site Plans

A WWII-era site plan of RAF Angle was obtained from the RAF Museum Hendon and is presented in **Annex M**. This plan, dated 1943, indicates that the airfield was predominantly characterised by three hard surfaced runways, a single T.2 Hanger and four blister hangers.

The easternmost section of the study area occupied the southern section of the airfield which, amongst other features, is labelled to have contained a machine gun range, a cannon test butt, flight offices, dispersal pens and a section of the outer taxiway. The main technical area is situated further north. Several external accommodation areas, situated to the far east of the airfield, are also labelled within the study area. These include the No.2, No.3 and No.4 communal sites strung along what is now the B4320. Each communal site is relatively similar in composition and predominantly comprises barracks huts, recreational buildings and air raid shelters.

16.3. RAF Operations Record Books

Written records regarding the daily life and operation of RAF Angle have been obtained from the National Archives. In general, logbooks recorded the day to day operations of an airfield and incidents of note, including aircraft crashes and enemy bombing raids. Relevant entries in the book to this assessment are transcribed below.

RAF Operations Record Books	
Date Range	**Comments**
20th March 1942	A Junkers 88 probably destroyed by No. 312 (Czech) Squadron.
26th April 1942	A demonstration was given by a Demonstration Rifle Flight of the R.A.F. Regiment.
6th July 1942	Enemy air activity in district from 03.00 to 03.45 hours. Bombs or mines dropped but not in vicinity of station or aerodrome. Suspected minelaying in Milford Haven.
7th July 1942	Enemy air activity in district 03.15 to 03.40. No mines or bombs dropped in the vicinity of the station or aerodrome. Suspected minelaying in Milford Haven.
8th July 1942	Enemy air activity between 03.10 and 03.50 hours. Suspected minelaying in Milford Haven.
26th August 1942	Two Spitfires of 152 Squadron missing from patrol. Sgt. Pilots Shaw and Woolrich missing.
28th August 1942	Sgt. Pilot Shaw, whose body was recovered from the sea, was buried at Carew Cheriton (152 Squadron).
3rd November 1942	Lockheed AN. 646 (No. 407 Squadron) crashed at KIlpaison, near Angle at 1710 hours whilst engaged on practice bombing in Angle Bay. Aircraft caught fire and was burnt out.
21st December 1942	Body of Pilot Officer J. Doucha (117613) recovered from sea at Freshwater West, Angle. It was ascertained that his parent Unit was No. 310 (Czech) Squadron. Medical Officer estimated body had been in sea at least 3 or 4 weeks.
5th January 1943	A U.S. Army Air Force Liberator forced landed here during bad weather en route from Gibraltar to Portreath. It proceeded to Portreath on 6th January 1943.
25th April 1943	About 1930 hours it was reported that bodies were being washed up by the sea in Freshwater Bay. 12 bodies of Royal Naval and Royal Marine personnel were recovered. From early 26th April until 12.00 hours a further 11 bodies were recovered. An officer and a Sergeant of the Royal Marines saved themselves by climbing the rocks during the early morning of 26th April. The circumstances of the accident or accidents are not known but it is believed that Tank Landing or Assault Craft were capsized by very heavy seas, which were running on 25th April and 26th April during a gale. The 23 bodies were transferred to the Royal Naval Depot, Milford Haven on 26th April.

16.4. Deductions

The likelihood of encountering historic Allied ordnance, such as Land Service Ammunition (LSA) and Small Arms Ammunition (SAA) is considered to be elevated within parts of the study area on and surrounding the former premises of RAF Angle. This is because of the presence of a number of features associated with ordnance usage and disposal, such as ranges, ammunition stores and dispersal pans and the potential for poor housekeeping, whereby items of ordnance were buried, burnt or otherwise disposed of unrecorded. This criteria is considered to apply to any land within and immediately surrounding any of the external accommodation areas depicted on RAF site plans, which are situated off what is now the B4320.

17. Coastal Defences

17.1. General

Prior to and during the early stages of WWII, defensive positions were established along the British coastline in order to delay or prevent the threat of invasion. This network was known as the 'coastal crust' and comprised a vast network of hundreds of pillboxes, constructed across vulnerable points, as well as a mixture of defensive features including coastal batteries, pipe mines, machine gun turrets, anti-tank guns and barbed wire. The 'coastal crust' was devised in conjunction with the General Headquarters Line (GHQ Line) defensive line and was then subdivided into a network of Command Lines and Corps Lines, designed to protect specific geographical areas or directional approaches.

In comparison, the Irish coastline was largely unprotected. This was due to the country's neutrality during the war, and location beyond Britain's own defences. Nevertheless, Ireland maintained an observation service to ensure the country was alert in case of invasion.

17.2. Defence of Pembrokeshire

The Defence of Britain Project database was accessed during the production of this report; this database records the '20th century militarised landscape of the United Kingdom' and is based on field and documentary work undertaken in the late 20th century. This records numerous defensive positions within and surrounding the east end of the study area in Wales.

In general, defensive positions can be split into two categories – anti-invasion and anti-aircraft. These will be discussed in the following subsections, alongside a summary of the relevant positions recorded on site. The locations of these positions are annotated on WWII-era RAF aerial photography, see **Annexes N and O**.

17.2.1. Anti-Invasion Defences

Anti-invasion lines were intended to slow the advance of enemy troops in case of land invasion. In most cases these were static and therefore were not employed during the war period, though defensive positions could be armed if associated with military training or related activity in the wider area.

Anti-Invasion Defences	
Type of Installation	**Summary**
Pillbox	Concrete dug-in guard post, normally equipped with loopholes through which to fire weapons. As a result, LSA/SAA was often stored in this fortification. Present in both WWI and WWII. One pillbox is recorded on site in the Carters Green area, near the former location of RAF Angle.

Observation Posts	Fixed position from which soldiers can watch enemy movements, to warn of approaching soldiers (such as in trench warfare) or to direct artillery fire. Three observation posts are recorded on site on the Welsh coastline, >1.7km west of Freshwater West beach, near the former location of RAF Angle.
Weapon Pits	Potential location of explosive ordnance storage or disposal, likely associated with other defensive positions located nearby. Three weapon pits are recorded on site. Two of these are plotted on the Welsh coastline approximately 1.7km west of Freshwater West beach, neighbouring the plotted location of an observation post. Another is recorded at the north of Freshwater West beach (Gravel Bay).

17.2.2. Anti-Aircraft Artillery (AAA)

Anti-aircraft guns were installed on the coastline to deter enemy aircraft from carrying out bombing raids inland on valuable targets. During WWII three main types of gun sites existed: heavy anti-aircraft (HAA), light anti-aircraft (LAA) and 'Z' batteries (ZAA). If the projectiles and rockets fired from these guns failed to explode or strike an aircraft, they would descend back to land.

Anti-Aircraft Artillery	
Type of Installation	**Summary**
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, usually initiated by integral fuzes which triggered by impact, area, time delay or a combination of aforementioned mechanisms. Two HAA batteries are recorded on site – one at Whetstone Hill near what is now the B4319 roadway, and another at Bangeston, near the former location of RAF Angle.
LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. Two of the weapon pits recorded on site (as referenced in the previous subsection) are stated to have been associated with Lewis LAA guns dug into the 'eastern rampart of Pickard Bay Iron-age promontory fort'. It is conceivable that additional LAA emplacements, such as portable 40mm Bofors guns, were employed in the defence of RAF Angle and were situated within this section of the study area.
Machine gun posts	These posts were established at some significant military and industrial positions. Machine guns rounds were a largely ineffective form of AAA (Anti-Aircraft Ammunition). Machine guns usually fired the .303 round. One machine gun emplacement is recorded on site at The Warren, Carters Green, Angle. This is stated to have included ammunition recesses, later infilled.

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Annex P**.

17.3. Defence of County Wexford

Under the Marine and Coastwatching Service (established 1939), a network of 83 Look Out Posts (LOPs) were built around the coast of Ireland and manned by members of the Local Defence Forces (LDF) between 1939-1945. The Coastwatchers were responsible for identifying and reporting on shipping and aircraft movements and also on any communications between ships and the shore.

Records held by the Defence Forces Ireland Military Archives confirm that a LOP was located near the western end of the study area, at Hook Head. The logbook for this LOP is currently only possible to view digitally covering the period 1st July to 1st October 1940 and could not be obtained in full during the production of this report. However, no references could be found within this document to defensive features or any other military presence within this section of the study area.

17.4. Deductions

It is likely that the defensive positions on and surrounding the east end of the study area, on the Welsh mainland, were manned for at least a period of the war and may have been maintained by the Home Guard. This suggests that SAA and LSA would have been stored in these areas and highlights the potential for contamination to have resulted at key points, especially when the threat of invasion rescinded and weaponry was no longer required and would have needed disposal. This is particularly prevalent due to the proximity of RAF Angle, which may have led to the transport of explosive ordnance from the airfield to defensive positions located across the area.

No evidence could be found to suggest that any defensive positions were established on or surrounding the Irish coastline in the west end of the study area during WWII.

18. Aerial Delivered Iron Bombs

18.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. However, the limited range and capability of such aircraft during this period meant that targets within Wales and Ireland were generally too far to be viably considered by the German military. No evidence could be found to suggest that Pembrokeshire was ever subject to German aerial delivered bombing or was the location of any aerial engagements in WWI.

18.2. World War II

18.2.1. Britain

The Luftwaffe's main objective for the attacks on Britain was to inhibit the country's economic and military capability. To achieve this they targeted airfields, depots, docks, warehouses, wharves, railway lines, factories, and power stations. As the war progressed the Luftwaffe bombing campaign expanded to include the indiscriminate bombing of civilian areas in an attempt to subvert public morale. Wales, alongside large parts of the west of Britain, was not considered to be within the range of Luftwaffe bombers at the start of WWII. This estimation changed following the German invasion of France and the Luftwaffe's acquisition of new airfields, in much greater proximity to Great Britain.

During WWII the easternmost section of the study area was situated within the Rural District of Pembroke, which sustained a very low density of bombing. It is anticipated that the area was not expressly targeted by the Luftwaffe on account of its isolated position, away from most flightpaths used to attack major cities, and its relatively rural nature. Though RAF Angle may have formed a potential target within the region it is considered likely that the majority of bombs recorded were the by-products of raids on Pembroke Dock, situated approximately 8km north-east. Pembroke Dock, see Luftwaffe Reconnaissance Photography in **Annex Q**, was of significance because it contained a number of military installations, including the naval dockyard, Llanion Barracks and RAF Pembroke Dock. The town subsequently suffered regular night attacks between 1940 and 1941, with the raid on the Llanreath naval oil depot in August 1940 widely reported to have created extensive damage and a blaze that lasted for 18 days.

18.2.2. Ireland

The Republic of Ireland was officially neutral during WWII and it is commonly held that the state was never intently bombed by the Luftwaffe. Nevertheless Ireland did sustain several isolated air raids, mostly due to navigational errors or mistaken targets; including raids on Dublin in January and May

1941. One such raid is recorded to have taken place within County Wexford, when five bombs were dropped at the village of Campile, approximately 13km north of the western end of the study area. However, no other air raids are documented within this section of the Irish mainland.

18.2.3. Offshore

In contrast any records concerning Luftwaffe activity over British and Irish waters are much more limited. This is because of restrictions in observation and the fact that very few permanent industrial or military targets of significance were situated offshore; though it was not uncommon for Luftwaffe pilots to target both merchant and naval shipping with aerial bombardment. Is also possible that bombs could have been aerially deployed within the waters surrounding the UK because of aerial engagements between Axis and Allied pilots, as well as the deliberate dumping of munitions by pilots attempting to return home.

18.3. WWII Home Office Bombing Statistics

The following table summarises the quantity of German aerial delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on the Rural District of Pembroke between 1940 and 1945. Note this record is not believed to cover any offshore areas.

Record of German Ordnance Dropped on the Rural District of Pembroke		
Area Acreage		**48,860**
Weapons	High Explosive bombs (all types)	165
	Parachute mines	10
	Oil bombs	0
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	0
	Long range rocket bombs (V-2)	0
Total		**175**
Number of Items per 1,000 acres		**3.6**

Source: Home Office Statistics
This table does not include UXO found during or after WWII.

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record. Although the risk relating to incendiary bombs (IB's) is lesser than that relating to larger high explosive bombs (HE's), they were similarly designed to inflict damage and injury. Anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous. Although Home Office statistics were not recorded, both types of item should not be overlooked when assessing the general risk to personnel and equipment.

Examples of German Air-Delivered Ordnance are presented in **Annex R**.

18.4. Written Incident Records

Written records of bombing incidents in Britain, detailing the calibre of a bomb strike, the number of any injuries and fatalities and the extent of any damage caused were often compiled by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as the port authorities and railways, maintained separate records. These records were often analysed to identify more information about German bombing strategies and bomb types, as well as to predict where future raids might take place.

18.4.1. RAF Log Books

Operation log books for RAF Angle were reviewed in relation to any information concerning aerial bombing within and surrounding the St Georges Channel. This record set is not believed to provide a comprehensive account of Luftwaffe activity in the region but does reference 'enemy air activity' during the nights of the 6th- 8th June 1942. On all three of these occasions bombs are believed to have been dropped in the region, though not in the vicinity of the station. These descriptions also refer to possible minelaying within Milford Haven.

18.4.2. Pembrokeshire Air Raid Precautions Records

No comprehensive set of written ARP records could be obtained for the Rural District of Pembrokeshire during the production of this report. A series of major incident files for this district, collated by the Mistry of Home Security, were reviewed at the National Archives but no reference could be found to Freshwater West or its surrounding area.

18.4.3. Irish Coastal Log Books

As previously referenced in Section 17.3, a portion of a logbook was obtained for the LOP (look out post) located at Hook Head, within the west of the study area. This covers the period 1st July 1940 to 1st October 1940. One entry was found within this document to a German bombing raid in County Wexford, Ireland; a scan of which can be viewed in **Annex S**. This states that on 26th August 1940 'explosions (were) heard 12 miles north of LOP. Informed… that they (sic) were bombs dropped from the passing aircraft'. A note is also given that the location of the incident was Campile, approximately 13km north of the western end of the study area, as is consistent with anecdotal information. No other references are present within this document to bombing raids in the region.

As previously noted, the remainder of this record set is not yet available digitally and was not possible to review within the time of the production of this report.

18.5. Bombing Decoy Sites

The decoy principal – drawing German bombers away from their designated targets onto dummy sites five or six miles away – began in WWI to protect RAF stations. In 1939 a new department was set up to investigate and coordinate the concept of defence by deception. A whole range of decoy sites were developed – some of them became very elaborate and covered large areas.

Common WWII Decoy Site Variants	
Decoy Type	**Description**
K-site	Daytime dummy airfield. Dummy aircraft and infrastructure.
Q-site	Night time dummy airfield. Intended to represent the working lights of an airfield after dark.
QL	Night time dummy infrastructure. Replicating the lights and workings of marshalling yards, naval installations, armament factories etc.
QF	Fire based decoy. Initially for aircraft factories, RAF maintenance units and ordnance works to simulate them on fire following bombing.
Oil QF	Simulation of burning oil tanks.
Starfish	Replicating a city under incendiary attack.

By June 1944, decoy sites had been attacked on 730 occasions. Attacks ranged from a single night-time bomber dropping its load onto a "Q" site, to the mass attacks on Starfish sites. In diverting the high explosives and incendiaries from the intended targets they were undoubtedly responsible for saving the lives of thousands of people.

Works planned in the vicinity of WWII decoy sites can be at an elevated risk from UXBs as the facilities were specifically designed to be bombed. It was not uncommon for evidence of UXBs at a decoy site to be overlooked following a raid. Given that the sites were on open ground, sometimes agricultural fields, UXB entry holes were not always evident.

Records indicate that several WWII-era bombing decoy sites were present in the general proximity of the easternmost section of the study area, on the Welsh mainland. N-Series naval decoy sites for Milford Haven are recorded at Sawdern Farm and East Popton Farm, situated approximately 1.5km and 3km north-east respectively; as well as across the waterway at South Hook Farm, Herbrandston Farm and Sandy Haven Farm to the north. Decoy site mapping, presented in **Annex T**, also labels these sites as Starfish and QF (fire based) decoys.

18.6. Abandoned Bombs

A post air-raid survey of buildings, facilities, and installations would have included a search for evidence of bomb entry holes. If evidence of an entry hole was encountered, Bomb Disposal Officer Teams would normally have been requested to attempt to locate, render safe, and dispose of the bomb. Occasionally, evidence of UXBs was discovered but due to a relatively benign position, access problems, or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an ‘abandoned bomb’.

Given the inaccuracy of WWII records and the fact that these bombs were ‘abandoned’, their locations cannot be considered definitive or the lists exhaustive. The MoD states that ‘action to make the devices safe would be taken only if it was thought they were unstable’. It should be noted that other than the ‘officially’ abandoned bombs, there will inevitably be UXBs that were never recorded.

1st Line Defence holds no records of officially registered abandoned bombs at or near the site of the proposed works.

18.7. Inland Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment is currently facing considerable delay. It has therefore not been possible to include any updated official information regarding bomb disposal tasks with regards to this site. A database of known disposal tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date Intertek will be advised.

Bomb Disposal Tasks (From 33 Engineer Regiment)	1st Line Defence could find no official evidence of bomb disposal tasks within the site boundary or immediate area.

18.8. Deductions

The easternmost section of the study area was situated within an area of Wales that sustained a very low density of bombing throughout the war, especially when compared to the major cities within the south-east of the country, such as Cardiff or Swansea. Bombing within the rural areas of Pembrokeshire were generally isolated incidents and the result of Luftwaffe bombers travelling to and from more significant targets within the wider region. This infrequency of incidents, combined with the nearby presence of RAF Angle, increases the probability that any bomb strikes within the Freshwater West area would have been recorded and any signs of UXO investigated. It is not possible however to completely discount the possibility of such incidents going unnoticed because of the open, rural nature of the groundcover of Freshwater West and its surrounds.

Likewise it is not anticipated that a significant number of aerial bombs were deployed within the St Georges Channel, though several attacks on merchant shipping are recorded within more central areas in 1940 and 1941. Any bombs falling during such raids are not likely to have been well observed or investigated and thus the possibility that aerially delivered UXO may be present within offshore areas also cannot be discounted, though the likelihood is again not considered to be high.

The risk from items of air delivered UXO within the westernmost section of the study area, within the Irish mainland, is considered to be negligible. The Republic of Ireland was never subject to a targeted bombing campaign during WWII and was only subject to accidental bombings by the Luftwaffe on a handful of isolated occasions. These incidents are relatively well documented with the closest occurring at Campile, approximately 13km north of this section of the study area.

19. Munitions Encounters in the St Georges Channel

19.1. OSPAR Commission Data

The OSPAR Commission has been collecting data on offshore encounters with munitions since 1999 and has compiled an extensive database of such incidents off the UK coast and in the North Sea. A total of 1879 encounters were reported by Belgium, France, Germany, Ireland, the Netherlands, Spain, Sweden and the UK. Of the 1879 munitions encounters reported, 1595 (85%) were described as conventional, 30 (2%) as chemical and 254 (14%) were of unknown type. In this report, phosphorus devices are taken to be conventional munitions. The devices encountered on 786 occasions (42%) were reported to be in various stages of corrosion, from partly to completely corroded, 14 (1%) were described as being live or in good condition and the state of the remainder were unknown or not reported.

An overlay depicting the approximate location of offshore munition encounters (reported by fishermen and other users of the sea and its coastline), as recorded by OSPAR since 2004, is presented in **Annex U**. This covers the OSPAR maritime area, including the 'Celtic Seas', which encompasses the St George's Channel and therefore the proposed site. Due to the nature of its compilation, this record should not be considered to be comprehensive.

One offshore munition encounter is indicated directly within the study area at the location of Freshwater West Beach, with six additional munition encounters denoted to the north of this location, within the Milford Haven Waterway. The munitions found are all of the conventional type. Data related to these encounters is transcribed below.

OSPAR Encounters with Dumped Conventional Munitions							
Ref	**Lat/Long**	**Distance**	**Nature of find**	**Date**	**Action taken**	**State of munitions**	**Remarks**
5678.0	51.6519 - 5.0522	On site	Found on shore	Jul 25, 2014	Destroyed	Heavily corroded	JSEODU destroyed object at 261235UTC
5650.0	51.6847 - 5.1516	>2.7km	Found on shore	Feb 15, 2014	Disposed of on land	Heavily corroded	None
5654.0	51.7011 - 5.0511	>2.9km	Found on shore	Mar 1, 2014	Destroyed	Partly corroded	None
2644.0	51.6982 - 5.1189	>3.5km	Other	Oct 23, 2009	Destroyed	Unknown	Located and destroyed by Royal Navy on

							routine survey duties
2731.0	51.71 - 5.0583	>3.8km	Found on shore	Jan 17, 2011	Destroyed	Unknown	Gas bottle to safe storage @ Pembrokeshire Yacht club by FRS. County Council wiil collect
721.0	51.704333 - 5.138167	>4.5km	Other	Jul 26, 2005	Destroyed	Heavily corroded	None
637.0	51.68 - 4.95	>6.6km	Found on shore	Apr 2, 2005	Disposed of on land	Heavily corroded	Found on farmland at Wrangle. Land was reclaimed from sea in 70s. Land was tilled to a fair depth to harvest potatoes. Land used to be a coastal artillery range.

19.2. UXO Clearance / EOC Tasks

1st Line Defence holds a database of historic EOC (Explosive Ordnance Clearance) tasks carried across Great Britain by 33 EOD Regiment. This is understood to not be comprehensive. Three EOC tasks are recorded within the east of the study area, on Freshwater West beach. Data related to these tasks is transcribed below.

EOC Tasks on Site				
DBID	**Lat/Long**	**Date**	**UXO live/exploded**	**Notes given**
EOC 2328	51.649906158, -5.0615592003	Jan 31st, 2000	None stated	WWII coastal defences reappearing (barbed wire). Area mined during WWII.
EOC 2488	51.650299072, -5.0616288185	July 10th, 2001	None stated	Dump of wartime barbed wire to be removed by Princes Trust Volunteers; minefields in vicinity.
EOC 4536	51.651721954, -5.0636048317	July 18th, 2001	None stated	None

In addition to these, over 75 EOC tasks are recorded in the 'Danger Area' of Castlemartin range. This includes four tasks in the 'naval aviation bombing range' area adjacent to the study area to the south. Data related to the tasks in this area is transcribed below.

EOC Tasks in Castlemartin Range 'Danger Area'				
DBID	**Lat/Long**	**Date**	**UXO live/exploded**	**Notes given**
EOC 3544	51.641151428, -5.052295208	July 3rd to April 27th 1989	120/1363	At RAC Range, Castlemartin.
EOC 3546	51.636627197, -5.053437233	January 21st to February 1st 1991	19/61	At RAC Range, Castlemartin.

EOC 3552l	51.639583588, -5.0435171127	January 3rd to April 29th 1996	115/242	At RAC Range, Castlemartin.
EOC 4620a	51.635448456, -5.0468530655	July 7th to August 22nd 1997	74/4976	At RAC Range, Castlemartin.

19.3. Media Reports

Three media reports have been identified relating to naval mine finds in the Milford Haven waterway area, located north of the study area. One of these is 'thought to have been a WWII-era Mark XIX anti-ship mine' according to a spokesman for the coastguard. In addition, a report in 2014 highlights that there had been a 'dramatic increase in the number of wartime bombs unearthed', largely due to storms and flooding. This resulted in double the amount of finds in the South West in comparison to the previous year. These reports are presented in **Annex E**.

19.4. Anecdotal Accounts

Anecdotal evidence has however been provided by the client to suggest that a bomb was discovered and detonated by the EOD within Milford Haven Waterway, to the north of the study site, in recent years. No further information regarding the location and nature of this bomb find was provided.

19.5. Deductions

The documented munition encounter on Freshwater West Beach, as well as several additional encounters across Milford Haven Waterway, could be attributed to the presence of several significant nearby historic military features, such as Pembroke Dock, RAF Angle and RAC Castlemartin Range. These encounters demonstrate the potential for other such items to be present within the region.

20. 1st Line Defence Risk Assessment

20.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk from unexploded ordnance is based on the following five considerations:

1. That the study area was contaminated with unexploded ordnance.
2. That unexploded ordnance remains within the study area.
3. That such items will be encountered during the proposed works.
4. That ordnance may be initiated by the works operations.
5. The consequences of encountering or initiating ordnance.

20.2. The Risk that the Site was contaminated with UXO

After considering the following facts, 1st Line Defence believes that there is a risk that the location of the study area may have been contaminated with UXO:

- The Castlemartin training area, a 6,000 acre former and current military range, with a danger area extending up to 14 miles, is situated within the immediate surroundings of the easternmost section of the proposed Greenlink route. Predominantly used by the RAC (Royal Armoured Corps) as a tank range, the Castlemartin area has been used extensively by both British and West German armed forces since its requisition in 1938. Its usage is also recorded to include infantry training, such as small arms training and naval aerial bombing, which is indicated to have taken place within an area immediately bordering Freshwater West Beach.
- The presence of Castlemartin range significantly increases the likelihood that items of Allied ordnance could have been expended, through training exercises, or discarded, through poor housekeeping within the easternmost section of the study area. This includes the section at Freshwater West Beach and the surrounding offshore danger area. Such items will include LSA and SAA but may also include larger, aerially delivered bombs, due to the presence of an air to land training. EOC tasks undertaken within Castlemartin range in the 1980's and 1990's are documented to have recovered thousands of expended items of ordnance and hundreds of live items.
- The island of Grassholm, approximately 7km to the north, is also recorded as a training range during WWII and was used by the USAF (Unites States Air Force) for target practice. The presence of the former Grassholm range is considered to have had less of an impact than Castlemartin though US aerially deployed ordnance, such as practice bombs, deployed in its surroundings waters could have migrated within the study area.
- An extensive British mine area, believed to comprise over 6,000 mines and several significant minefields, was laid in the St George's Channel in 1940 to protect naval and merchant shipping in the Irish Sea from German U-boat attacks. Historical mine mapping of UK waters shows the former location of this mine area to include a significant portion of the western/Irish side of the study area. References to several smaller minefields, including a WWI-era German minefield and two WWII-era German minefields have been found on and in the general proximity of the eastern/Welsh side of the study area. These appear to have been deployed to restrict British naval activity originating from important military sites at Milford Haven and Pembroke Dock.
- A precise assessment of the current risk from mines within the St Georges Channel is difficult to ascertain. Efforts were made by the Royal Navy at the end of the war to clear/make safe mined areas. However, such clearance tasks are not considered to guarantee the complete

removal of all mines within a danger area, especially if such items have the potential to migrate or became covered due to sediment and tidal action over a period of time. It is therefore not possible to discount the possibility of encountering surface or submarine laid sea mines across any location of the study area.

- A number of listed historic wrecks have been identified on and around the study area. The majority of these wrecks are situated within shallower waters, off the coastlines of both Ireland and Wales, and often demonstrate the presence of both sea mines and torpedoes during WWI and WWII. The majority of these wrecks are also British cargo ships, though military vessels are recorded within the area during both world wars, including an unnamed German warship in 1917, the German submarine UC-44 in 1917, the British warship HMS Arbutus in 1917 and the British warship HMS Minicoy in 1941. Such vessels are anticipated to have carried items of ordnance at the time of their loss and, if not recovered, could have contaminated their immediate surroundings.

- Torpedoes and anti-submarine weaponry were commonly deployed in the waters around Britain on account of German U-Boat activity during both world wars. The Irish Sea, including the St George's Channel was particularly affected by U-boats during WWI due to the high volume of merchant shipping travelling to and from important docks such as Liverpool and the Clyde from the south-west approaches, leading the region to be subsequently dubbed 'U-Boat alley'. Anti-submarine weapons, most commonly depth charges, were deployed by Royal Navy vessels to combat this threat, with Hedgehog and Squid spigot mortars put into operation from 1942. Although generally deployed in low numbers when compared to other types of munitions, it is not possible to discount the presence of such items at the site location, due to their recorded usage in the wider area.

- Three munitions dumps are recorded within the wider surrounding area, off the Pembrokeshire coastline. These are believed to have operated in conjunction with surrounding military sites and to have been used in the immediate post period. These dumps are not anticipated to pose a significant risk to the study area, unless its location is altered and situated on or in their immediate proximity. It is also possible that dumped munitions may have either been deposited outside the designated areas or have else migrated within the region over time.

- The likelihood of encountering historic Allied ordnance, such as Land Service Ammunition (LSA) and Small Arms Ammunition (SAA) is considered to be elevated within the sections of the study area on and surrounding the former premises of RAF Angle or any coastal defences. This is because of the presence of a number of features associated with ordnance usage and disposal, such as pillboxes, ranges and ammunition stores and the potential for poor housekeeping, whereby items of ordnance were buried, burnt or otherwise disposed of unrecorded. EOC reconnaissance tasks undertaken in 2000 and 2001 also refer to 'WWII-era coastal defences (barbed wire) reappearing' on Freshwater West Beach and suggest that the area was mined during the war.

- The easternmost section of the study area was situated within an area of Wales that sustained a very low density of bombing throughout the war. Bombing within the rural areas of Pembrokeshire were generally isolated incidents and the result of Luftwaffe bombers travelling to and from more significant targets within the wider region. This infrequency of incidents, combined with the nearby presence of RAF Angle, increases the probability that any bomb strikes within the Freshwater West area would have been recorded and any signs of UXO investigated. It is not possible however to completely discount the possibility of such incidents going unnoticed because of the open, rural nature of the groundcover of Freshwater West and its surrounds.

- Likewise, it is not anticipated that a significant number of aerial bombs were deployed within the St Georges Channel, though several attacks on merchant shipping are recorded within more central areas in 1940 and 1941. Any bombs falling during such raids are not likely to have been well observed or investigated and thus the possibility that aerially delivered UXO may be present within offshore areas also cannot be discounted, though again the likelihood is not considered to be high.

- The risk from items of air delivered UXO within the westernmost section of the site, within the Irish mainland, is considered to be negligible. The Republic of Ireland was never subject to a targeted bombing campaign during WWII and instead only sustained bombing by the Luftwaffe on a handful of isolated occasions, none of which are recorded within the study area.
- Based on these findings it has only been possible to confidently reduce the risk from UXO within the section of the study area situated in the Irish mainland, on the Hook Head peninsula. There is a potential risk of encountering UXO across the remainder of the site location, which is significantly elevated on and surrounding the eastern end at Freshwater West, due to the presence of the Castlemartin Training Area and the former RAF Angle.

20.3. The Risk that UXO Remains

One of the main activities which can reduce the risk of encountering UXO in the marine environment is dredging. For instance, regular dredging can lower the risk of encountering smaller items of ordnance, such as projectiles. However, no evidence could be found during the production of this report to suggest that any significant or regular dredging operations have occurred in the study area, increasing the likelihood of UXO remaining in situ.

Generally, UXO in the marine environment will not have a great penetration capability into the seabed. However, heavier items such as iron bombs can settle into soft sediment or mud and on occasions become completely buried and thus remain in situ. (This penetration depth will vary based on the depth of water and geotechnical properties present.) The composition of offshore geology is understood to vary considerably across the study area and will likely include superficial deposits of a soft nature. At such locations there is a potential risk that UXO could be buried or partially beneath the seabed which would require further investigation/consideration.

As well as the risk from ordnance remaining in-situ there is also a possibility that ordnance may have migrated within the works area. As physical processes, such as currents and tidal action can result in UXO being moved significant distances from their point of origin.

20.4. The Risk that UXO may be Encountered during the Works

The probability of encountering items of UXO is based both on the composition of the site, i.e. its history and physical environment and the type of project works undertaken. These factors are addressed in turn below:

20.4.1. Historical Context

1st Line Defence has identified several potential historical sources of UXO contamination within the proposed Greenlink route. There is a residual risk from torpedoes, anti-submarine weapons, mines, air-delivered bombs and from munitions associated with military related wrecks / dump sites within the offshore environment. A more significant risk from Allied Land Service Ammunition (LSA) of various age and calibre has been identified in the area surrounding Freshwater West. This site history will also affect the prospective distribution and positions of items of UXO, as well as its initiation failure rates.

20.4.2. Physical Environment

Physical environmental factors affecting UXO encounter will include the bathymetry and depth of water present, the seabed geology and the impact of physical processes, such as storm surges and tidal currents, which may cause UXO uncovering, burial and migration.

20.4.3. Type of Project Works

Given the nature of the proposed works, there is a risk that UXO may be encountered during intrusive activities during both the initial survey campaign and the subsequent cable installation. Intrusive works within the marine survey includes geotechnical sampling, consisting of vibrocore and cone penetration tests and seabed sampling, consisting of environmental grabs. Trial pits and boreholes are proposed within the landfall survey.

Intrusive activities during the subsequent cable installation include the usage of pre-lay grapnel runs and removal ploughs to clear boulders and debris; as well as the use of cable trenching equipment to install cabling into the seabed. During such operations the risk to the vessel and to operatives will depend on factors such as the distance behind the vessel that the equipment and cabling will be towed. There is also a small potential for smaller items of UXO to be caught up on equipment which comes into contact with the seabed and brought on board the vessel.

20.5. The Risk that UXO may be Initiated

The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. Most unexploded munitions do not become less dangerous with age and could still function as designed if disturbed. Furthermore, it is possible that seawater may have degraded certain types of munition over time leaving them in a more sensitive state.

Unexploded munitions do not spontaneously explode. All high explosive requires significant energy to create the conditions for detonation to occur. In the case of unexploded munitions discovered within the marine environment, there are a number of potential initiation mechanisms:

- Direct impact onto the main body of the weapon

  Unless the fuze or fuze pocket is struck, there needs to be a significant impact e.g. from piling or large and violent mechanical excavation, to initiate an item of ordnance such as an iron bomb. Such violent action can cause the bomb to detonate.

- Re-starting the clock timer in the fuze

  A small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion would have taken place within the fuze mechanism over the last 60 years that would prevent clockwork mechanisms from functioning, but the possibility cannot be discounted.

- Friction impact initiating the shock-sensitive fuze explosive

  This is the most likely scenario resulting in the weapon detonating. The combined effects of seasonal changes in temperature and general degradation over time can cause explosive compounds to crystallise and extrude out from the main body of the bomb. It may only require a limited amount of energy to initiate the extruded explosive which could detonate the main charge.

- It is considered unlikely that magnetic or acoustic sea WWI and WWII-era mines would function as originally designed, due to failures in their power supply, however there have been reports of such mines brought up in fishing nets detonating in recent history – possibly as a result of mishandling. In principle, WWI and WWII contact mines could still be initiated through impact with chemical horns. If the firing circuit was intact the release of electrolyte could theoretically activate the battery and detonate the mine.

- In cases where multiple items of UXO are situated in close proximity, there is also the potential for the initiation of one item to initiate others through a process known as sympathetic detonation.

In summary the risk of initiation is dependent on what part of the UXO is contacted and with what type and degree of force, as well as the sensitivity of the component in question. In any case an item of UXO encountered that has not been initiated should always be treated as live.

20.5.1. Initiation and the Type of Project Works

Generally more aggressive activities increase the risk of initiating items of UXO. To illustrate this effect some examples of common offshore project works are displayed in the table below.

Probability	Factors	Example
Very Low	Benign Activities	Non-intrusive geophysical surveys, eg side scan sonar and magnetometry.
Low	Relatively Benign Activities	Vibrocore Sampling
Medium	Relatively Aggressive Activities	Jack up barge installation, including the application of loads to each leg.
High	Aggressive Activities	Cable ploughing under load
Very High	Very Aggressive Activities	Pile driving from a jack up barge.

20.6. The Consequences of Encountering or Initiating UXO

When considering the potential consequences of a detonation, it is necessary to identify the significant receptors that may be affected. The receptors that may potentially be at risk from UXO detonating offshore might include but are not limited to the following summarised below:

- People – death or injury of vessel operatives, divers, nearby public etc.
- Equipment – damage to vessels, ploughs, anchors etc.
- Natural Environment – death or injury to marine fauna (fish/marine mammals) and habitats.
- Historic Environment – damage or destruction of listed buildings, wrecks and landscapes

The initiation of a small item of ordnance such as a small calibre projectile at depth during intrusive works may result in damage to plant and potentially injury of personnel. However, the initiation of a larger weapon such as a high explosive bomb or sea mine during works could have severe consequences in terms of both damage and loss of life and limb.

If an item of ordnance is accidentally brought on board without it being noticed, even a small projectile or item of Land Service Ammunition can pose a significant risk to vessel operatives.

20.7. Assessed Risk Level

Taking into consideration the findings of this study, 1st Line Defence does not consider the risk from UXO to be homogenous across the study area. Different sections have been assessed as at varying levels of risk, originating from different ordnance types. An assessment of risk across the Greenlink route has therefore been divided into the following four areas, which are outlined in **Appendix i**.

Section 1: The Irish Mainland

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
Air Delivered Bombs		✓		

<table>
<tr><td>Anti-Aircraft Artillery Projectiles</td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>Allied Military Land Service Ammunition (Grenades, Mortars etc.)</td><td></td><td>✓</td><td></td><td></td></tr>
</table>

Section 2: West and Central Offshore Area

<table>
<tr><th rowspan="2">Ordnance Type</th><th colspan="4">Risk Level</th></tr>
<tr><th>Negligible</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Air Delivered Bombs</td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>British Sea Mines</td><td></td><td></td><td colspan="2">✓</td></tr>
<tr><td>German Sea Mines</td><td></td><td colspan="2">✓</td><td></td></tr>
<tr><td>Allied Military Land Service Ammunition (Grenades, Mortars etc.)</td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>Torpedoes</td><td></td><td colspan="2">✓</td><td></td></tr>
<tr><td>Anti- Submarine Weapons</td><td></td><td colspan="2">✓</td><td></td></tr>
<tr><td>UXO from Wrecks/Crashed Aircraft</td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>Munitions Dumpsites</td><td></td><td>✓</td><td></td><td></td></tr>
</table>

Section 3: Eastern Offshore Area (including the Castlemartin Danger Area)

<table>
<tr><th rowspan="2">Ordnance Type</th><th colspan="4">Risk Level</th></tr>
<tr><th>Negligible</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Air Delivered Bombs</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>British Sea Mines</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>German Sea Mines</td><td></td><td></td><td colspan="2">✓</td></tr>
<tr><td>Allied Military Land Service Ammunition (Grenades, Mortars etc.)</td><td></td><td></td><td colspan="2">✓</td></tr>
<tr><td>Torpedoes</td><td></td><td colspan="2">✓</td><td></td></tr>
<tr><td>Anti- Submarine Weapons</td><td></td><td colspan="2">✓</td><td></td></tr>
<tr><td>UXO from Wrecks/Crashed Aircraft[3]</td><td></td><td>✓</td><td></td><td></td></tr>
</table>

[3] _The risk from UXO originating from wrecks/crashed aircraft is considered to be low across the study area as a whole, as such features have been identified as few and far between. The localised risk will however be increased within the area of any military related wrecks present directly on route._

<table>
<tr><td>Munitions Dumpsites[4]</td><td></td><td colspan="2">✓</td><td></td></tr>
</table>

Section 4: The Welsh Mainland

<table>
<tr><th rowspan="2">Ordnance Type</th><th colspan="4">Risk Level</th></tr>
<tr><th>Negligible</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Air Delivered Bombs</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Anti-Aircraft Artillery Projectiles</td><td></td><td colspan="2">✓</td><td></td></tr>
<tr><td>Allied Military Land Service Ammunition (Grenades, Mortars etc.)</td><td></td><td></td><td colspan="2">✓</td></tr>
</table>

21. UXO Risk Mitigation

21.1. General

This report has concluded that there is a risk from unexploded ordnance along the proposed Greenlink route corridor. The risk has been broadly split into four different zones with slightly varying risks:

- Irish mainland – no significant risk of UXO identified.
- Western and central offshore – primary risk is from larger items of ordnance, mainly sea mines.
- Eastern offshore –risk from both larger items such as sea mines and from smaller items such as LSA and SAA. (The smallest item of LSA is anticipated to be a three pounder projectile.)
- Welsh mainland – risk from LSA, SAA and UXB's identified.

21.2. Offshore UXO Risk Mitigation

It is recommended that the proposed cable route and areas subject to intrusive investigation techniques (any time when the seabed is being affected) are subject to a UXO survey to identify targets which might be UXO related. It is understood that various survey techniques are already proposed along the survey corridor including side scan sonar and magnetometer survey. It is recommended that these surveys be designed with sufficient resolution to allow for the detection of large items of ordnance across the entire length of the route such as sea mines, bombs and torpedoes. If there is the potential for larger items to become buried due to localised sea bed conditions/sediment, then a magnetometer survey in these areas would be especially recommended. 1st Line Defence would recommend the use of Geometrics G-882 marine magnetometers used in an array. This equipment can detect an item the size of a grenade (similar to a 3 pounder projectile) at 3m (0.5 to 2 nT).

Any anomalies detected with the potential to be UXO related should be inspected as part of an ROV video survey to identify them. If they are found to be UXO related, they can either be avoided or if necessary, moved or disposed of remotely.

Smaller items such as projectiles and other items of LSA pose a lesser risk if encountered on the sea bed, and are generally too small to be detected by most survey techniques except visual. These types of items are most likely to be present in the far eastern end of the route, in the vicinity of the firing

[4] This assessed risk level is based on the current location of the study area, as depicted in the annexes of this report. If the location of the study area was to change significantly in relation to the location of recorded munition dumpsites 1st Line Defence should be contacted and this risk level reassessed.

range and munitions dumps. The main concern regarding smaller items of UXO is if they come into direct contact with personnel – for example if brought on-board on equipment deployed on the seabed, or incorporated within seabed sediment samples. For this reason, it would be prudent to have a UXO Specialist present on board to check over any equipment brought on deck and to check and identify any suspect items found within sediment samples. A UXO Specialist on-board can also review any ROV video footage undertaken to identify any potential UXO on the seabed.

21.3. Onshore/Nearshore UXO Risk Mitigation

Because no significant risk has been identified at the Irish mainland, is it not recommended that any proactive risk mitigation measures are necessary on the landward side at this end beyond UXO Safety and Awareness Briefings.

For onshore/foreshore works at the eastern end of the route, it is recommended that proactive support is provided. It is recommended that trial pits are supported by a UXO Specialist and that all proposed boreholes are subject to a magnetometer survey. All operatives should receive UXO Safety and Awareness Briefings. It may be viable to undertake a non-intrusive magnetometer survey and target investigation on the beach area for the cable trench as it goes onshore.

In making this assessment and recommending these risk mitigation measures, the proposed works outlined in the 'Scope of the Proposed Works' section were considered. Should the planned works be modified or additional intrusive engineering works be considered, 1st Line Defence should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary

1st Line Defence Limited **15th April 2019**

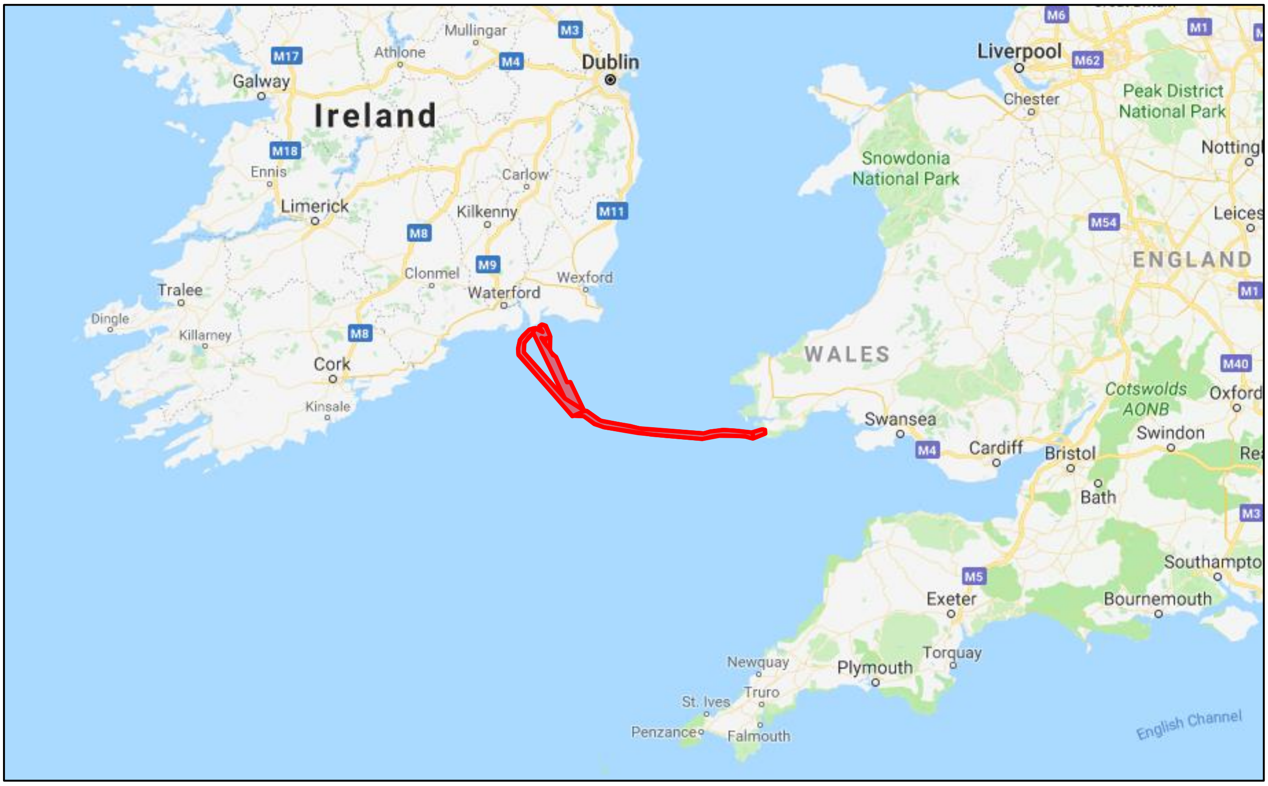
This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for the writing of Detailed UXO Risk Assessments.

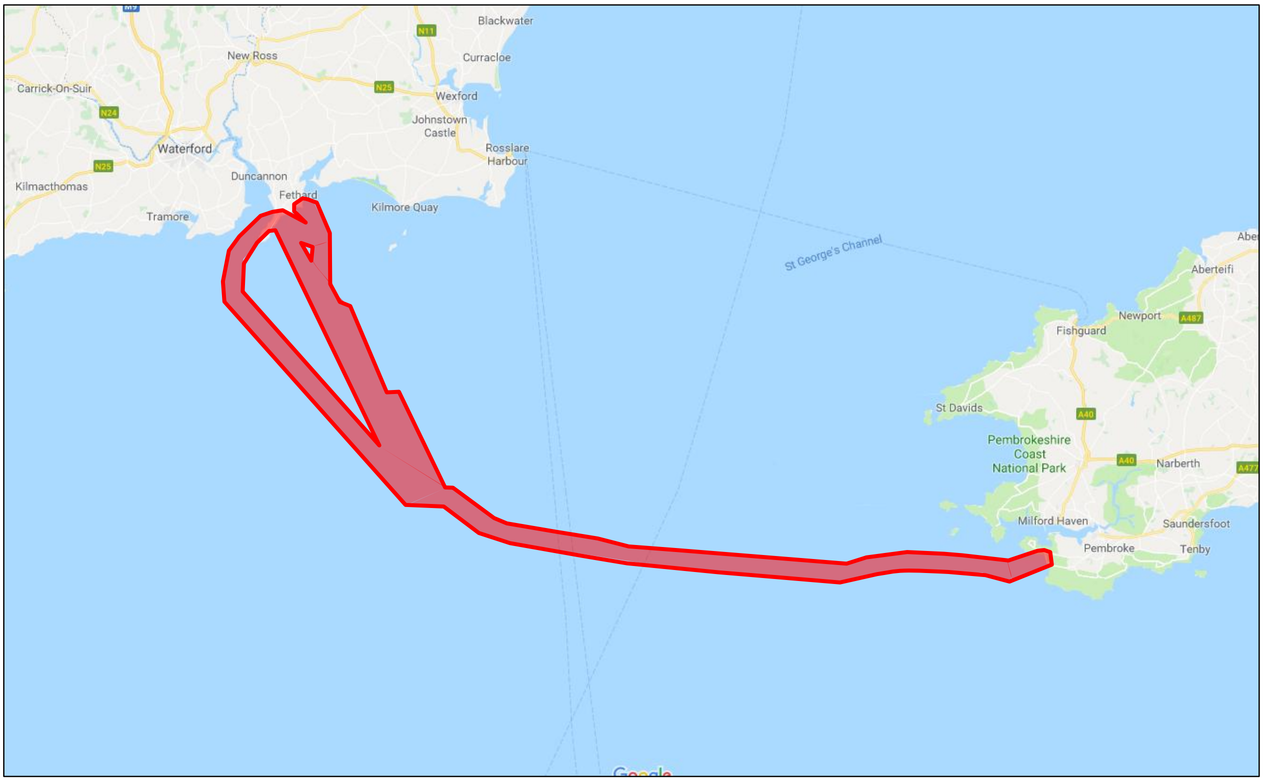
Bibliography

- Bates, H. E., *Flying Bombs over England*, Frogletts Publications Ltd., 1994
- Campbell, J., *Naval Weapons of World War Two*, Conway Maritime Press, 1985
- Clarke, N. J., *Adolf's British Holiday Snaps: Luftwaffe Aerial Reconnaissance Photographs of England, Scotland and Wales*, Fonthill Media Ltd., 2012
- Corbett, S.J., and Newbolt, H., *Naval Operations: History of the Great War,* Naval and Military Press, 2005
- Delve, K., *The Military Airfields of Britain: Wales and the West Midlands*, The Crowood Press, 2007
- Dobinson, C., *AA Command: Britain's Anti-Aircraft Defences of the Second World War*, Methuen., 2001
- Fegan, T., *The 'Baby Killers': German Air raids on Britain in the First World War*, Leo Cooper Ltd., 2002
- Fleischer, W., *German Air-Dropped Weapons to 1945,* Midland Publishing., 2004
- Friedman, N., *Naval Weapons of World War One: Guns, Torpedoes, Mines and ASW of All Nations*, Seaforth Publishing 2011
- Jappy, M. J., *Danger UXB: The Remarkable Story of the Disposal of Unexploded Bombs during the Second World War*, Channel 4 Books., 2001
- Morris, J., *German Air Raids on Britain: 1914 – 1918*, The Naval & Military Press., 1993
- Price, A., *Blitz on Britain, The Bomber Attacks on the United Kingdom 1939 – 1945*, Purnell Book Services Ltd., 1977
- Ramsey, W., *The Blitz Then and Now, Volume 1*, Battle of Britain Prints International Ltd., 1987
- Ramsey, W., *The Blitz Then and Now, Volume 2*, Battle of Britain Prints International Ltd., 1988
- Ramsey, W., *The Blitz Then and Now, Volume 3*, Battle of Britain Prints International Ltd., 1990
- Roskill, S.W, *The War at Sea 1939-1945: Volume 1, The Defensive*, The Naval and Military Press, 1954
- Scofield, J., *Modern Military Matters*., Council for British Archaeology, 2004
- Stone, K., et al., *Unexploded Ordnance (UXO) A Guide For The Construction Industry (C681)*., CIRIA, 2009
- Whiting, C., *Britain Under Fire: The Bombing of Britain's Cities 1940-1945*, Pen & Sword Books Ltd., 1999

Study Area Location Maps

Annex: **A**





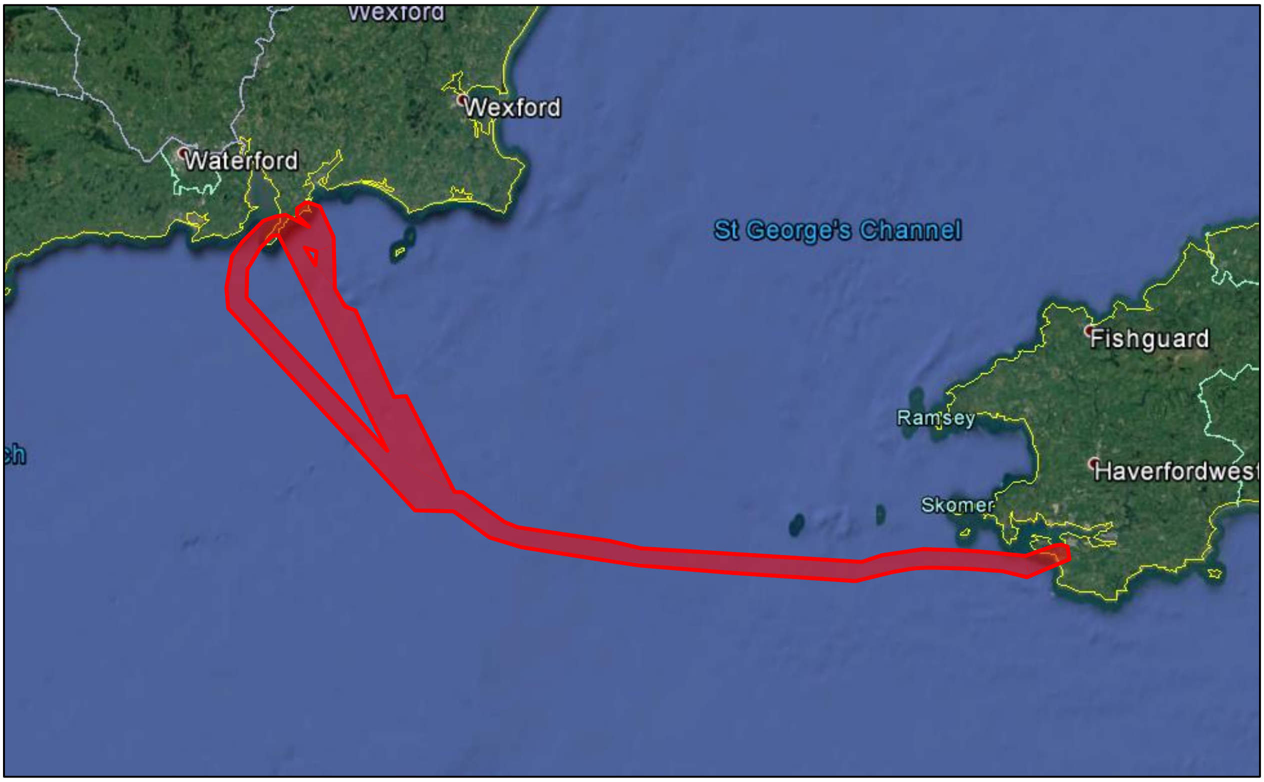
Client: **Intertek**	**Approximate study area**	N
Project: **Greenlink**		
Ref: **DA2985-01**	Source: Google Maps	

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Recent Aerial Photography

Annex: **B**



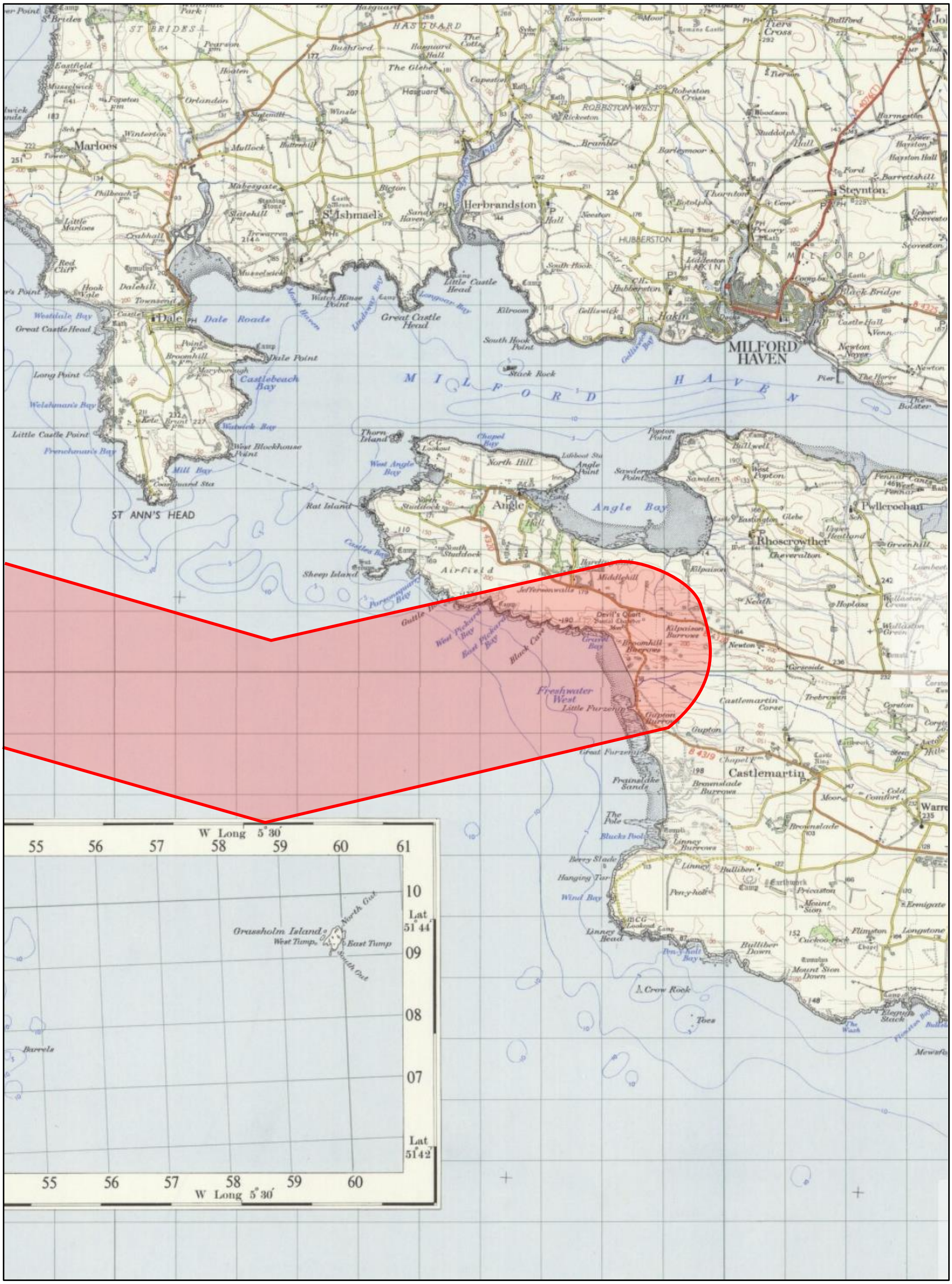
1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**	**Approximate study area**	N
Project: **Greenlink**		
Ref: **DA2985-01**	Source: Google Earth ™ Mapping Services	

1952- 1961 Historical Map

Annex: C1



Client: **Intertek**

Approximate study area

Project: **Greenlink**

Ref: **DA2985-01**

Source: NLS Mapping

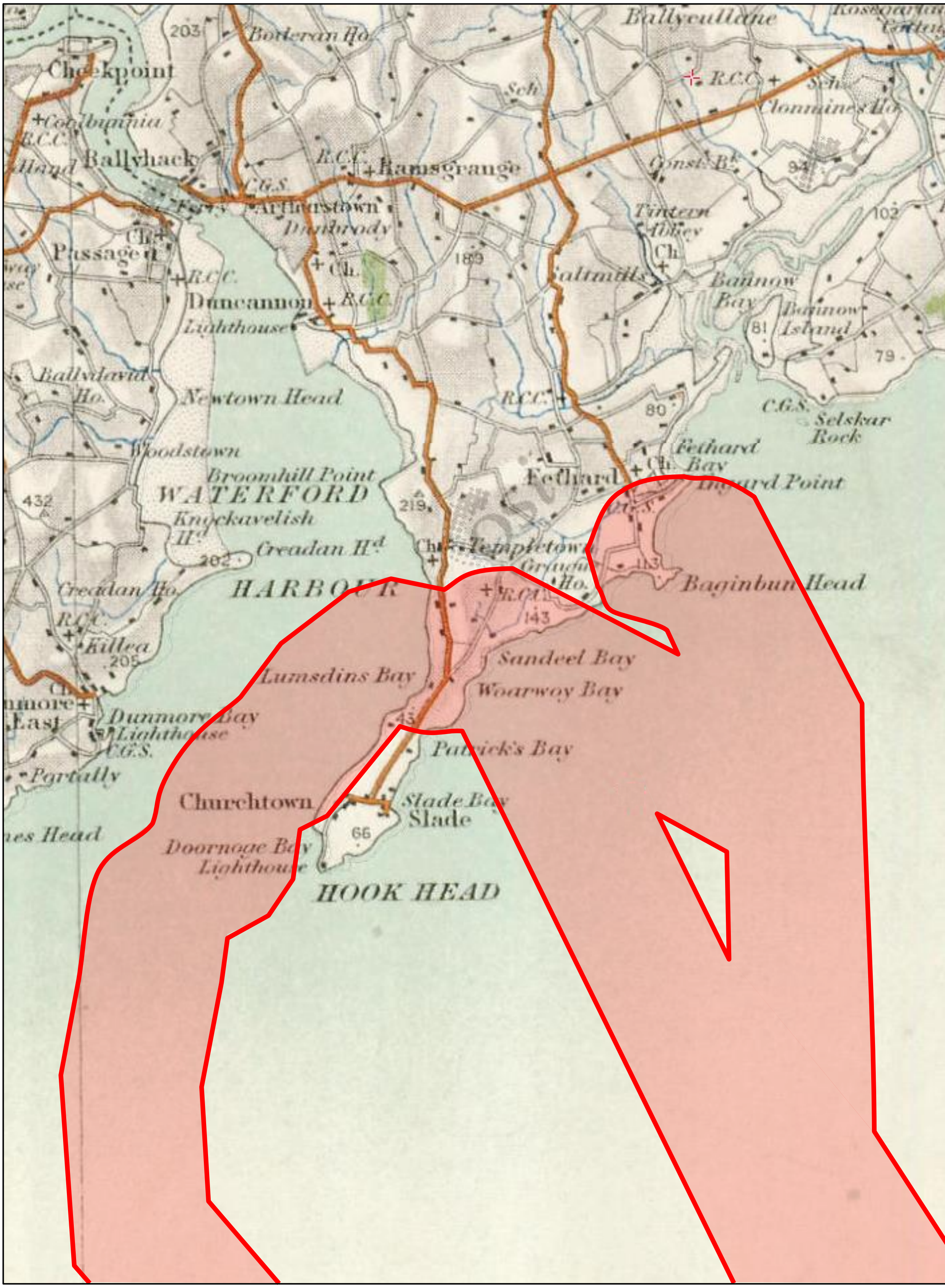
N

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

1940 Historical Map

Annex: **C2**



Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

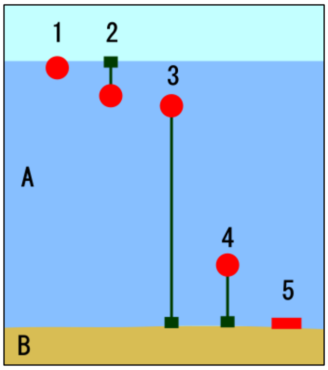
Client:	**Intertek**	**Approximate study area**	N
Project:	**Greenlink**		
Ref:	**DA2985-01**	Source:	NLS Mapping

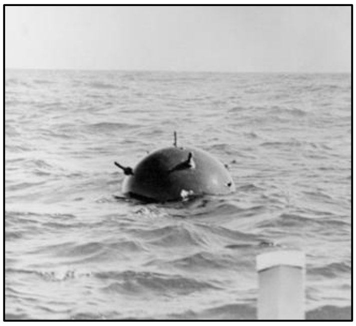
Naval Mine Classification

Annex: **D1**

1. Position in the Water

- **Bottom mines** are most effective in shallow waters, such as rivers, harbours and tidal areas. These mines rest on the ground or sea bed and are intended to block passageways and prevent amphibious invasion.
- **Moored mines** are used for deep water areas and are designed to float below the surface of the water. They take into account the tidal level to remain out of site below the waterline and are connected via steel cable to an anchor on the sea bed. These mines are intended to inflict damage to valuable marine craft targets, such as aircraft carriers or battleships.
- **Drifting mines** are allowed to float freely in the water. They were generally utilised less frequently and mostly as a deterrence tactic. Moored mines could break from their anchoring cable and become drifting mines.





Top left: Diagram displaying mine types. A: Underwater, B: Sea bed 1/2: Drifting Mine, 3/4: Moored Mine, 5: Bottom Mine.
Top right: Photograph of drifting mine. Left: Bottom mine.

2. Delivery Method

- **Aircraft-laid mines** were deployed in the same manner as other aerial delivered items of ordnance, see **Section 11.2.2**. Fins or parachutes were stored in the mine to slow its velocity and reduce its impact when meeting the surface of the water. These mines were later converted to be used on land and are often referred to as parachute mines.
- **Surface-laid mines** are planted by surface marine craft and are used primarily for defensive purposes. The British Navy used these mines within and near Allied waterways to protecting shipping lanes from enemy attack.
- **Submarine-laid mines** are deployed as offensive weapons and are used primarily for defensive purposes. During WWII submarines planted a total of 576 mines resulting in 27 sunk ships and 27 damage. This is approximately one ship sunk or damaged for every 10 mines planted.

Top right: Horned contact mines on the HMS Aurora .

Top left: Photograph of mine loading onto US aircraft. Bottom left: Mine-laying submarine UC-1, which could carry a total of 12 mines.

3. Method of Activation

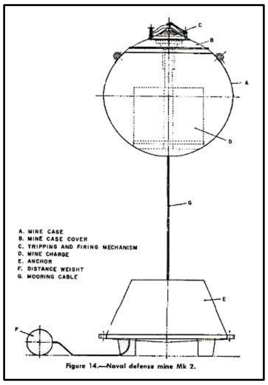
- **Contact mines** are designed to explode on direct contact with the hull of ship or other marine craft. They were mostly used by German forces during WWI although also saw later deployment. The specifics of this type of mine are fully detailed in **Annex D2**.
- **Influence mines** are trigged by the 'influence' of a ship, submarine or other marine craft rather than by direct physical contact. Advances in technology allowed these mines to utilise a range of sensors that would trigger their explosive filing. These mines are fully detailed in **Annex D3**.

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Examples of Naval Mines

Contact mines

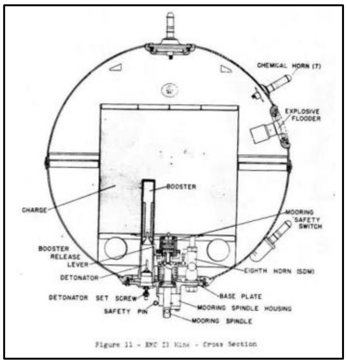
- Earliest form of naval mines used throughout both WWI and WWII. Contact mines need to be touched by the target to detonate, which limits the damage usually to vessel that triggers them. These were used primarily for defensive purposes, such as in the Royal Navy's defence of the English Channel.
- The main distinction in contact mine design was between inertia and Hertz-horn mines. Most adapted the latter during or after WWI; these proved effective as they remained active in water for several years after deployment. The mine's upper half would be studded with hollow lead protuberances, each containing a glass vial filled with sulfuric acid. Upon collision with an vessel the horn would be crushed, cracking the vial and allowing the acid to run down a tube into a lead-acid battery. This energises the battery, and detonates the explosive.
- By the onset of WWI, Germany had large stocks of reliable Hertz horn contact mines, all equipped with automatic anchors that used hydrostats to set mine depth and lock the mooring cables. Britain copied this design in 1917 by capturing a German mine and subsequently produced their first reliable model (Type H Mark II).



Schematics of Navy Spherical Mine Mk 2.

Common types

Name	Type of laying	Diameter	Explosive charge	Notes
Navy Spherical Mine Marks I and II	Moored	Unknown	250 lbs. (113 kg)	British mine using an automatic anchor and an arm-operated firing mechanism. only 4,000 available by the start of World War I.
"Type I" (British designation)	Moored	31.5 in. (80 cm)	180 lbs. (81.6 kg)	WWI-era German "Hertz horn" contact mine.
"Type II" (British designation)	Moored	31.5 in. (80 cm)	290 lbs. (131 kg)	Same as above.
Type H Mark II	Moored	Unknown	320 lbs. (145 kg)	First reliable British "Hertz horn" contact mine, available from 1917 and used in early years of WWII.
EMA	Moored	31.5 in. (80 cm)	331 lbs. (150 kg)	First German mine with a chemical-horn firing system.
UMA	Unknown	31.5 in. (80 cm)	66 lbs. (30 kg)	German mine with five Hertz and three switch horns. Could be moored at either 160 or 320 feet (50 or 100 m).



Left: found July 1917 in Thames Estuary. Centre: found December 1914 in water off Scarborough, identified as "Type I" mine. Right: Schematics of moored contact mine with "Hertz horn" mechanics.

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

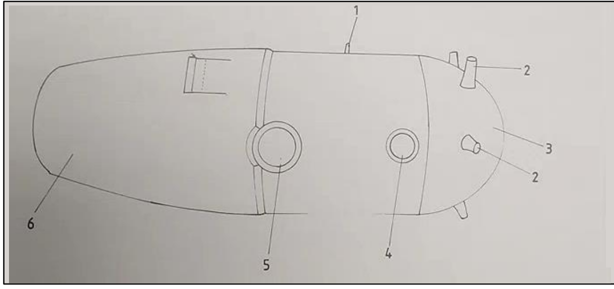
Influence mines

- Influence mines are triggered by influences from external sources, such as a ship or submarine. Common sensors are:
  - **Magnetic sensors** – an induction or needle system detects a displacement of the ambient magnetic field, normally by the introduction of a ferrous metal object (such as a passing vessel), which initiates the detonation sequence.
  - **Acoustic sensors** – any 'positive shift' (i.e. closing) underwater sonar signal may be interpreted as a potential target vessel and so the mine's arming sequence is initiated followed by detonation.
  - **Hydrostatic pressure sensors** – any detected difference in water pressure (i.e. generated by a passing vessel) initiates detonation.
- Magnetic and acoustic mines were developed by German intelligence before the onset of WWII; some 1,500 magnetic mines were available in the Spring of 1940. Pressure mines were developed in 1943 but were not used until the 6-7th June 1944 in the Normandy Invasion area. The Allies developed separately, though utilised these mines largely for defensive purposes in contrast to the offensive approach taken by Axis forces.

An SMA Mine.

Common types

Name	Type of laying	Diameter	Explosive charge	Notes
SMA (British designation "GO"	Moored	46 in. (177 cm)	772 lbs. (350 kg)	German moored influence mine laid by Type VIID and XB U-boats, introduced in 1942. Made of a aluminium alloy shell to reduce detection. Could be moored either 219 fathoms (400 m) or 328 fathoms (600 m) deep.
TMA (British designation "GT"	Moored	21 in. (5cm)	507 lbs. (230 kg)	German moored influence mine laid from the TT of U-boats. Used an aluminium alloy shell and used a 82 fathom (150 m) or 148 fathom (270 m) cable.
LMA	Floating	26 in. (66 cm)	661 lbs. (300 kg)	German magnetic mine, later converted to be aircraft-deployed. See **Annex X** for an example of one of these converted items.
Mark XVII	Moored	Unknown	320 lbs. (145 kg), later upped to 500 lbs.	British moored acoustic mine for use against S and R-boats.
M Mark III	Ground	Unknown	1,500 lbs. (680 kg), later upped to 1,750 lbs. (794 kg).	British CR magnetic mine, designed for laying from wide-track mine-layer rails in 6-20 fathoms (11-37 m). First deliveries in 1941.



1. Lifting Lug
2. Anti-roll bars
3. Filling plate
4. Detonator cover plate
5. Clock starter plate
6. Parachute housing

Left: Schematic of an LMA early pattern airborne parachute ground influence mine. Right: Mines aboard HMS Apollo ca 1945, likely to be M Mark I mines.

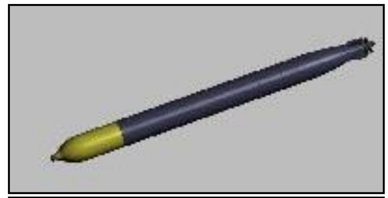
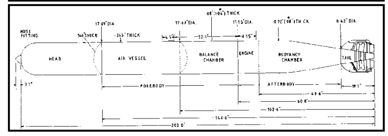
1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Examples of Torpedoes

Annex: **D4**

British 18in Mark XII

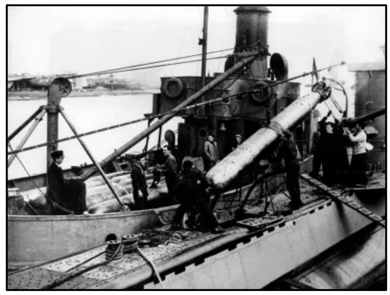
Deployed by	Aircraft
Date of design/service	1935/1937
Weight	1,548 lbs. (702kg)
Overall length	16 ft 3 in (4.95m)
Explosive charge	388 lbs. (176kg) TNT
Range / speed	1,500 yards (1,370m)/40 knots or 3,500 yards (3,200 m)/37 knots
Remarks	Standard British airborne torpedo for the first half of WWII and still in limited use at the end.

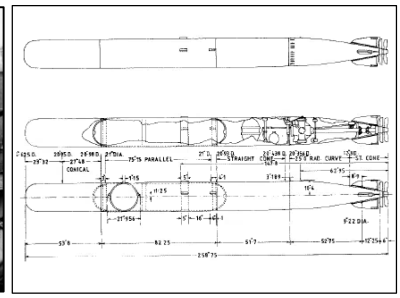
Left: A Mark XII torpedo fitted to a Bristol Beaufighter. Top right: Model of the torpedo. Bottom left: schematics.

British 21in Mark VIII**

Deployed by	All submarines from the "O" class on and MTBs
Date of design/service	About 1925/1927
Weight	3,452 lbs. (1,566 kg)
Overall length	21 ft 7 in (6.58 m)
Explosive charge	722 lbs. (327 kg) TNT
Range / speed	5,000 yards (4,570 m) / 45.5 knots
Remarks	First burner-cycle torpedo. Used more than any other British torpedo, accounted for 56.4% of torpedoes fired by September 1944 (3,732 fired in this period).



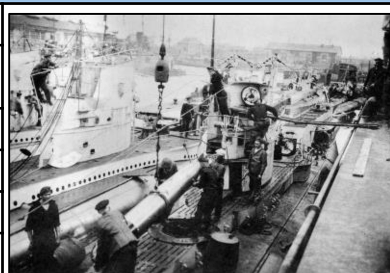
Mark VIIIs loading to Polish Navy submarine ORP Sokół



Schematics of a 21in MKVIII tornado

German 45cm (17.7") C/06

Deployed by	U-boats, starting with U-3
Date of design/service	1906/1907
Weight	1,704 lbs. (773 kg)
Overall length	222 in (5.65 m)
Explosive charge	270 lbs. (122.6 kg) TNT
Range / speed	1,640 yards (1,500 m)/34.5 knots 3,380 yards (3,000 m)/26 knots
Remarks	First German torpedo which received a 4-cylinder instead of a 3-cylinder engine.

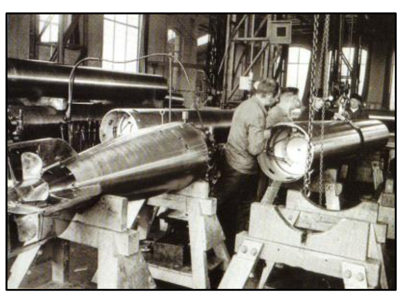


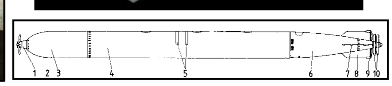
Loading torpedoes aboard a U-Boat of the German Flanders Flotilla at Bruges

A German Flotilla in port.

German 53.3cm (21") G7a T1

Deployed by	Surface ships and submarines
Date of design/service	1930/1938
Weight	3,369 lbs. (1,528 kg)
Overall length	23 ft. 7 in. (7.186 m)
Explosive charge	617 lbs. (280 kg) Hexanite
Range / speed	6,560 yards (6,000 m) / 44 knots 8,750 yards (8,000 m) / 40 knots 15,000 yards (14,000 m) / 30 knots
Remarks	Issued throughout WWII and considered to be very reliable.





Left: G7a Torpedoes being repaired at Ostende in 1940. Top right: Model of the torpedo. Bottom right: Schematics.

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

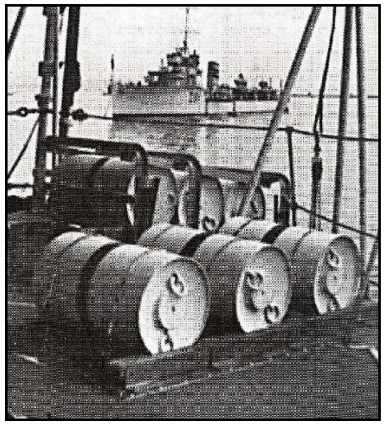
Project: **Greenlink**

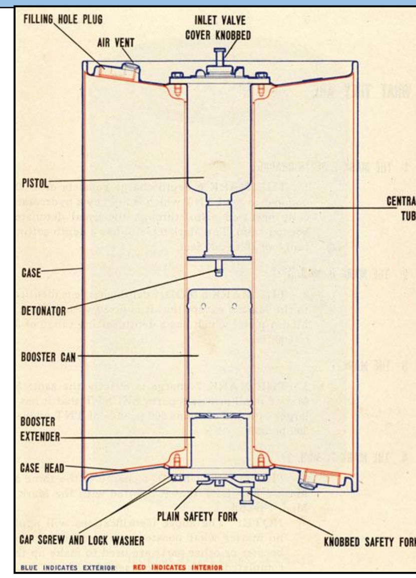
Ref: **DA2985-01** Source: Various sources

Examples of Anti-Submarine Weapons

Depth Charge. Mk VII

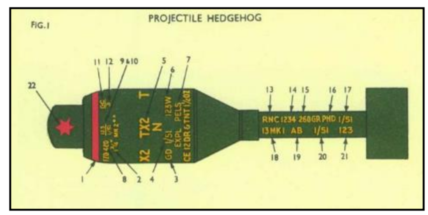
Shape	Cylindrical, drum shaped
Explosive Weight	132 kg
Fuze Type	Hydrostatic pistol
Dimensions	70 cm long, 45 cm diameter
Use	Amatol charge was estimated to be capable of splitting a 2.2 cm submarine pressure hull at a distance of 6.1 m. Torpex (or Minol) explosives used post 1942 were reported to increase this distance to 7.9 and 15.8 m.
Remarks	The Mk VII was little changed from the WWI Type D. Initially the depth charge was simply dropped from the attacking vessel but from late 1940 /early 1941 a launcher was used which projected the weapon some 35 m.





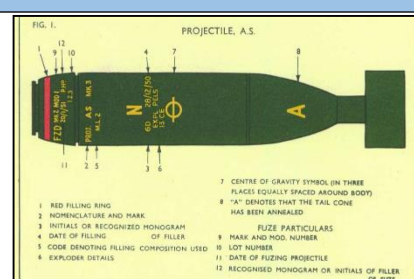
"Hedgehog" Spigot Mortar

Weight	29 kg
Explosive Weight	14 kg
Dimensions	118 cm long, 17.8 cm diameter
Fuse Type	Contact fuze
Use	Fired from a launcher on the attacking ship, these projectiles were fired in an arc and were designed to land in an elliptical pattern in the water to hit enemy submarines.
Remarks	This weapon was invented in order to address the issue of "instantaneous echo" when an enemy submarine was so close to the attacking ship that it could not be accurately plotted by a sonar operator and was effectively invisible.



"Squid" Mortar

Weight	200 kg
Explosive Weight	94 kg
Diameter	30.5 cm diameter
Fuse Type	Timer fuze
Use	Fired from a launcher on the attacking ship, these projectiles were fired in an arc and were designed to land in a triangular pattern in the water to hit enemy submarines.
Remarks	Reportedly nine times more effective than standard depth charges in post-war trials, these bombs were designed to fall on either side of a submarine, with the resulting pressure wave crushing the enemy vessel.



1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01** Source: Various sources

Examples of Land Service Ammunition finds in the UK

Unexploded Second World War bomb discovered under Somerset footpath

By Western Daily Press | Posted: January 21, 2014

The unexploded bomb was found in Somerset

Comments (0)

Report this article

An unexploded bomb dropped in Britain during the Second World War has finally been discovered – underneath a popular footpath in Somerset.

Unexploded bomb found in farmer's field

17 May 2010

A live Second World War mortar shell was blown up by Army experts after a farmer found it in his field.

The discovery was made in the field alongside the A20 between Folkestone and Dover.

The mortar shell, which was around a foot long and 3in in diameter, was around 50ft from the main road.

The farmer alerted police and PC Trevor Moody and PCSO Michelle Brady went to the field.

PC Moody contacted the Army who sent in a bomb disposal unit.

An Army officer confirmed the live shell was from the Second World War and was packed with high explosives.

They moved it a safe distance away from the A20 and carried out a controlled explosion.

PC Moody said: "Given that we live in an area that saw much action during the Second World War, it is not uncommon for us to be alerted about unexploded bombs."

The incident was on Thursday.

- Click here for more news from Kent.

Army bomb disposal team called to Blacksole Bridge in Herne Bay

by Aidan Barlow abarlow@thekmgroup.co.uk 08 July 2015

It was like a scene from Dad's Army when Army bomb disposal experts found wartime explosives made by the Home Guard in makeshift bottles.

A team was called to the Blacksole Bridge in Herne Bay after the wartime bombs were found.

The team from the Royal Logistics Corps set up a 30 metre exclusion zone for pedestrians around the railway embankment after the suspected homemade phosphorous bombs were found.

The scene at Blacksole Bridge after wartime explosives were found in the railway cutting

23 August 2014 Last updated at 15:01

Unexploded WW2 bomb found at Kenfig Pool, Bridgend

Dean Smith believes the shell was made in Germany

Bomb experts have been called to a south Wales nature reserve after an unexploded World War Two shell was discovered by a walker in Bridgend.

Dean Smith, 38, of Pyle, was walking near Kenfig Pool on Saturday when he saw a fin sticking out of the sand.

He reached down to pick it up, but ending up falling and landed with the 2ft-long (0.6m) bomb on top of him.

The site has been cordoned off by police and the Royal Logistics Corps will carry out a controlled explosion.

Related Stories

'Panic' as dog nearly thrown grenade

WW2 bomb found at wind farm exploded

WWII bomb found in kitchen cupboard

Royal Navy bomb disposal experts remove a World War Two shell discovered in a nature reserve

- **A World War Two bomb was discovered in a Plymouth nature reserve**
- **Amateur metal detector found the shell and partially dug it up**
- **Royal Navy experts carried the explosive away before disposing of it**

By VALERIE EDWARDS FOR MAILONLINE
PUBLISHED: 01:29, 13 January 2016 | **UPDATED:** 09:51, 13 January 2016

Share 338 shares 10 View comments

A World War Two bomb was reportedly found at Efford Nature Reserve in Plymouth after a member of the public was metal detecting and partially dug it up.

The Royal Navy Bomb Disposal team was called in to remove the bomb and police have closed off Military Lane, with the possibility of Military Road also being closed.

Police were called at around 1.30pm yesterday after what appeared to be a shell was discovered and partially dug up near Military Lane, Efford.

Tweet

Published by Huw Oxburgh
Posted: 03/06/14
Updated: 03/06/14

Unexploded bomb found in Axminster

Update: The bomb disposal unit has made the device safe and the road has re-opened.

Six homes have been evacuted today after the discovery of an unexploded device in Axminster.

A Royal Navy bomb disposal team have been called to the scene after a 'historic German device' was discovered in a garden.

Police have set up a 20m cordon around the garden in Alexandra Road and evacuated homes in the surrounding area as a precaution.

Mortar thought to be from WWII found on Oshawa's Camp-X grounds

August 24, 2016 | 5:42 am

What is believed to be a World War II mortar has been discovered in south Oshawa. A man out in Intrepid Park, the site of the Camp-X Second World War training grounds, discovered the round with his metal detector on Tuesday evening. Durham police are held the scene overnight awaiting military officials from Trenton to come and properly detonate the mortar.

Holiday beach cordoned off after landslip sends more than a THOUSAND Second World War bombs and rockets tumbling onto the sands

- Bad weather led to ground movement which exposed the huge arsenal at Mappleton, East Riding

Bomb Beach Alley: Rockets were found after a landslide on Mappleton beach in 2012

Storms and floods unearth unexploded wartime bombs

By Claire Marshall
BBC environment correspondent

There has been a dramatic increase in the number of wartime bombs unearthed because of the winter storms and flooding.

The storms have uncovered a lethal past

Bomb disposal teams in the South West have dealt with double the number of unexploded ordnance than in the same period last year.

Since mid December, the Royal Navy's Southern Dive Unit has recovered or disposed of 244 items of ordnance.

During the same period last year, they dealt with just 108 items.

Almost 70 years after the end of WWII, one legacy of that conflict continues to turn up on beaches and harbours around Britain.

Unexploded shells, bombs and mines continue to be discovered every year, and the Royal Navy's Southern Dive Unit is tasked with making these devices safe.

Its area of responsibility stretches for some 2,250km (1,400 miles). It begins from the highwater mark in Hull and proceeds seaward to the territorial limit, and then runs clockwise around the British Isles - including the Isle of Wight, Channel Islands, and Isles of Scilly - to finish in Liverpool.

Related Stories

Ancient trees revealed by storms

Land Service Ammunition (LSA) resulting from historic military activity is commonly encountered across the UK by the public and construction industry alike. Such finds are much more common in rural areas than in urban environments, and can often be anticipated in areas such as former RAF stations or ranges. However, many such items are encountered entirely by surprise where the landowner or developer has no knowledge of any previous military use of the land.

30th April 2010

renewable energy focus.com

Bomb at Sheringham Shoal offshore wind site

A 250lb air-dropped German WWII bomb has been safely detonated on the Sheringham Shoal Offshore Wind Farm site.

Wind farm developer, Scira Offshore Energy Ltd commissioned an unexploded ordnances (UXO) survey as part of its reconstruction preparations and the bomb was found at the site of one of its foundation locations in the north-west of the offshore wind farm site.

A total of 52 targets were investigated by divers and using a remote operated vehicle (ROV). While most of the targets were debris or geological concentrations, several anchors and an old canon were found, as well as the unexploded bomb.

The bomb was found by divers from diving specialists Red7Marine and verified and detonated with explosives by disposal experts MACC International, earlier this month.

Project Director Rune Rønvik says safety is a priority during construction of the offshore wind farm and the discovery of the bomb full justified the use of such a technically precise survey, despite the additional time it required.

19th March 2014

BBC NEWS

Plans to explode WW2 bombs found in seabed at Gwynt y Mor wind farm

Preparations are under way to remove three unexploded bombs found on the sea bed at a wind farm site off the north Wales coast.

The World War Two bombs were discovered three weeks ago during ongoing construction at the Gwynt y Mor wind farm in Liverpool Bay.

Specialist contractors will carry out controlled explosions when the conditions are right in the next few weeks, RWE Innogy UK said.

9th August 2016

Worthing Herald

Unexploded WW2 ordnance found during wind farm construction to be detonated

Two unexploded WW2 devices will be detonated in a controlled explosion this week as works continue on the Rampion offshore wind farm.

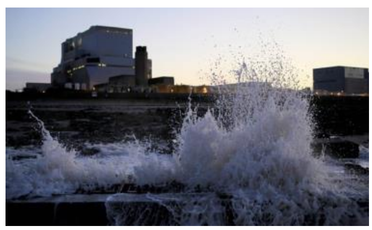
Thought to date from the Second World War, the devices are located on the seabed, 3km off Lancing Beach at a depth of 13m.

They were discovered during unexploded ordnance (UXO) surveys which are carried out as protocol during offshore construction.

30th August 2017

The Guardian UK edition

Third WWII bomb found in Bristol Channel near Hinkley Point



A half-mile (1km) exclusion zone has been set up in the Bristol Channel near the Hinkley Point nuclear power stations after a third unexploded second world war bomb was discovered in as many weeks.

Bomb disposal experts will carry out a controlled explosion on the 250lb (113kg) ordnance on Wednesday, two miles north-west of the power plants.

On 8 August, a 500lb device was discovered 2.5 miles from the coast. On 16 August, a 250lb bomb was found less than half a mile from the power station. Both were destroyed in controlled explosions.

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Local Offshore UXO Finds

23rd October 2009

BBC | Your account | News | Sport | Weather | iPlayer | TV | Radio | More...

NEWS — LIVE BBC NEWS CHANNEL

Page last updated at 18:23 GMT, Friday, 23 October 2009 19:23 UK

E-mail this to a friend — Printable version

WWII naval mine found near port

A routine survey exercise of the Milford Haven waterway has uncovered a World War II naval mine.

Milford Haven port will be temporarily closed while the mine is made safe

The discovery was made by the Royal Navy as it scoured the seabed on the approach to the haven.

Officials say the mine poses no threat to shipping, however the port will be temporarily closed while the unexploded device is made safe.

Milford Haven Port Authority said the Royal Navy was now co-ordinating efforts to dispose of the old mine.

Milford Haven port is the largest in Wales, and home to a giant liquefied gas terminal and petrochemical plants.

During WWII, Milford Haven port was an important naval base, playing a major role in the D-Day landings.

It was also a target for German naval mines, leading to an Australian naval officer, Leon Goldsworthy being awarded the George Cross in 1944 after he defused an acoustic mine that had been in the waterway for more than two years.

12th June 2012

BBC | Your account | News | Sport | Weather | iPlayer | TV | Radi

NEWS

Home | UK | World | Business | Politics | Tech | Science | Health | Family & Education

Wales | Wales Politics | North West | North East | Mid | South West | South East | Cymru

Milford Haven: WWII mine in waterway blown up

12 June 2012 — Share

Bomb disposal experts have carried out a controlled explosion on a German World War II mine found by a diver near Milford Haven port in Pembrokeshire.

The controlled explosion took place shortly after 17:00 BST on Tuesday

The device was discovered on the bed of Milford Haven waterway just off Watwick Point, near Dale, at the weekend.

The controlled explosion took place late on Tuesday afternoon.

Milford Haven Port Authority worked with the coastguard, police and a Royal Navy bomb disposal team.

Two port authority patrol boats and two police patrol boats were sent to the area to ensure people remained safe during the detonation.

The authority also issued a navigational warning for all sailors.

Earlier, it said three ships were due to sail out of Milford Haven before the controlled explosion.

The authority said it understood the coastal path around Watwick Point was closed temporarily while the mine was disposed of.

18th February 2014

Western TELEGRAPH

WWII mine found on beach

BIG BANG THEORY: Bomb disposal crews visited Watwick Beach after a suspected mine was discovered.PICTURE: Gareth Reynolds

THE discovery of a suspected bomb at Watwick Bay, near Dale, on Saturday (February 15) led to the beach being cordoned off by police.

Surfer Ryan Sheppard, from Milford Haven, had been making the most of the first sunny day all week when he and his friend Gareth Reynolds discovered two suspicious objects on the beach.

A controlled explosion of one of the items was carried out by Explosive Ordnance Disposal (EOD) early on Sunday morning, covering the beach in shrapnel.

A spokesman for the coastguard said the detonated object is thought to have been a Mark XIX anti-ship mine, used in the Second World War.

28th February 2014

BBC | Sign in | News | Sport | Weather | iPlayer | TV | Radi

NEWS

Home | UK | World | Business | Politics | Tech | Science | Health | Family & Education

Science & Environment

Storms and floods unearth unexploded wartime bombs

By Claire Marshall
BBC environment correspondent

28 February 2014 — Share

There has been a dramatic increase in the number of wartime bombs unearthed because of the winter storms and flooding.

The storms have uncovered a lethal past

Bomb disposal teams in the South West have dealt with double the number of unexploded ordnance than in the same period last year.

Since mid December, the Royal Navy's Southern Dive Unit has recovered or disposed of 244 items of ordnance.

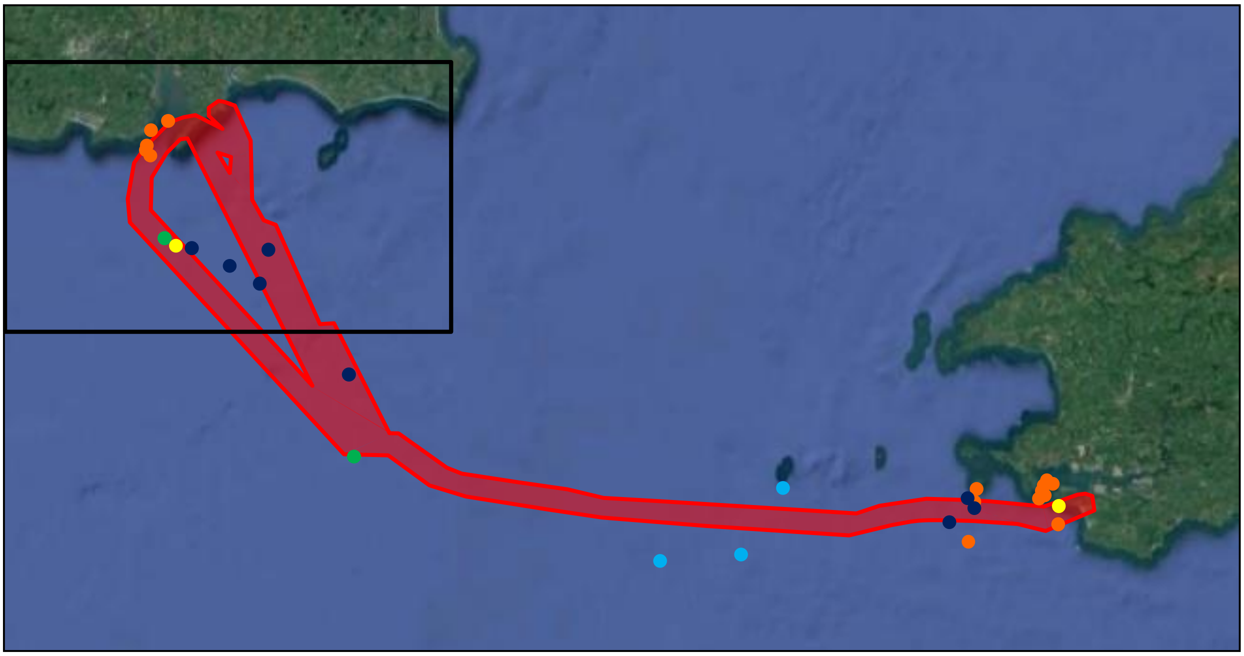
During the same period last year, they dealt with just 108 items.

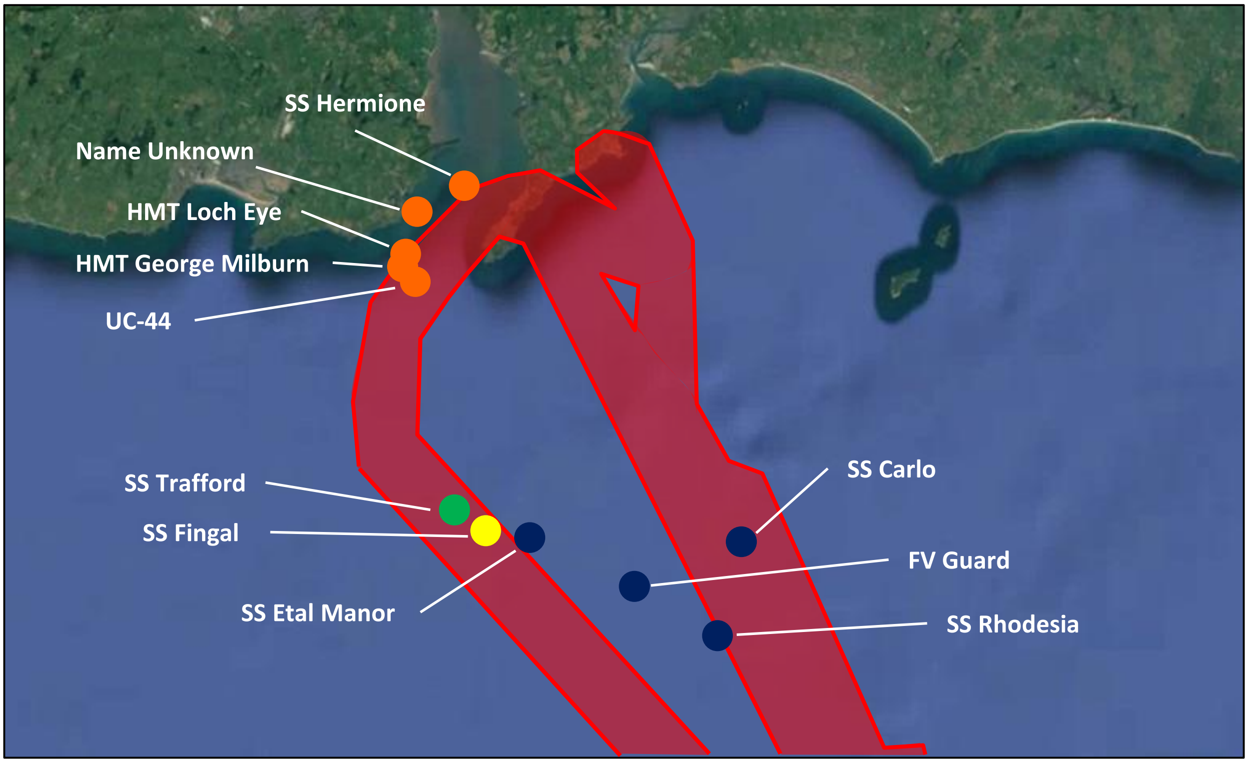
Almost 70 years after the end of WWII, one legacy of that conflict continues to turn up on beaches and harbours around Britain.

Unexploded shells, bombs and mines continue to be discovered every year, and the Royal Navy's Southern Dive Unit is tasked with making these devices safe.

Overlay of Wreck Sites – Irish Waters

Annex: **F1**





Key:

Mine · Torpedo · Gunfire · WWII-era air raid

WWI/WWII-era wreck – brought down in circumstances unrelated to explosive ordnance

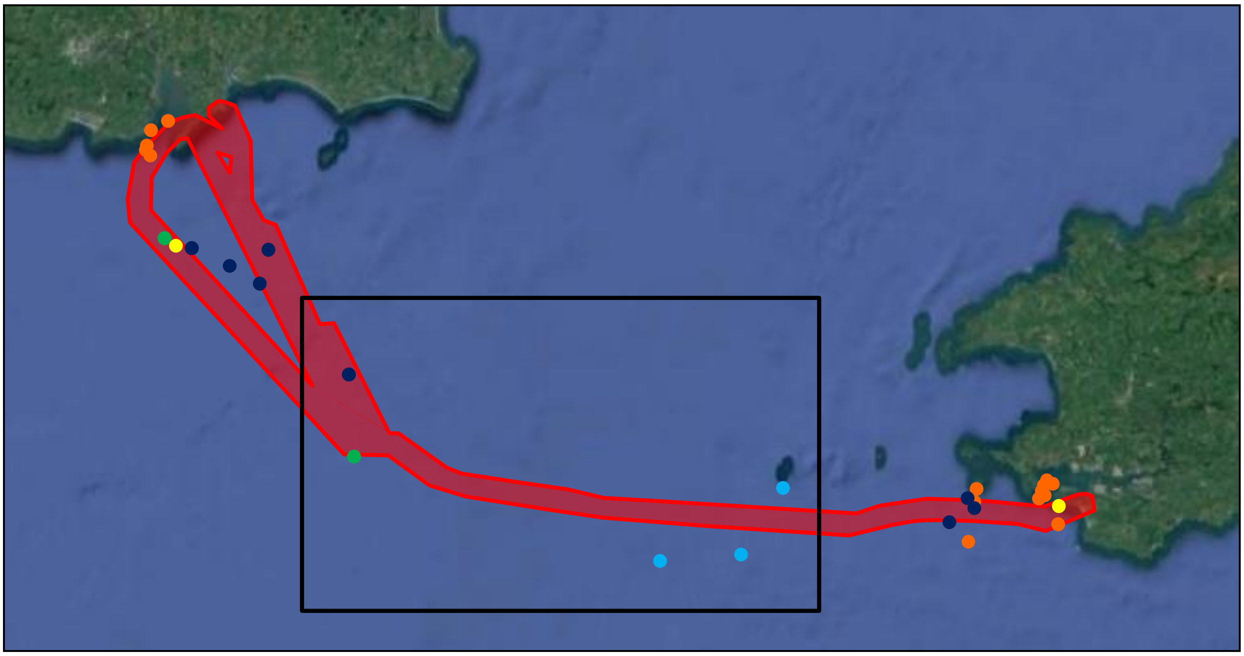
1ST LINE DEFENCE

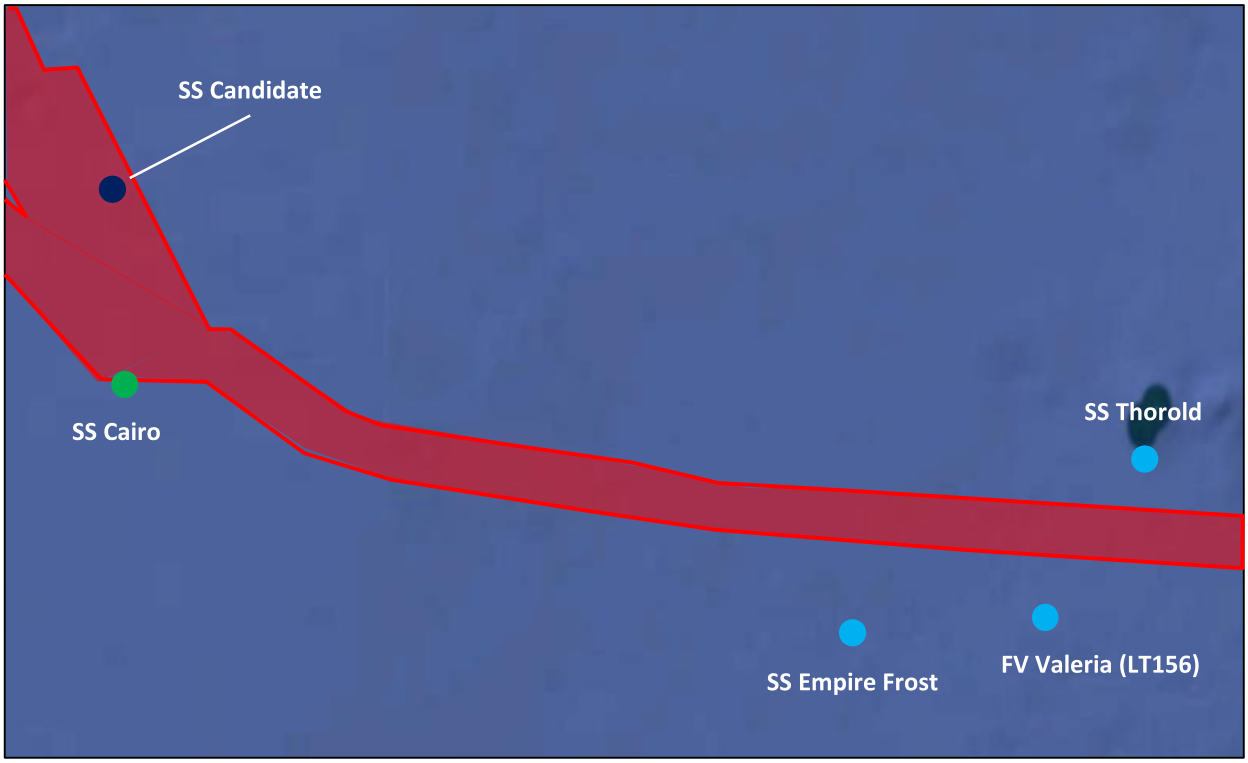
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**		**Approximate study area**
Project: **Greenlink**		N
Ref: **DA2985-01**	Source: Wrecksite.eu	

Overlay of Wreck Sites – Intervening Waters

Annex: **F2**





Key:

- Mine
- Torpedo
- Gunfire
- WWII-era air raid
- WWI/WWII-era wreck – brought down in circumstances unrelated to explosive ordnance

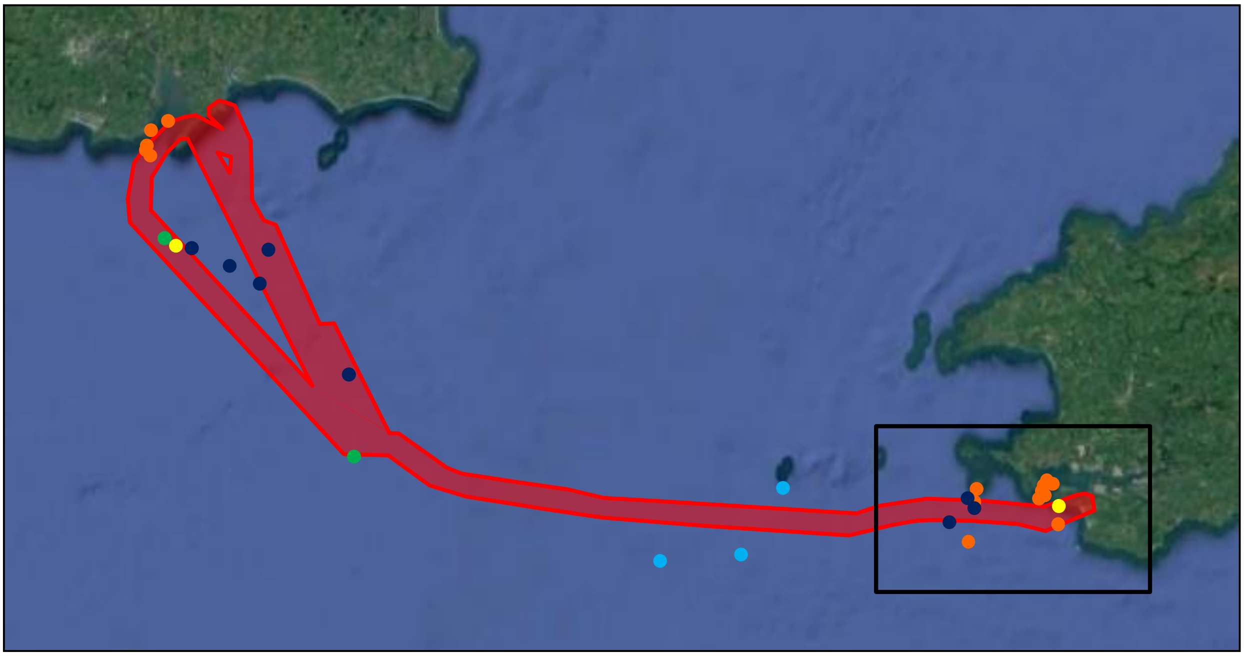
1ST LINE DEFENCE

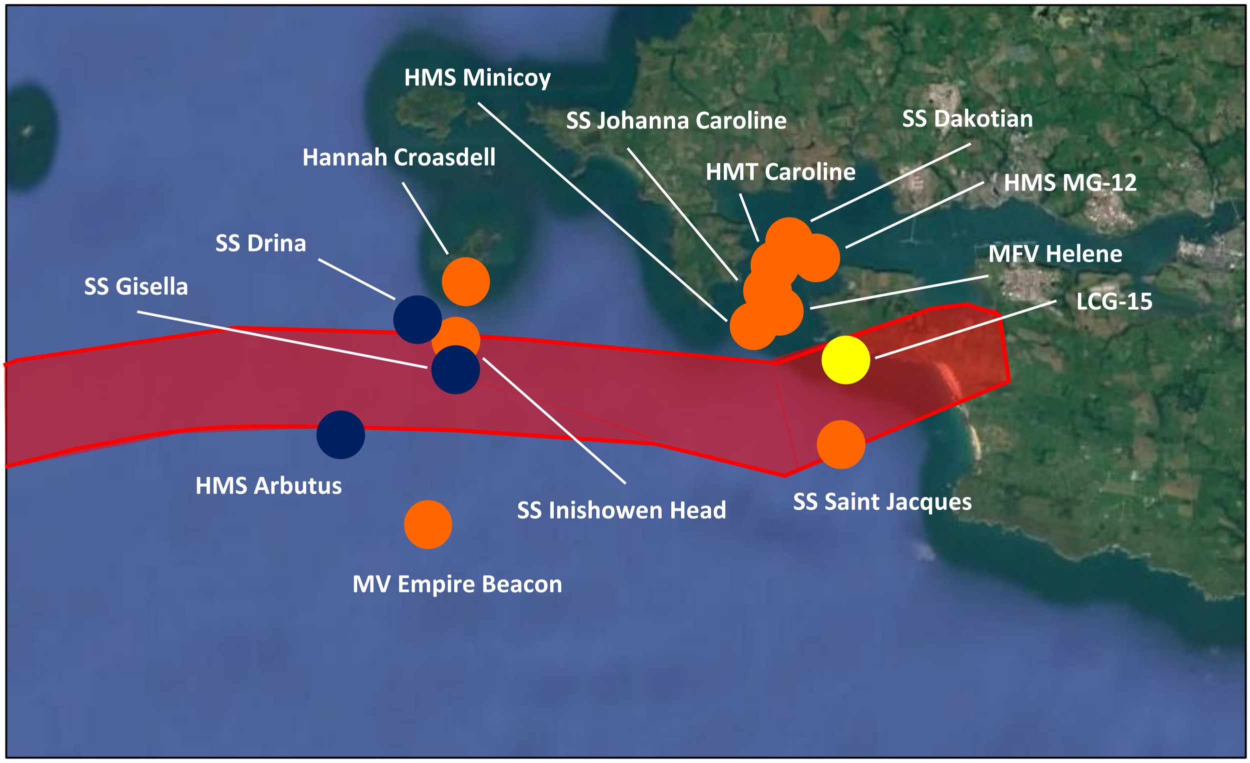
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client:	**Intertek**	**Approximate study area**	N
Project:	**Greenlink**		
Ref:	**DA2985-01**	Source:	Wrecksite.eu

Overlay of Wreck Sites – Welsh Waters

Annex: F3





Key:

Mine | Torpedo | Gunfire | WWII-era air raid

WWI/WWII-era wreck – brought down in circumstances unrelated to explosive ordnance

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

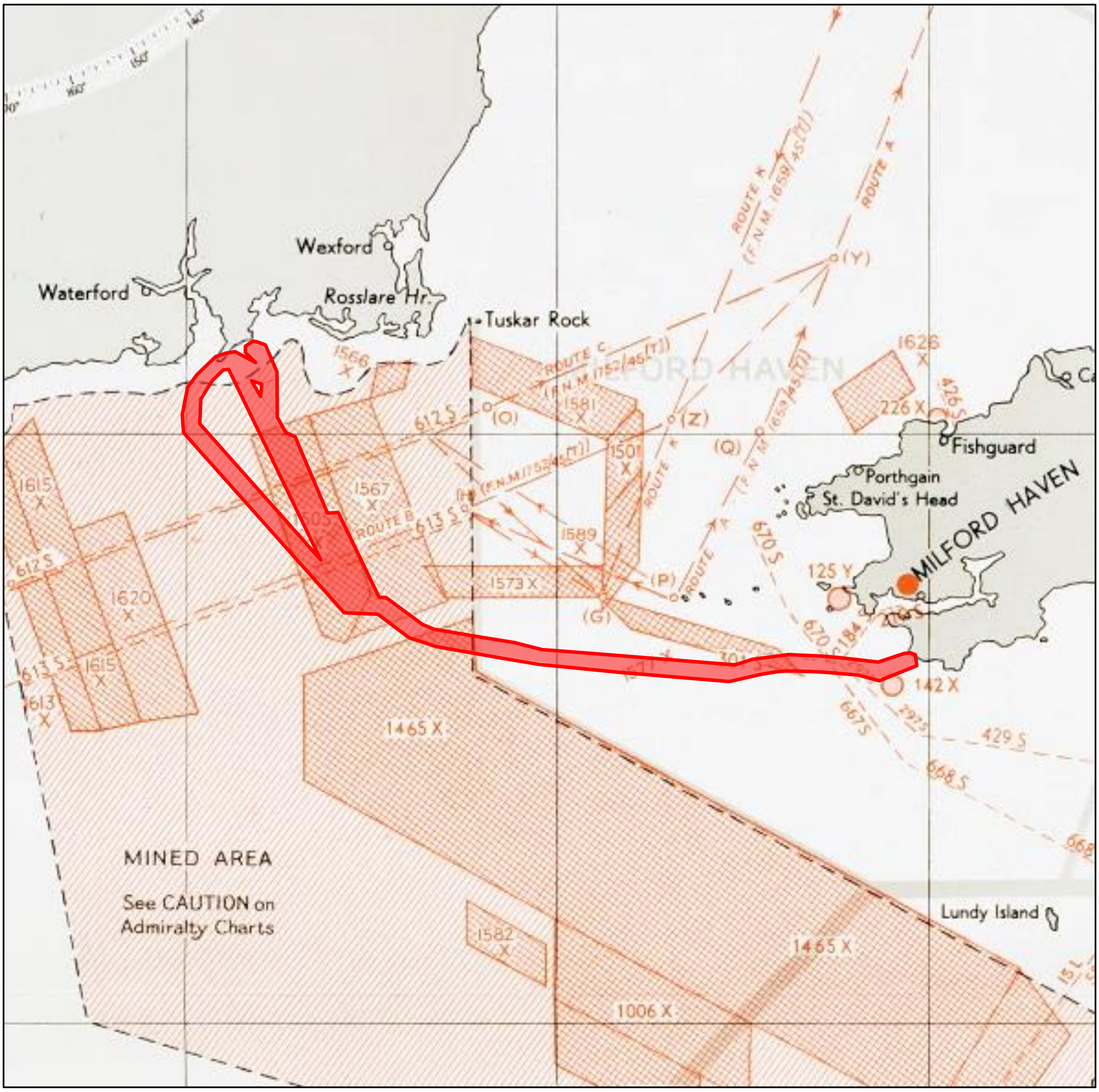
Client:	**Intertek**
Project:	**Greenlink**
Ref:	**DA2985-01**
Source:	Wrecksite.eu

Approximate study area

N

Offshore Minefield Map

Annex: **G1**



British declared Areas
British Minefields
Enemy Minefields
Searched Channels
Standard Traffic Routes
Naval Command Headquarters (C. in C.)
Naval Sub-Command Headquarters (F.O.I.C.) or (N.O.I.C.)
Naval Officer in Charge (N.O.I.C. unless otherwise shown)

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Approximate study area

Project: **Greenlink**

N

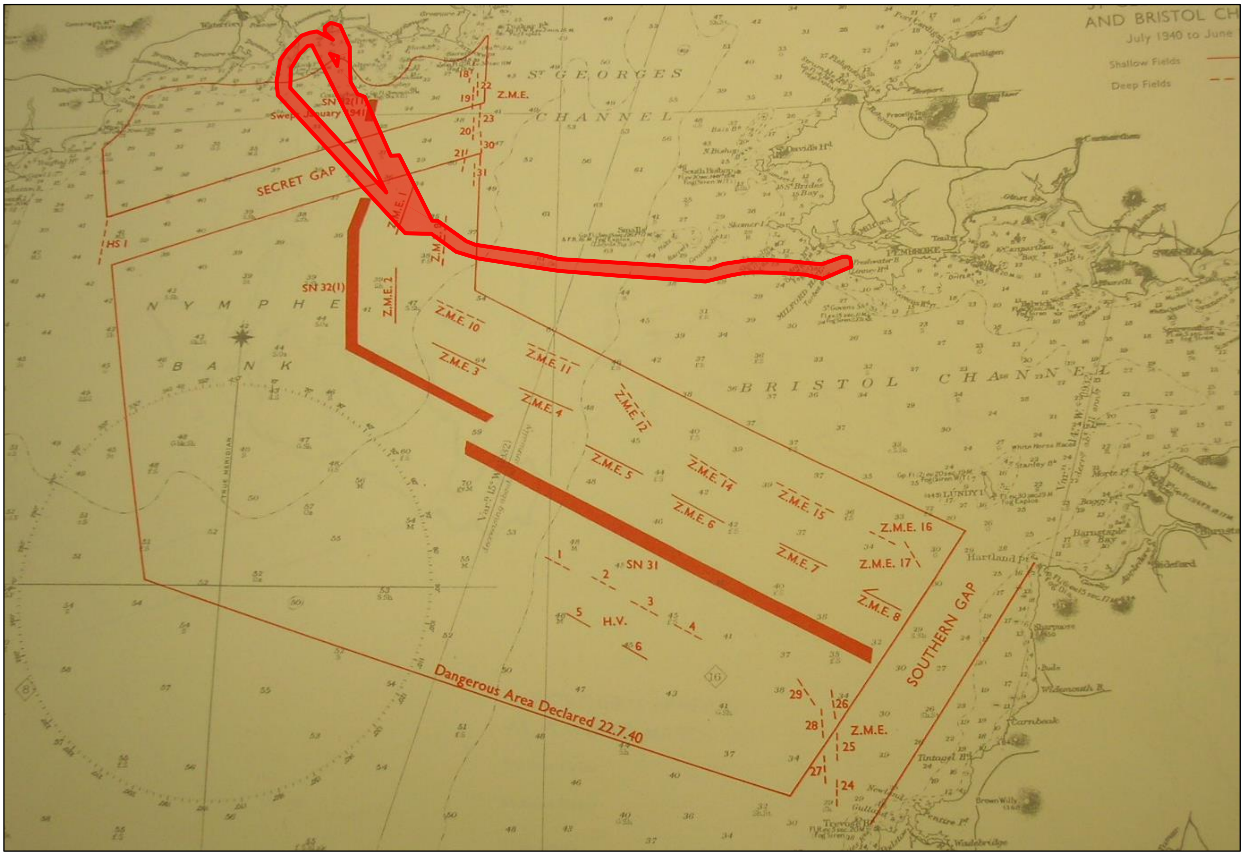
Ref: **DA2985-01**

Source: The National Archives, Kew

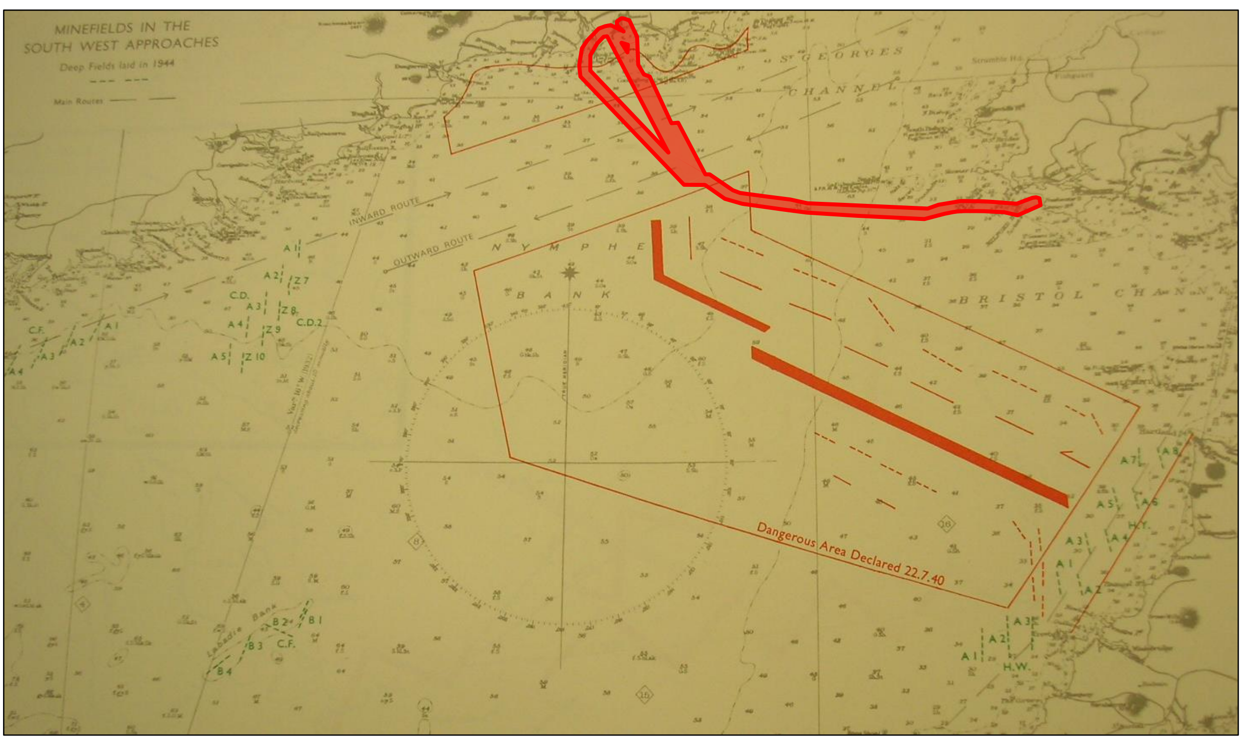
Offshore Minefield Charts

Annex: **G2**

July 1940 to June 1943



1944



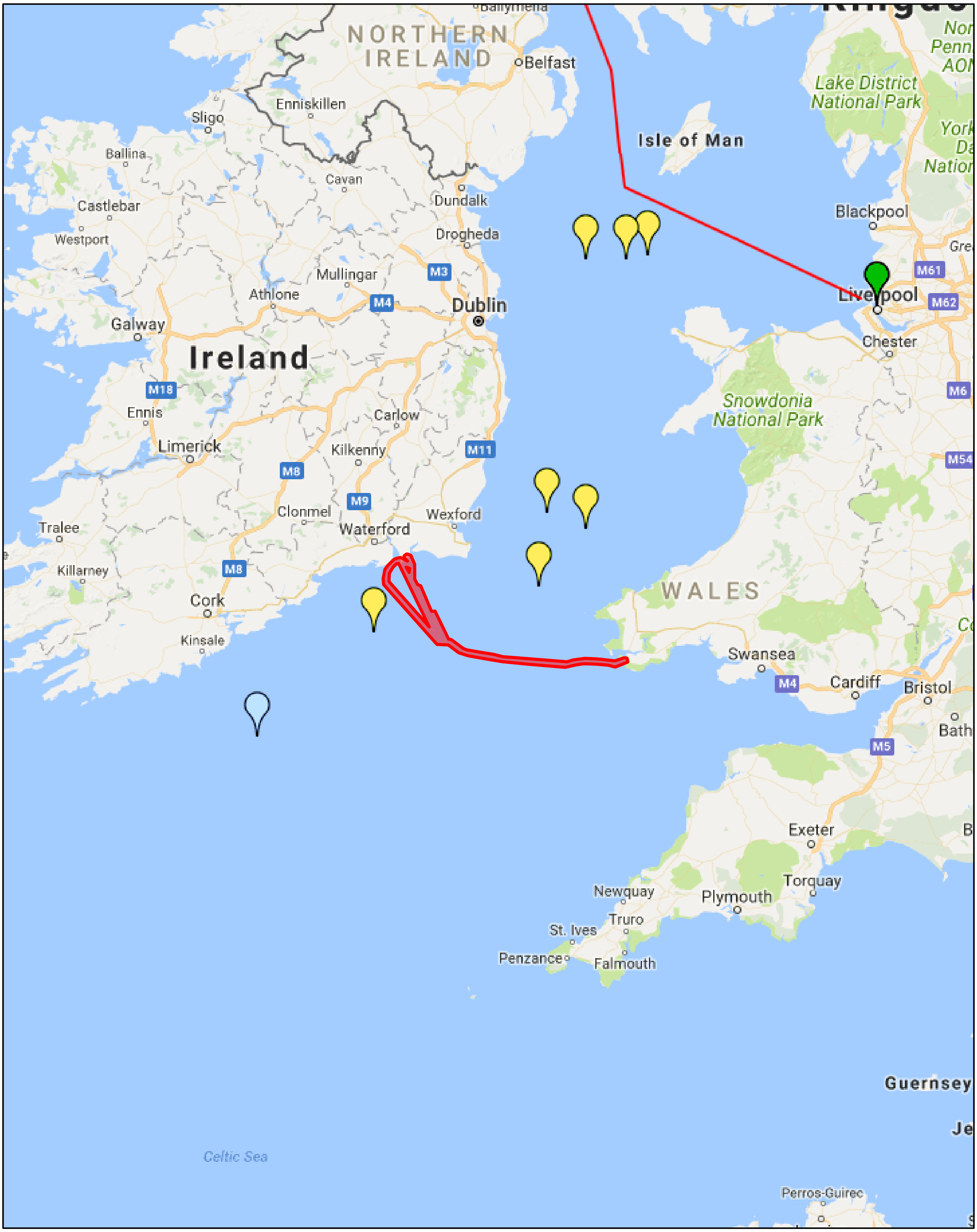
Client: **Intertek**	**Approximate study area**	N
Project: **Greenlink**		
Ref: **DA2985-01**	Source: The National Archives, Kew	

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Overlay of U-boats lost in the Irish Sea in WWII

Annex: **H**



Key:

1940   1944   1945

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Approximate study area

Project: **Greenlink**

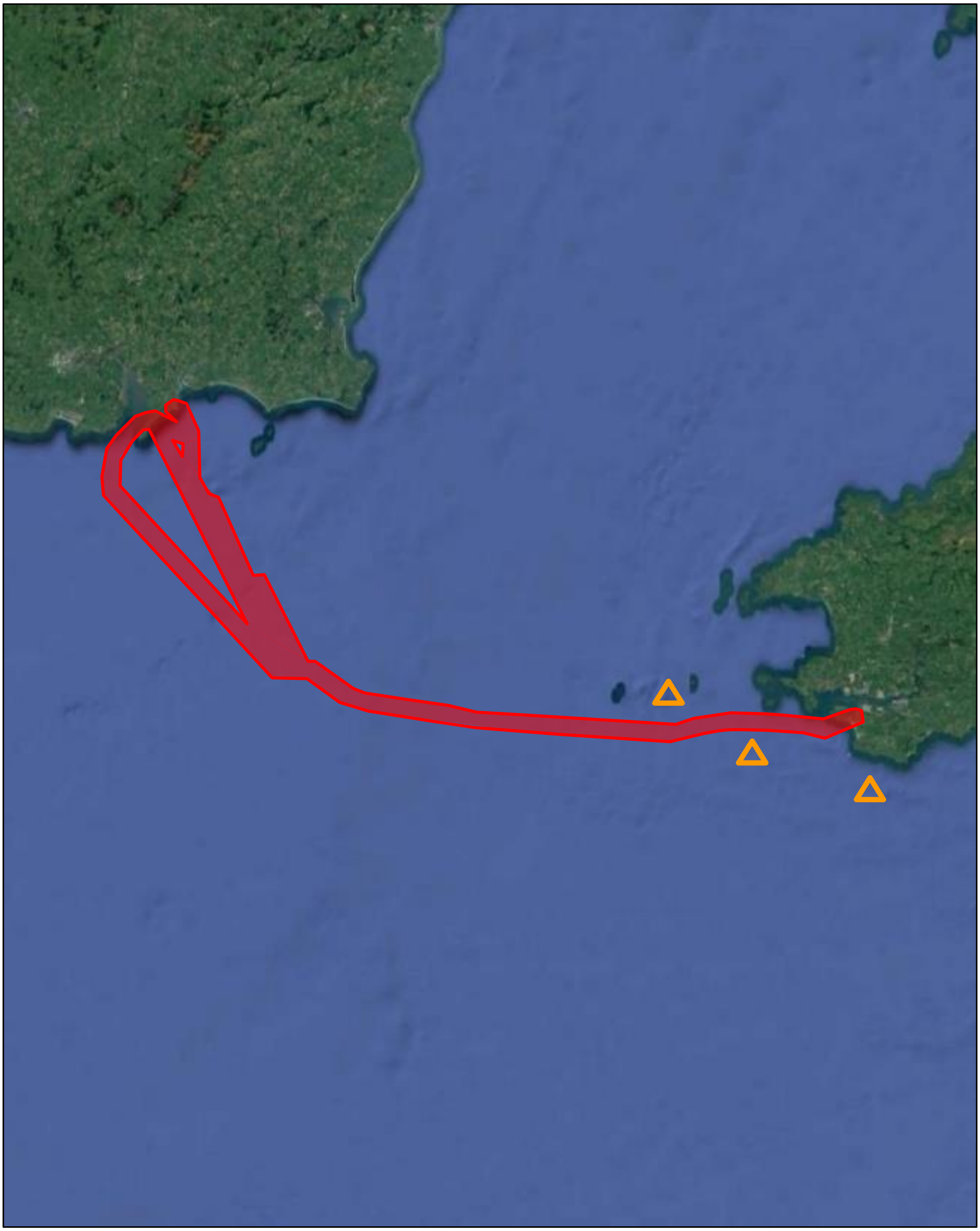
Ref: **DA2985-01**

Source: Wrecksite.eu

N

Overlay of Conventional Munitions Dumpsites

Annex: I



Key:

△ Conventional Munitions Dumpsite

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Approximate study area

Project: **Greenlink**

N

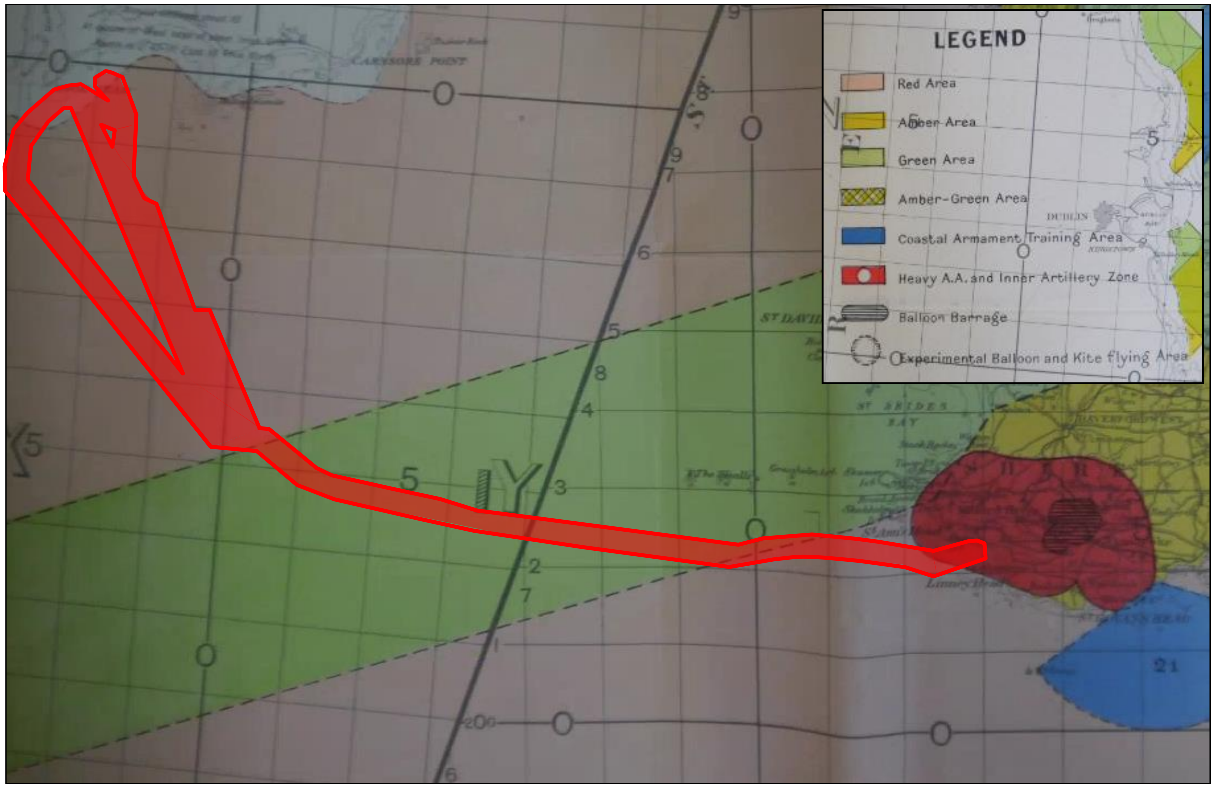
Ref: **DA2985-01**

Source: OSPAR

Restricted Flying Areas, Defended Areas & Balloon Areas

Annex: J1

March 1941



March 1943

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

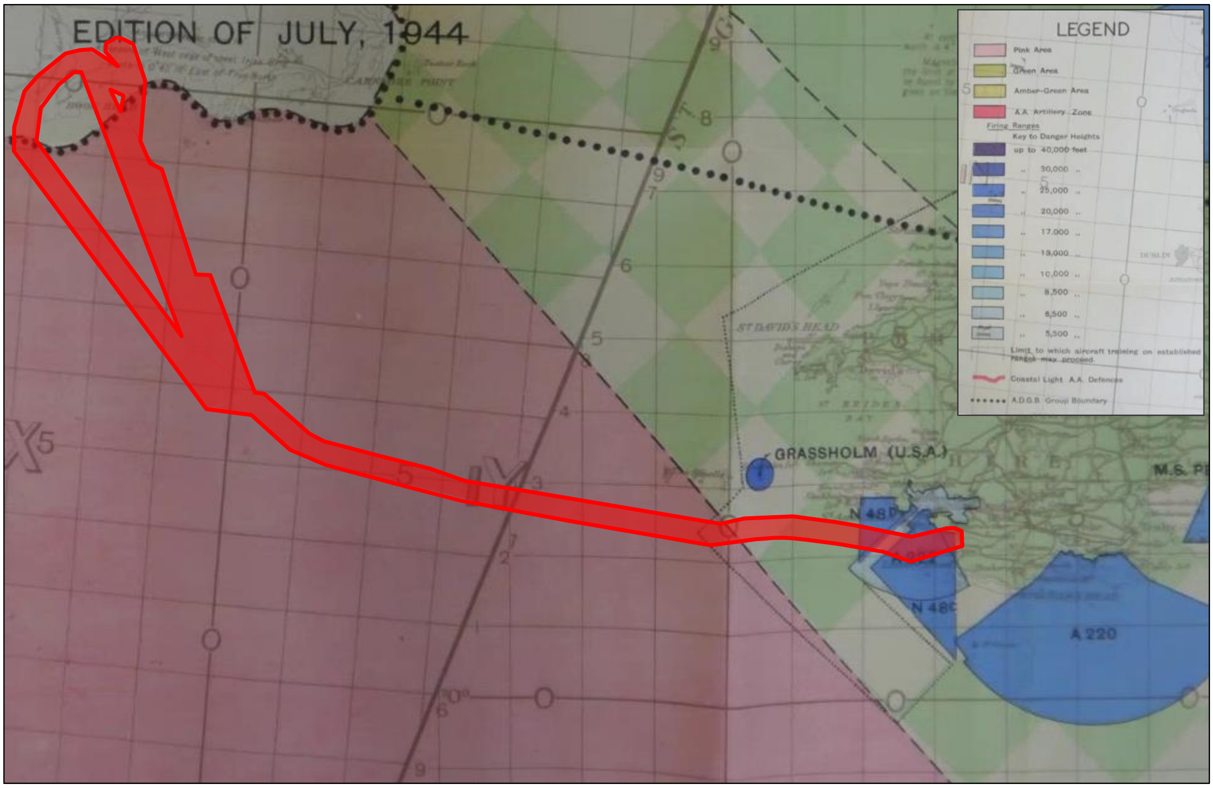
Client:	**Intertek**
Project:	**Greenlink**
Ref:	**DA2985-01**

Approximate study area

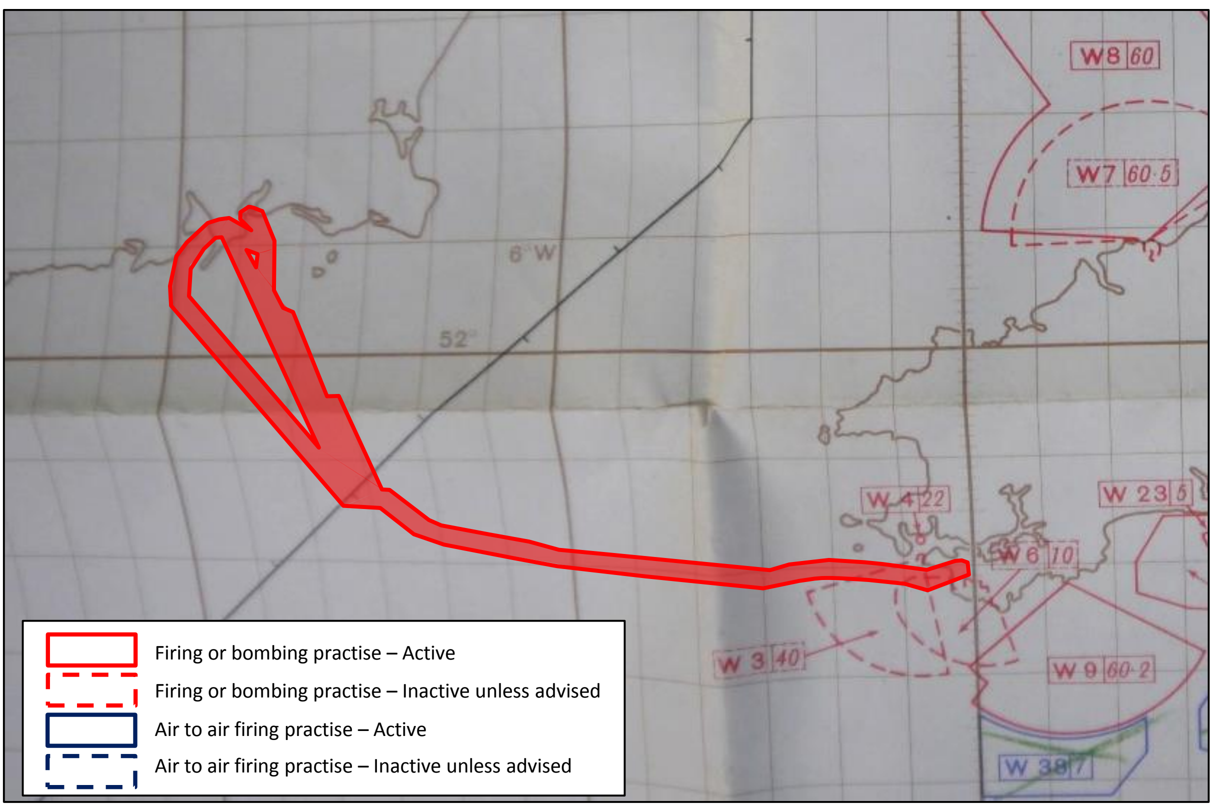
N

Source: The National Archives, Kew

July 1944



'Notices to Airmen' – Danger Areas in the UK, Date Unknown



1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Approximate study area

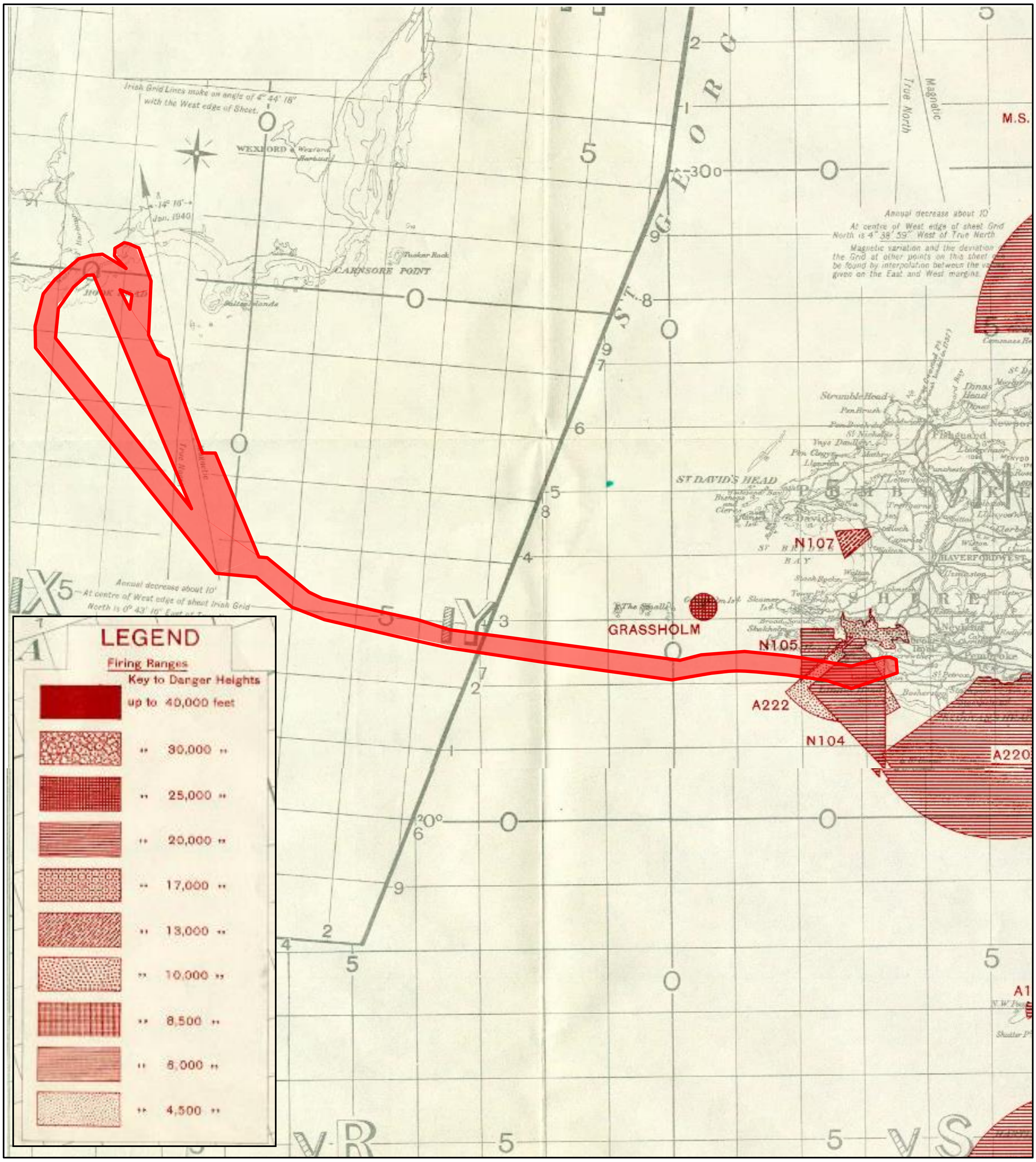
N

Project: **Greenlink**

Ref: **DA2985-01**

Source: The National Archives, Kew

Armament Training Areas Mapping



1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client:	**Intertek**
Project:	**Greenlink**
Ref:	**DA2985-01**
Source:	The National Archives, Kew

Approximate study area

N

DETAILS OF FIXED AFV FIRING POINTS
CASTLEMARTIN RAC RANGE

FIRING POINT		
1	Main Armament up to 3,400 M.	Hard Standing 90x x 30x
2	Main Armament up to 3,400 M. Broadside Mover at 750 M.	Hard Standing 150x x 30x
4	MG and Main Armament up to 1,800 M	Hard Standing 90x x 30x
5	Troop Battle Run. Approx 2 miles.	
6	MG, DST/PRAC and SH PRAC up to 850 M. Broadside Mover 700 M.	
7	MG and Main Armament, DST/PRAC, SH PRAC only. Broadside Mover Oblique 900-1260 M. Travelling Distance of Mover 800 M.	Hard Standing 100x x 30x
8	MG only up to 700 M. Broadside Mover 600 M.	
9	Small Arms only.	
10	Single Tank Battle Run, firing from fixed positions. Length of Run approx 1 mile.	
10A	Single Tank Battle Run (NIGHT), firing from fixed positions. Length of Run approx ¾ mile.	

Night firing will only take place on Ranges 7, 8 or 10A, limited to two nights in one week not consecutively.

There are two concrete Stab Runs Range 6 which affords limited Stab shooting up to 1,000 M and Range 8 MG only up to 650 M.

When Ranges 1 and 2 are being used simultaneously, the firing of MG from Range 1 is forbidden.

When the Mover is being used on Range 2 and firing is also taking place on Range 1, delays may occur due to changing of Mover Target.

APDS will not be fired on Battle Runs or Night Firing.

* * * * * *

THE FOLLOWING COMBINATIONS OF FIRING POINTS CAN BE USED SIMULTANEOUSLY:

1 - 2 - 4 - 8 - 9
1 - 2 - 6 - 8 - 9
1 - 2 - 7 - 8 - 9
1 - 2 - 8 - 9 - 10
5 - 8 - 9
7 - 8 } NIGHT FIRING
10A }

STAB RUNS ARE NOT INCLUDED IN THESE COMBINATIONS

CASTLEMARTIN 1970
(All previous details to be cancelled)

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

CONFIDENTIAL

Castlemartin as a Site for the
Proof & Experimental Establishment now at Shoeburyness
(Note by Ministry of Defence)

Introduction

1. The Castlemartin range is divided into two separate parts. The bulk of it is a tank and armoured car weapons range, but the south eastern corner is used as an air-to-ground range. The whole range has been held by the MOD since World War II and is an area designated a National Park in 1952. It consists of some 6,000 acres plus a danger area extending 14 miles out to sea. The tank range is not used for about four months in the year because of bad weather and in order to let the ground recover. During this period it is used for grazing of sheep from the Prescelly Mountains.

Present and Future Military Use

Tank Range

2. The facilities on the tank range provide for tank and armoured car gunnery practice and are unique in combination in UK. They provide the only place in the UK where the annual gunnery continuation training of unit tank and armoured car crews in UK can take place. The bulk of these units are stationed in the South of England. With the introduction of new equipment the use of the range by British troops will intensify in the near future.

3. Under an agreement dating from 1962 a German Army (FRG) Corps fires at Castlemartin for six months each year. They make intensive use of the range and consider it superior to and less restrictive than the ranges in Germany used by all NATO troops. They have recently confirmed their wish to continue using Castlemartin for the foreseeable future.

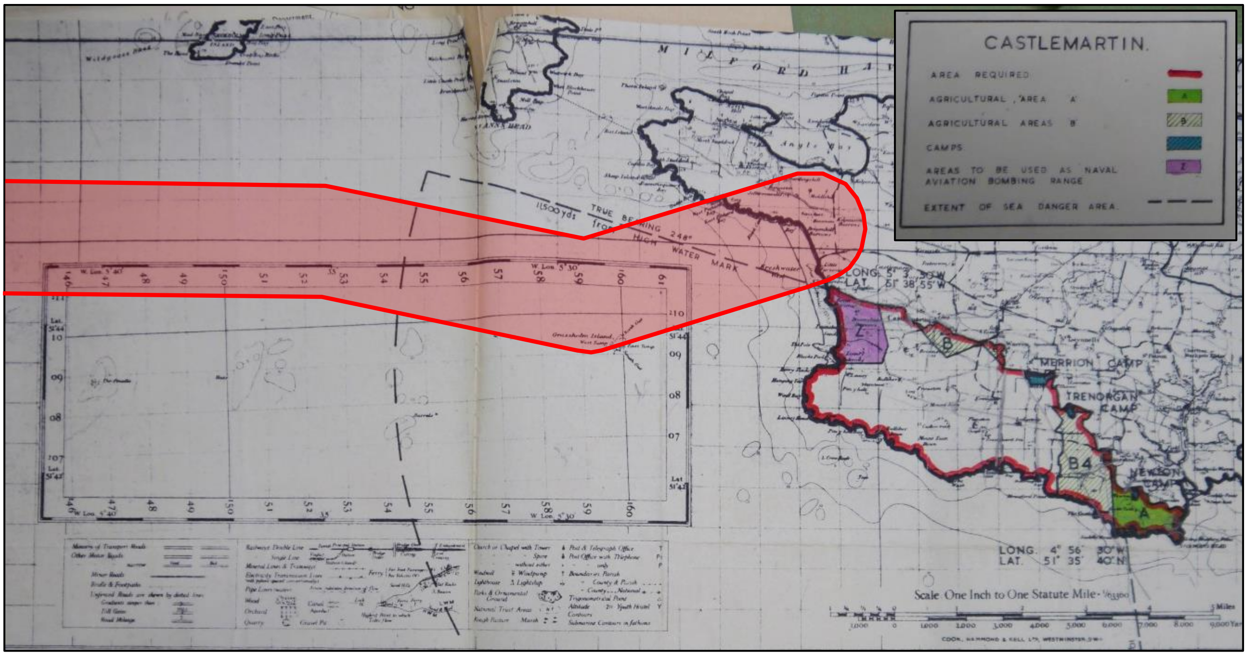
Air-to-Ground Range

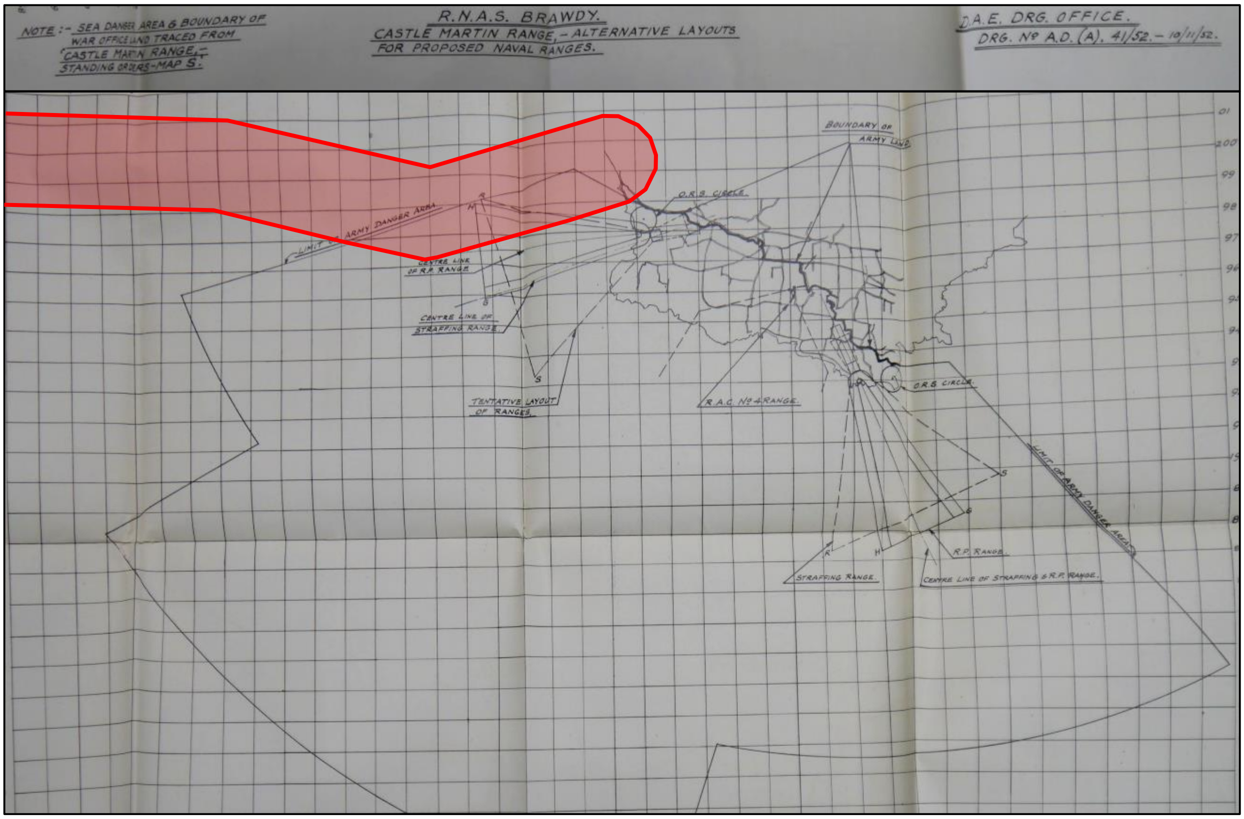
4. Apart from Pembrey, Castlemartin is the only air-to-ground land range in the South-West of UK and is required for weapon firing by Naval helicopters of the training and front line Commando Squadrons based in the South-West. There is also a strong likelihood that Army helicopters will, in future, require use of the range to fire the weapons with which they are being armed.

5. As a result of pressure on regional policy grounds to retain a Defence presence in Brawdy it has been decided that an RAF Jaguar operational training unit should be based there from 1972. This decision is conditional on there being available a suitable air-to-ground weapons range within economic flying

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020





Client: Intertek	Approximate study area
Project: Greenlink	N
Ref: DA2985-01	Source: The National Archives, Kew

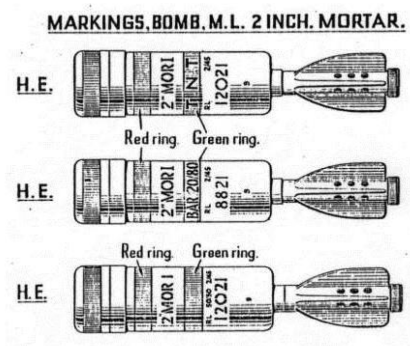
1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Examples of Land Service Ammunition – Mortars

Annex: **L1**

2 inch Mortar High Explosive

Weight	1.02kg (2.25lb)
Maximum Range	460m (500yards)
Filling	200g RDX/TNT
Dimensions	51 x 290mm (2in x 11.4 in)
Fuze Type	An impact fuze which detonates the fuze booster charge and in turn the high explosive charge.
Use	It had greater range and firepower over hand and rifle grenades, and was used to attack targets behind cover with high explosive rounds.
Identification	HE has a rounded edge to a flat back. Can either be a black body colour with red and yellow band or dark green with yellow band. Brass cap on top. Practice will have hole all the way through the top.



2 inch Mortar Smoke

Weight	910g (2lb)
Maximum Range	460m (500yards)
Filling	White phosphorus and smoke fill
Dimensions	51 x 290mm (2in x 11.4 in)
Fuze Type	An impact fuze which initiates a bursting charge. This ruptures the mortar bomb's body and disperses the phosphorus filler
Identification	Smoke mortars have a recess and emission holes. May still see light green body paint. Look for stained ground around munition.
Use	As a screening devices for unit movement or to impair enemy field of vision.

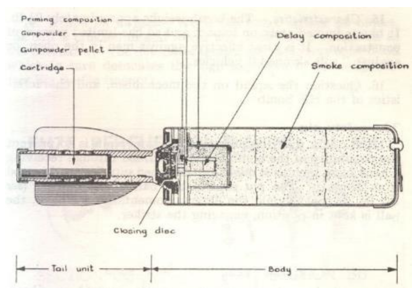
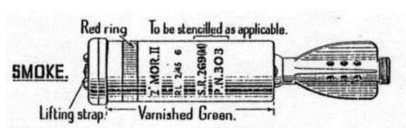
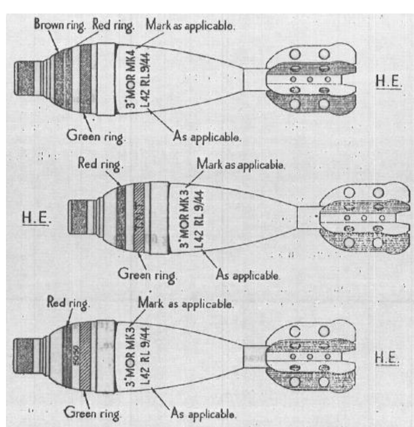


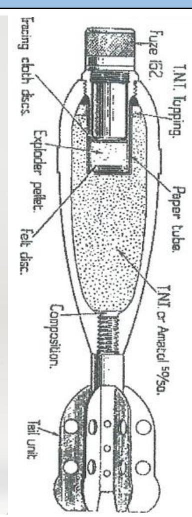
Fig 11.—The smoke bomb (mechanism)



3 inch Mortar High Explosive

Weight	4.5kg (10lb)
Maximum Range	1,460 (Mk1) – 2,560m (Mk2) (1,600 – 2,800yds)
Dimensions	81mm (3in)
Filling	Amatol
Firing Mechanism	Drop, fixed striker
Remarks	Fin-stabilised bomb fired by means of a charge consisting of a primary cartridge in the tail and four secondary cartridges
Identification	An old style mortar. No way of telling if HE or practice so treat as HE



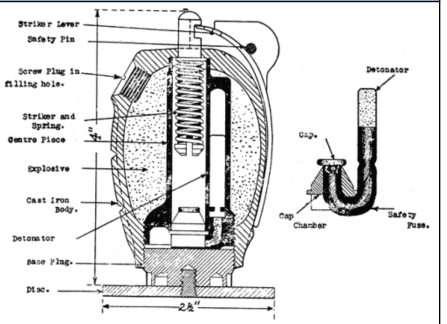


Examples of Land Service Ammunition – Grenades

Annex: **L2**

No. 36 'Mills' Grenade

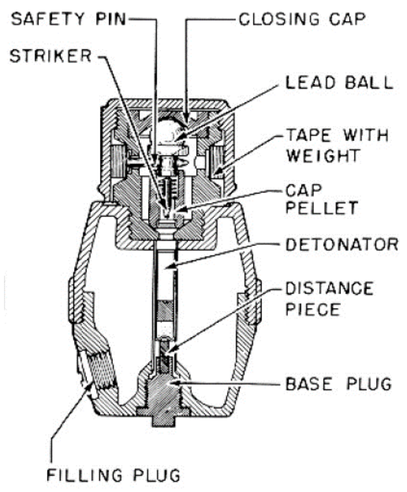
Weight	765g filled (1lb 11.25oz)
Explosive Weight	71g (2oz) filling.
Fuze Type	4-7 second delay hand-throwing fuze. No. 6 Detonator
Dimensions	95 x 61mm (4 x 2.4in)
Use	Fragmentation explosive at approx. 30m range 100m range of damage.
Remarks	First introduced in 1915 its classic grooved, cast-iron 'pineapple' design was designed to provide uniform fragmentation. The detonator is inserted before use after removing the base plug.



Left: baseplate and detonator removed

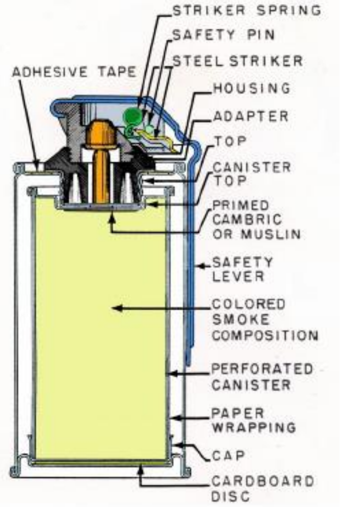
No. 69 Grenade

Weight	383g (13.5oz)
Fill Weight	93g (3.25 oz) of either Amatol, Baratol or Lyddite
Fuze Type	'All-ways' Fuze. Compromised of a safety cap, a weighted streamer attached to a steel ball bearing and a safety bolt designed to detonate from any point of impact.
Dimensions	115 x 60mm (4.5 x 2 .4 in)
Use	A blast grenade for use as an offensive weapon. Detonator was inserted before use.
Remarks	Introduced December 1940 and made from the plastic Bakelite as opposed to conventional metals. Detection is difficult due to this low metal content.



No. 83 Smoke Grenade

Weight	Approx. 680g (1.5lb)
Explosive Weight	Approx. 170-200g. (6-7 oz)
Fuze Type	Originally used a friction system using a match head composition. Later developed to a striker lever ignition system.
Dimensions	Approx. 62 x 140mm (2.44 x 5.5 in)
Use	Use as a target or landing zone marking device and as a screening method for troop / unit movement.
Remarks	This basic design stayed relatively unchanged up to the 1980's. The letters CCC were often etched into the body of the grenade in the colour of the smoke.



Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01** Source: Various sources

Examples of Projectiles

From left to right: a 6 pounder 8 cwt; 3 pdr 2 cwt; 2 pdr No. 2; 6 pdr 7 cwt.

Ordnance QF 2-Pounder Gun

Total weight	Between 1.86lb and 2.69lb
Calibre	40 mm (1.575 in)
Remarks	British anti-tank and vehicle mounted gun, used early in WWII.

Firing practise against beach obstacles in 1942

Ordnance QF 3-Pounder Gun

Total weight	3lb 4oz
Calibre	47-millimetre (1.85 in)
Remarks	British tank gun based on earlier naval gun, mounted on Vickers Medium Tanks in the 1920s and 1930s

Vickers Medium Mk II (special) tank

Ordnance QF 6-Pounder Gun

Total weight	Between 6lb 4 oz and 7lb 2oz
Calibre	2.24 in (57 mm)
Remarks	Primarily an anti-tank gun incorporated subsequently on a number of armoured fighting vehicles. First tank to go into action armed with the 6 pounder gun, was the Mark III version of the Churchill tank, in the Dieppe Raid of August 1942.

6-pounder platoon

Ordnance QF 20-Pounder Gun

Total weight	20lb
Calibre	84 millimetres (3.31 in)
Remarks	British tank gun introduced in 1948 and used the Centurion main battle tank, Charioteer medium tank, and Caernarvon Mark II heavy tank.

British Centurion Mk.3

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

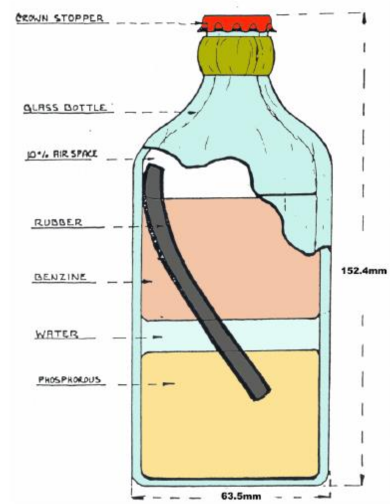
Ref: **DA2985-01** Source: Various sources

Home Guard

Annex: **L4**

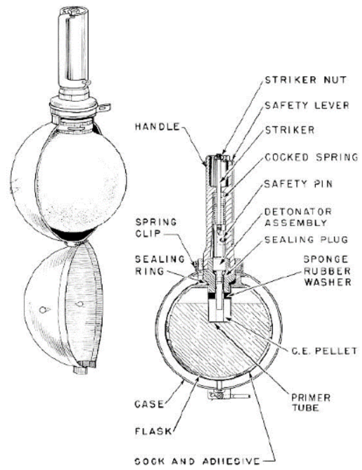
No. 76 Self Igniting Phosphorous (SIP) Grenade

Weight	1lb 3oz
Filling	White Phosphorous and Benzene
Design	The filling was contained in a ½ pint sized glass bottle with water and a strip of rubber. Over time the rubber dissolved to create a sticky which would self ignite when the bottle broke.
Use	Originally intended as an anti-tank incendiary weapon deployed by hand. Designed to be produced cheaply without consuming materials needed to produce armaments on the front line.
Remarks	The Home Guard hid caches of these grenades during the war for use in the event of an invasion. Not all locations were officially recorded and some caches were lost and encountered post-war. In all cases, the grenades are still found to be dangerous.



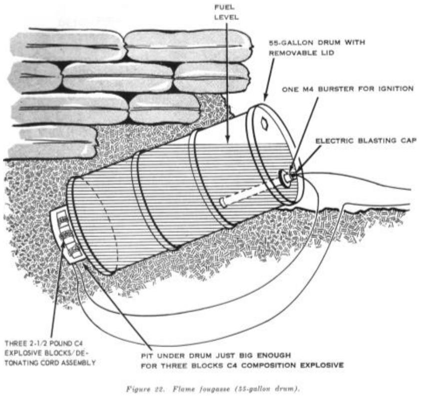
No. 74 Grenade ("Sticky Bomb") Mk1

Weight	Approx. 1.1kg (2.25lb)
Filling	Approx. 600g Nobel's No.283 (Nitro-glycerine) (1.33lb)
Design	A glass ball on the end of a Bakelite (plastic) handle. The inside of the ball would contain the explosive filling and the outside a very sticky adhesive coating.
Use	An anti-tank grenade primarily issued to the home guard. It required the user to come in very close proximity with the target and smash the glass explosive container against it.
Remarks	Timer fuze was located in the handle. This would explode after 3-6 secs. 9.5in Long 4.5in Diameter



Flame Fougasse Bomb

Weight	Various
Filling	Initially a mixture of 40% petrol and 60% gas. Ammonal provided the propellant charge.
Design	Usually constructed from a 40-gallon drum dug into a roadside and camouflaged.
Use	As an improvised anti-tank bomb. When triggered the Fougasse could project a beam of burning sticky fuel in a fixed direction from up to 3m (10ft) wide and 27m (30yards) long.
Remarks	A highly unorthodox weapon designed by the Petroleum Warfare Department to address a critical lack of weapons in 1940. 50,000 are estimated to have been distributed around the UK.



1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01** Source: Various sources

Examples of Small Arms Ammunition

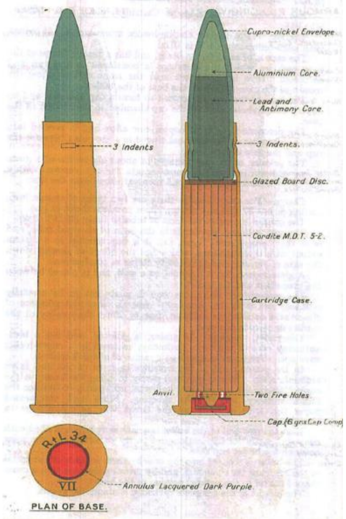
Annex: **L5**

Examples of British Small Arms Ammunition

.303 Rifle

Bullet Diameter	7.92mm
Case length	56.44mm
Overall length	78.11mm
Type	Rifle Ammunition
Propellant	Originally black powder. Later Cordite followed by Nitrocellulose
Remarks	First produced in 1889 and still in use today, the .303inch cartridge has progressed through ten ‘marks’ which eventually extended to a total of around 26 variations.

Bullet Type	Colour of tip	Colour of Annulus
Armour Piercing	Green	Green
Ball	None	Purple
Incendiary	Blue	Blue
Observing	Black	Black
Proof	None	Yellow
Tracer Short Range	White	Red
Tracer Dark Ignition	Grey	Red
Tracer Long Range	Red	Red



Buried and Decayed Ammunition

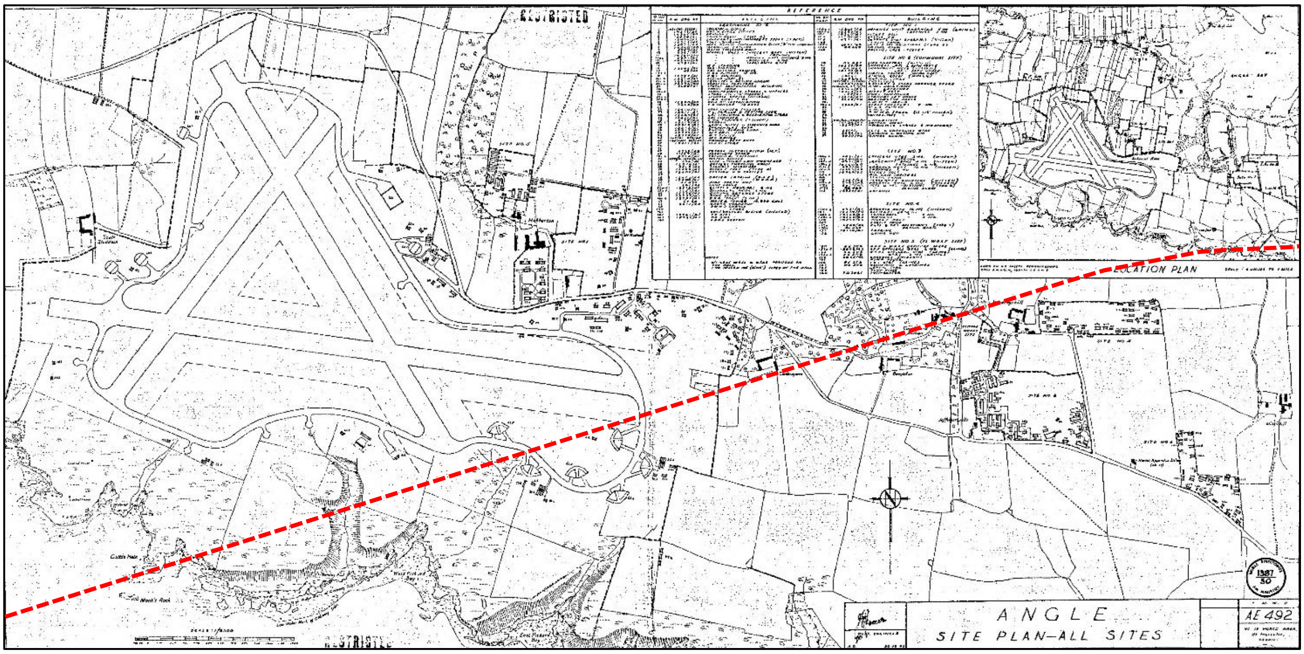
1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

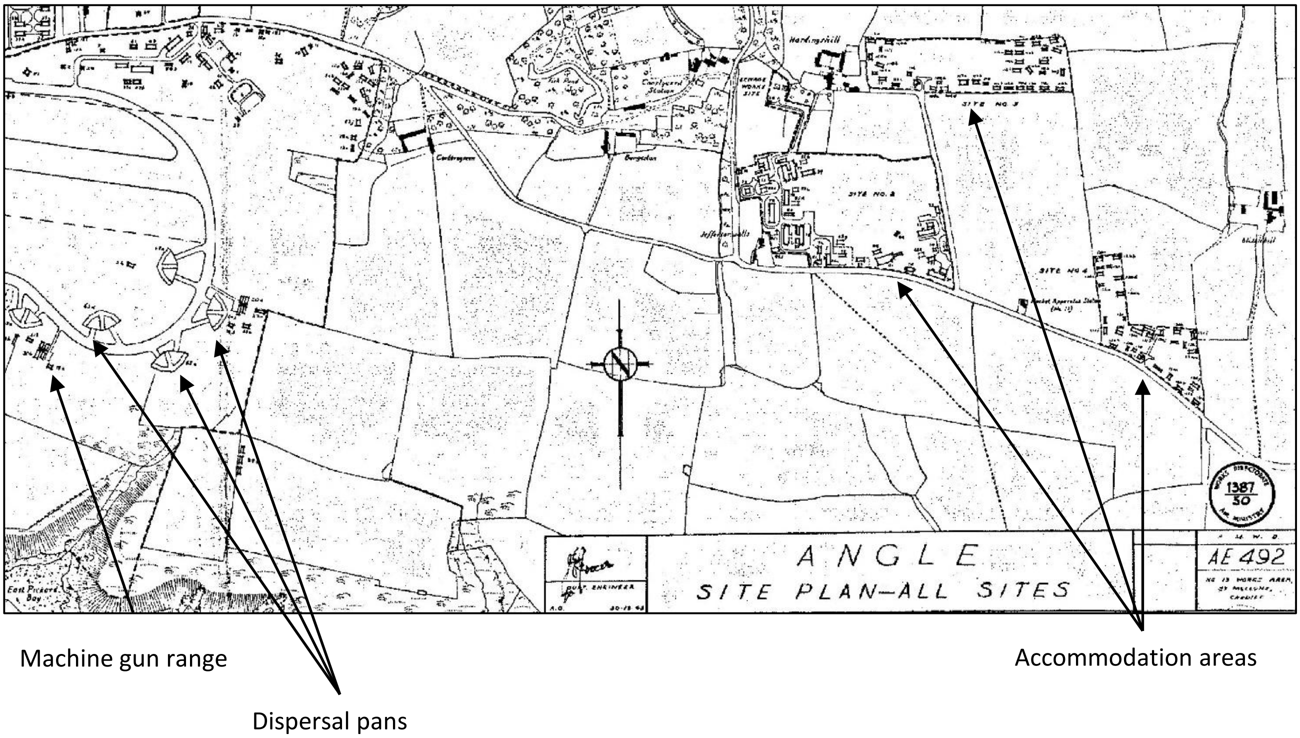
Project: **Greenlink**

Ref: **DA2985-01** Source: Various sources

RAF Angle Site Plan



Above: Land south of boundary indicates route coverage. *Below*: Enlarged and annotated.

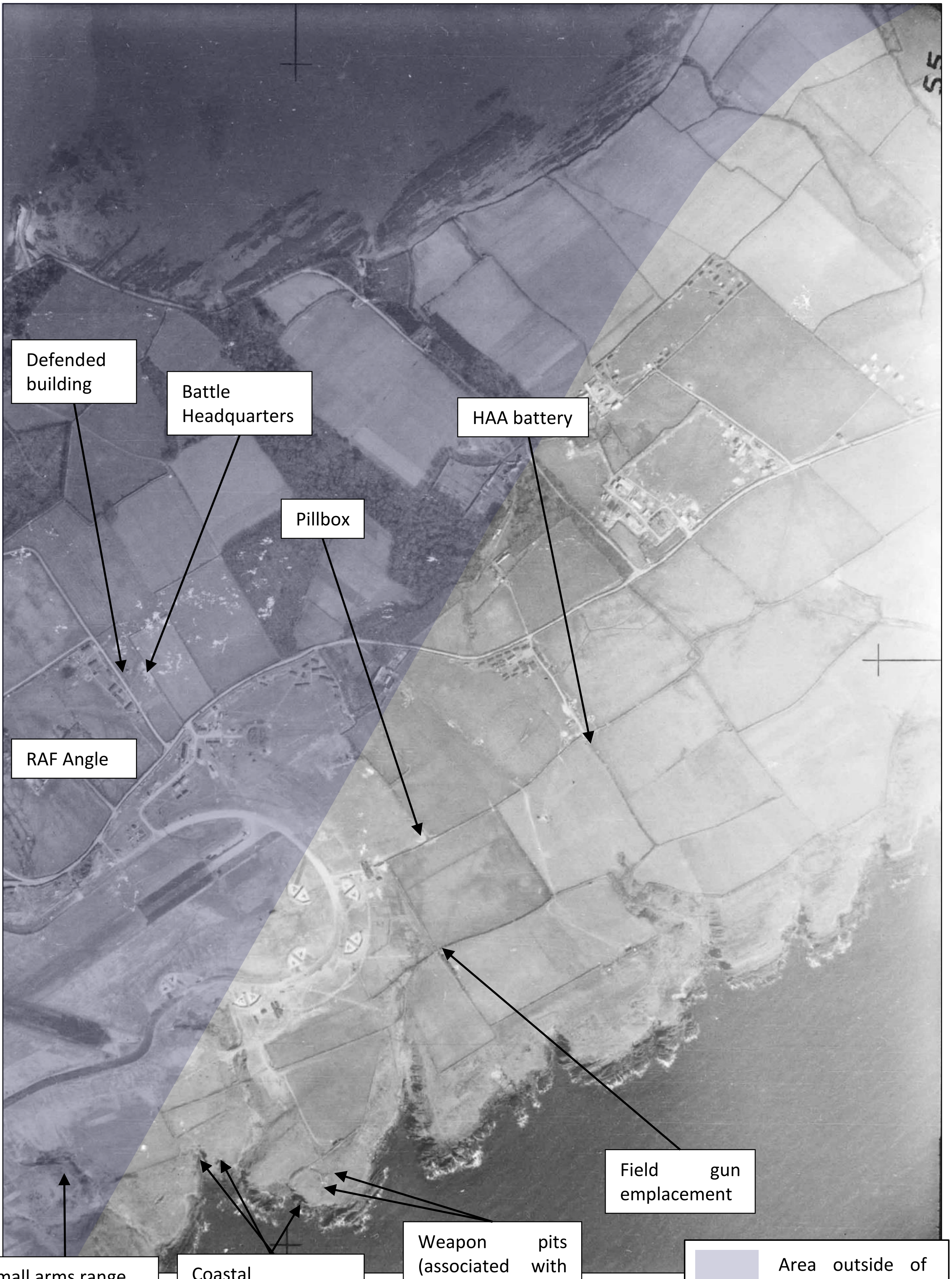


1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**	**Approximate study area boundary**	N
Project: **Greenlink**		
Ref: **DA2985-01**	Source: RAF Hendon	

RAF Aerial Photography 23rd March 1942

Annex: **N1**



1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

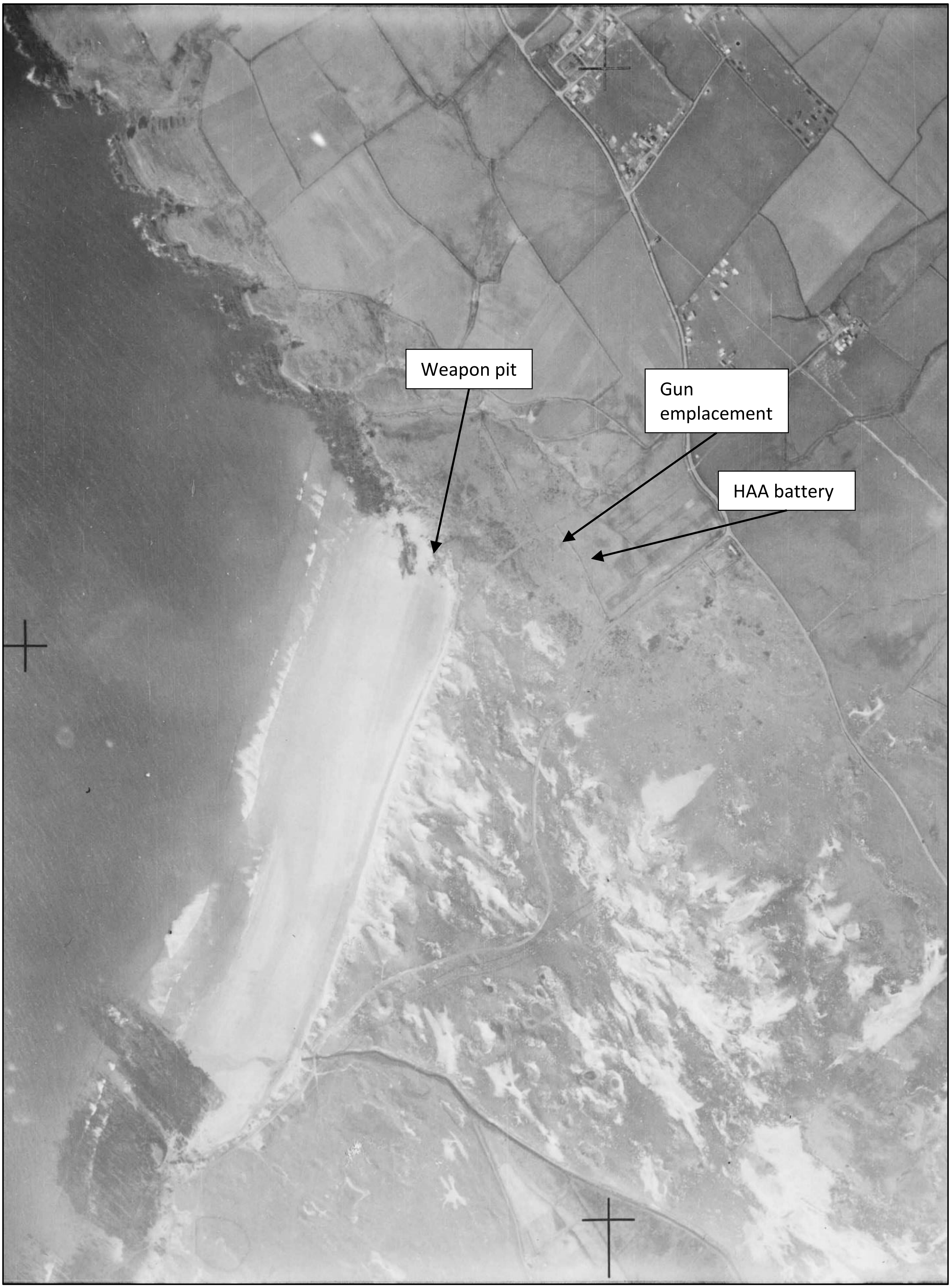
Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

N

RAF Aerial Photography 23rd March 1942

Annex: **N2**



1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

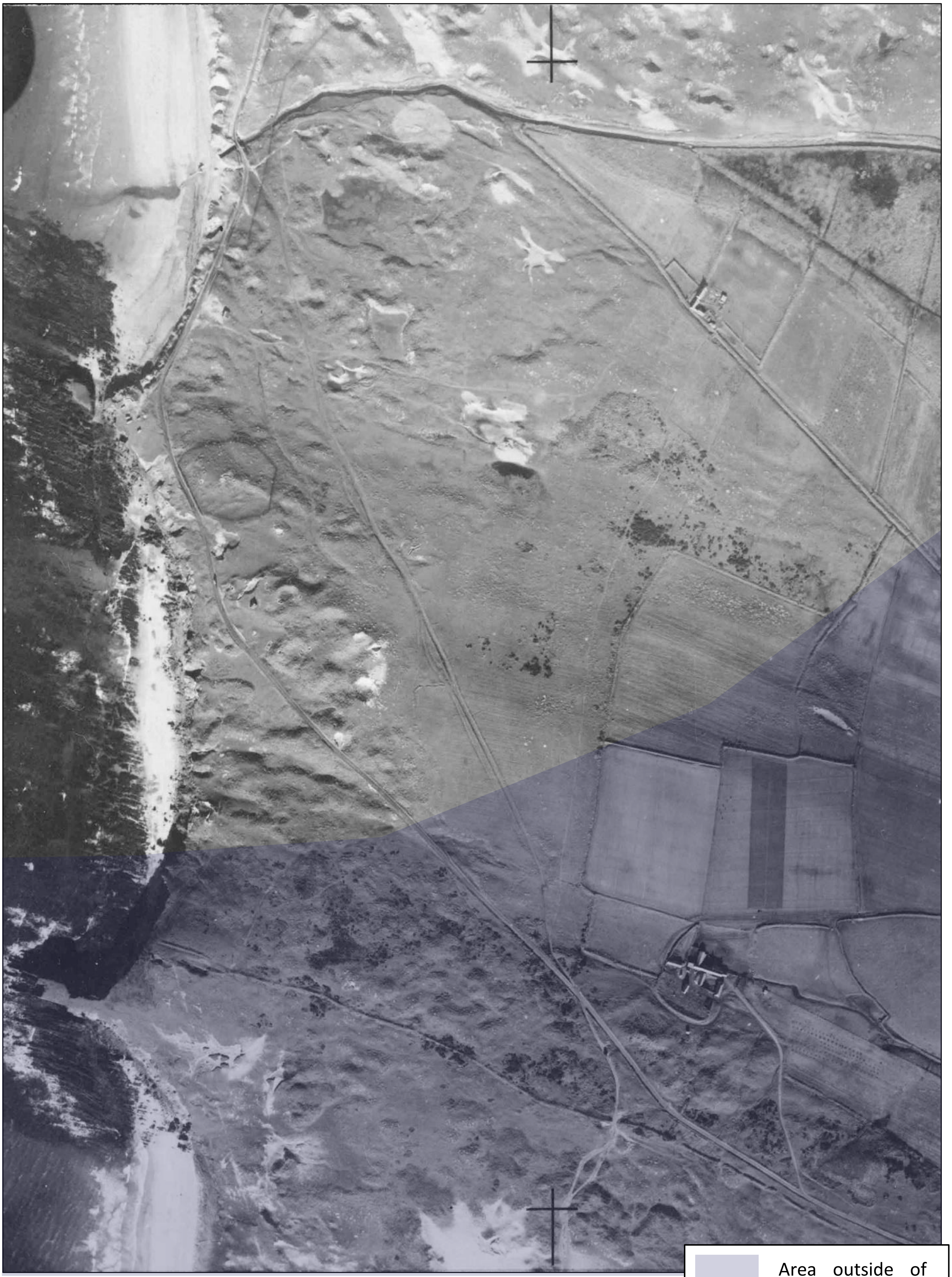
Project: **Greenlink**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 10th February 1942

Annex: **N3**



Area outside of study area

1st Line Defence

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

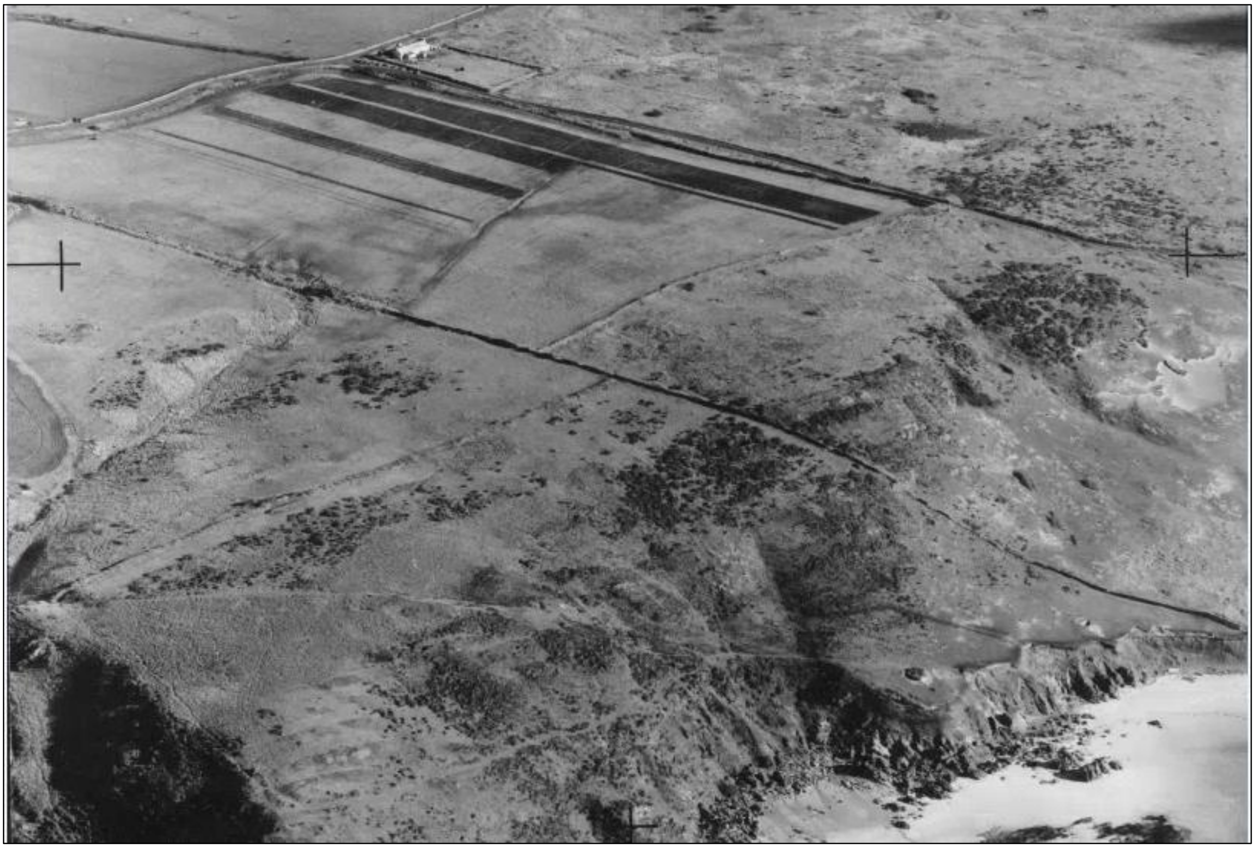
Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

N

RAF Aerial Photography 10th February 1942

Annex: N4



1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

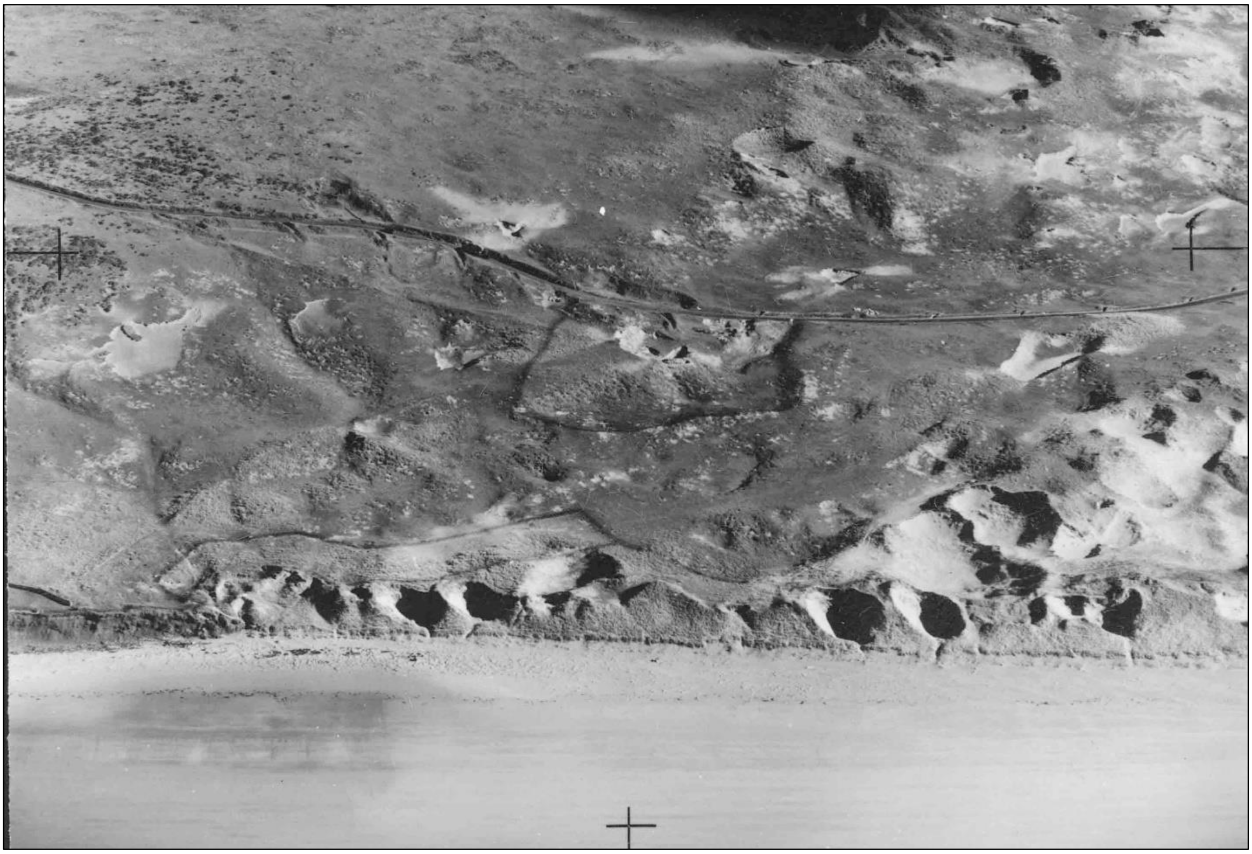
Project: **Greenlink**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 10th February 1942

Annex: N5



1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 10th February 1942

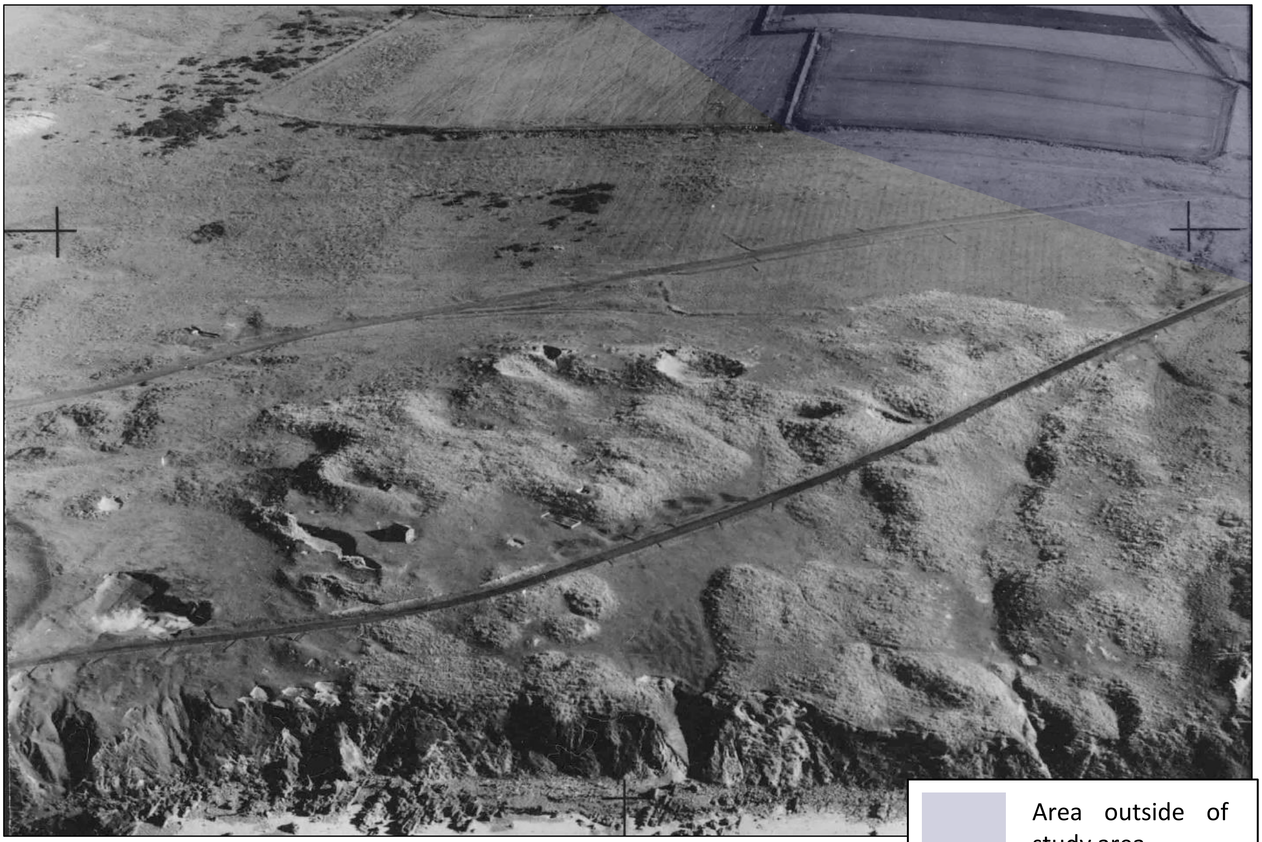
Annex: N6

Client:	**Intertek**	
Project:	**Greenlink**	
Ref:	**DA2985-01**	Source: National Monuments Record Office (Historic England)

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

RAF Aerial Photography 10th February 1942

Annex: N7



Area outside of study area

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 7th July 1946

Annex: O1

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 7th July 1946

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01**

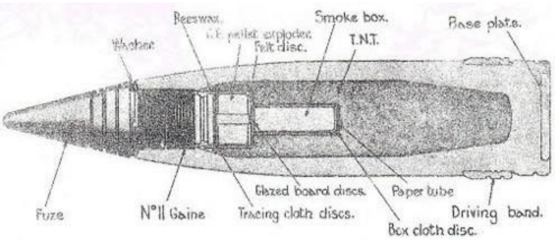
Source: National Monuments Record Office (Historic England)

N

Examples of Anti-Aircraft Projectiles

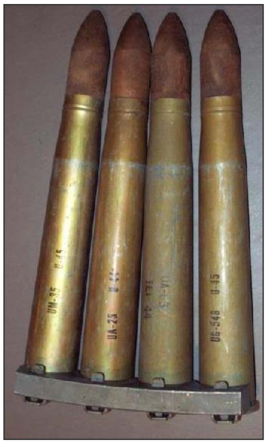
3.7 Inch QF Anti-Aircraft Projectile

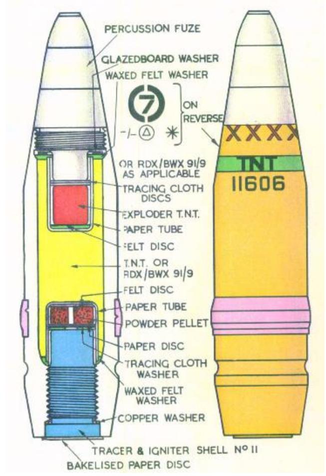
Projectile Weight	28lb (12.6 kg)
Explosive Weight	2.52lbs
Fuze Type	Mechanical Time Fuze
Dimensions	3.7in x 14.7in (94mm x 360mm)
Rate of Fire	10 to 20 rounds per minute
Use	The 3.7in AA Mks 1-3 were the standard Heavy Anti-Aircraft guns of the British Army.
Ceiling	30,000ft to 59,000ft



40mm Bofors Projectile

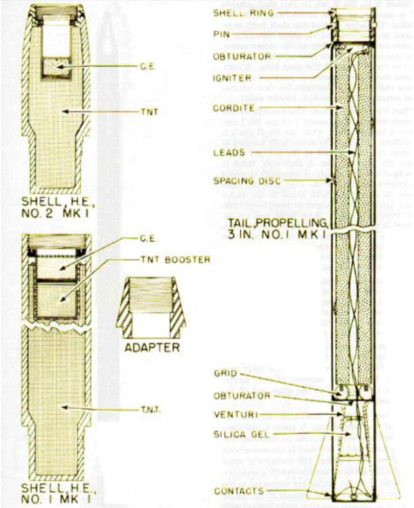
Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Impact Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40 x 180mm
Ceiling	23,000ft (7000m)
Remarks	Light quick fire high explosive anti-aircraft projectile. Each projectile fitted with small tracer element. If no target hit, shell would explode when tracer burnt out. Designed to engage aircraft flying below 2,000ft





3in Unrotated Projectile (UP) Anti-Aircraft Rocket ("Z" Battery)

HE Projectile Weight	3.4kg (7.6lb)
Explosive Weight	0.96kg (2.13lb)
Filling	High Explosive – TNT. Fitted with aerial burst fuzing
Dimensions of projectile	236 x 83mm (9.29 x 3.25in)
Remarks	As a short range rocket-firing anti-aircraft weapon developed for the Royal Navy. It was used extensively by British ships during the early days of World War II. The UP was also used in ground-based single and 128-round launchers known as Z Batteries. Shell consists of a steel cylinder reduced in diameter at the base and threaded externally to screw into the shell ring of the rocket motor

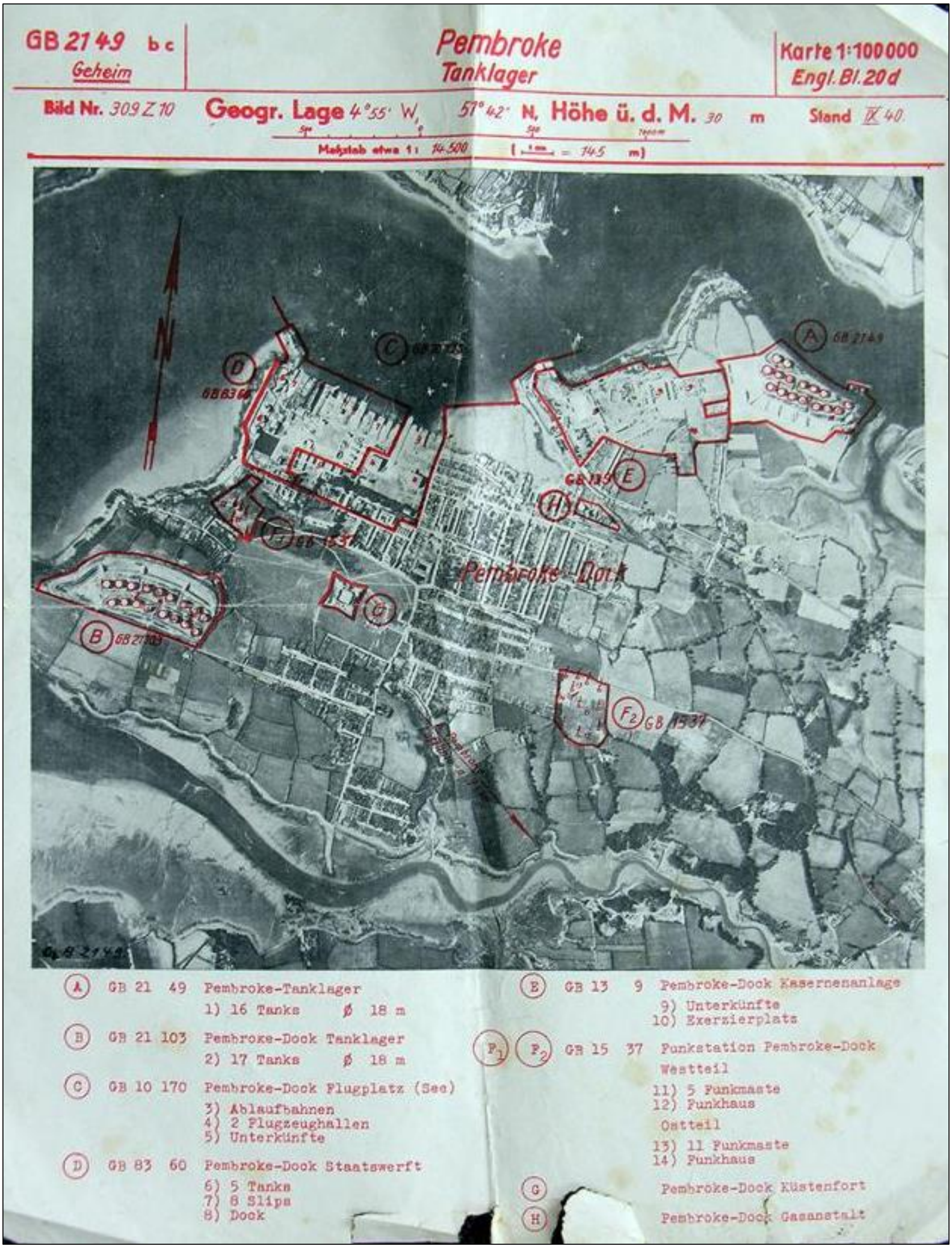


1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01** Source: Various sources

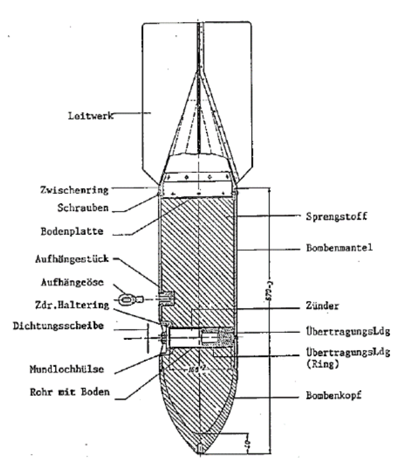


Luftwaffe aerial photograph of Pembroke Dock, 1940. The military installations have been marked and identified. This document was retrieved from a German airbase in Schleswig Holstein in late 1945, by Reg McKenzie while he was serving with the Royal Corps of Signals.

Examples of German Air-Delivered Ordnance

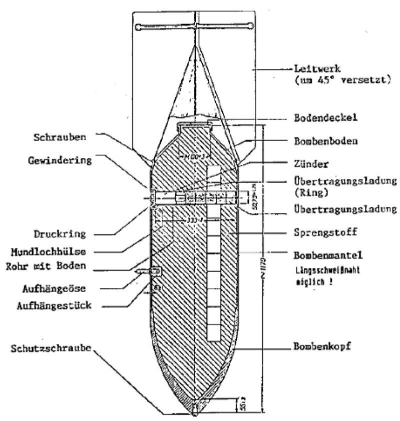
SC 50kg High Explosive Bomb

Bomb Weight	40-54kg (88-119lb)
Explosive Weight	c25kg (55lb)
Fuze Type	Impact fuze/electro-mechanical time delay fuze
Bomb Dimensions	1,090 x 280mm (42.9 x 11.0in)
Body Diameter	200mm (7.87in)
Use	Against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to three stories.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.



SC 250kg High Explosive Bomb

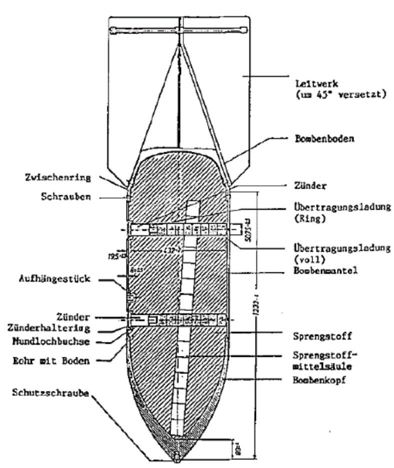
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground installations.
Remarks	It could be carried by almost all German bomber aircraft, and was used to notable effect by the Junkers Ju-87 Stuka (Sturzkampfflugzeug or dive-bomber).

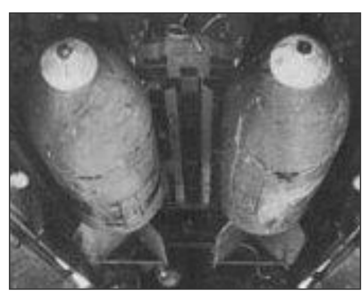



SC250 bomb being loaded onto German bomber

SC 500kg High Explosive Bomb

Bomb Weight	480-520kg (1,058-1,146lb)
Explosive Weight	250-260kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1957 x 640mm (77 x 25.2in)
Body Diameter	470mm (18.5in)
Use	Against fixed airfield installations, hangars, assembly halls, flyovers, underpasses, high-rise buildings and below-ground installations.
Remarks	40/60 or 50/50 Amatol TNT, trialene. Bombs recovered with Trialen filling have cylindrical paper wrapped pellets 1-15/16 in. in length and diameter forming





1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

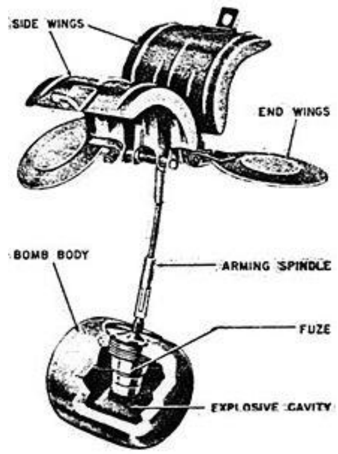
Ref: **DA2985-01** Source: Various sources

Examples of German Air-Delivered Ordnance

Annex: **R2**

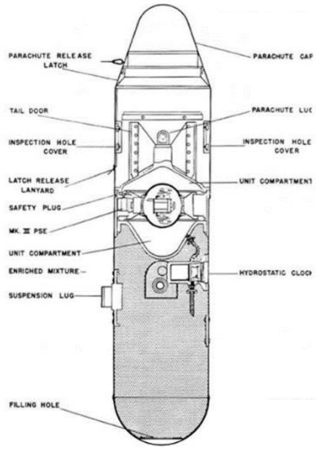
SD2 Anti-Personnel 'Butterfly Bomb'

Bomb Weight	2kg (4.41lb)
Explosive Weight	7.5oz (225 grams) of Amatol surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	Designed as an anti-personnel/ fragmentation weapon. They were delivered by air, being dropped in containers of 23-144 sub-munitions that opened at a predetermined height, thus scattering the bombs.
Remarks	Very rare. First used against Ipswich in 1940, but were also dropped on Kingston upon Hull, Grimsby and Cleethorpes in June 1943, amongst various other targets in UK. As the bombs fell the outer case flicked open by springs which caused four light metal drogues with a protruding 5 inch steel cable to deploy in the form of a parachute & wind vane which armed the device as it span.



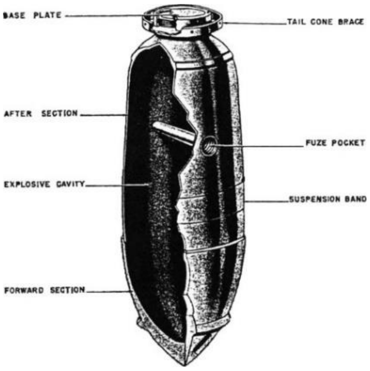
Parachute Mine (Luftmine B / LMB)

Bomb Weight	Approx. 990kg (2176lb)
Explosive Weight	Approx. 705kg (1,554lb)
Fuze Type	Impact/ Time delay / hydrostatic pressure fuze
Dimensions	2.64m x 0.64m (3.04m with parachute housing)
Use	Against civilian, military and industrial targets. Used as blast bombs and designed to detonate above ground level to maximise damage to a wider area.
Remarks	Deployed a parachute when dropped in order to control its descent. Had the potential to destroy a whole street of housing in a 100m radius.



SC 1000kg

Bomb Weight	993-1027kg (2,189-2,264lb)
Explosive Weight	530-620kg (1168-1367lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Filling	Mixture of 40% amatol and 60% TNT, but when used as an anti-shipping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder.
Bomb Dimensions	2800 x 654mm (110 x 25.8in)
Body Diameter	654mm (18.5in)
Use	SC type bombs are General Purpose Bombs used primarily for general demolition work. Constructed of parallel walls with comparatively heavy noses. They are usually of three piece welded construction



1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **Greenlink**

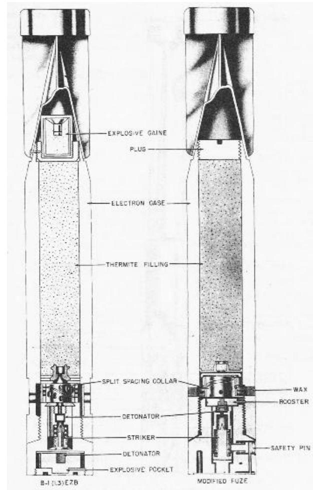
Ref: **DA2985-01** Source: Various sources

German Incendiary Bombs

Annex: **R3**

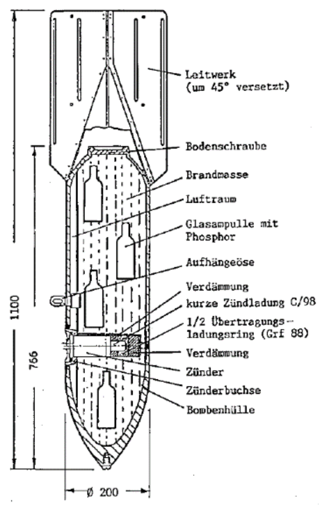
1kg Incendiary Bomb

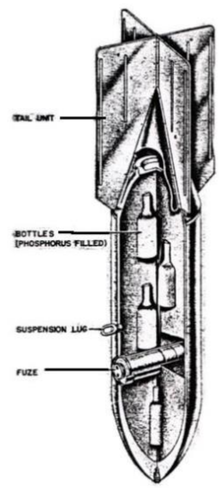
Bomb Weight	1.0 and 1.3kg (2.2 and 2.9lb)
Explosive Weight	680g (1.3lb) Thermite 8-15gm Explosive Nitropenta
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters against towns and industrial complexes
Remarks	Magnesium alloy case. Sometimes fitted with high explosive charge. The body is a cylindrical alloy casting threaded internally at the nose to receive the fuze holder and fuze.



C50 A Incendiary Bomb

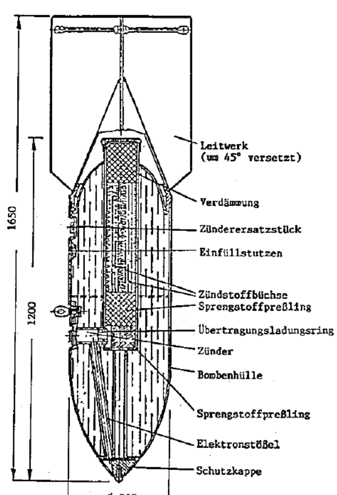
Bomb Weight	c41kg (90.4lb)
Explosive Weight	0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against all targets where an incendiary effect is required
Remarks	Early fill was a phosphorous/carbon disulphide incendiary mixture





Flam C-250 Oil Bomb

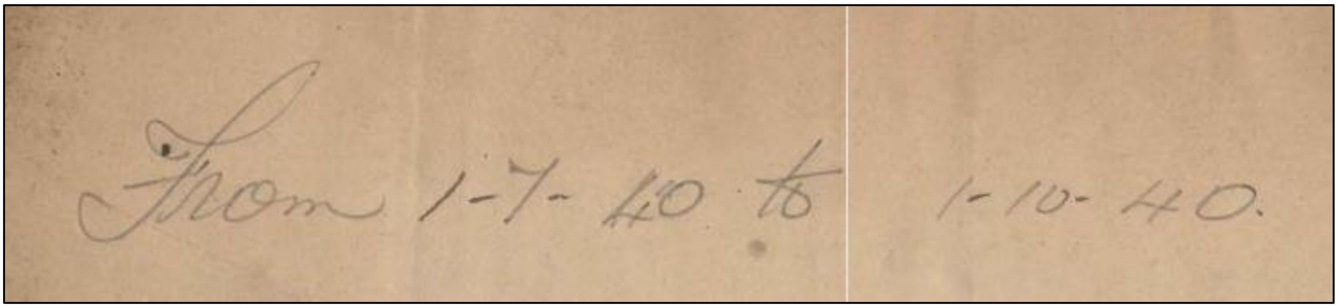
Bomb Weight	125kg (276lb)
Explosive Weight	1kg (2.2lb)
Fuze Type	Super-fast electrical impact fuze
Filling	Mixture of 30% petrol and 70% crude oil
Bomb Dimensions	1,650 x 512.2mm (65 x 20.2in)
Body Diameter	368mm (14.5in)
Use	Often used for surprise attacks on ground troops, against troop barracks and industrial installations. Thin casing – not designed for ground penetration



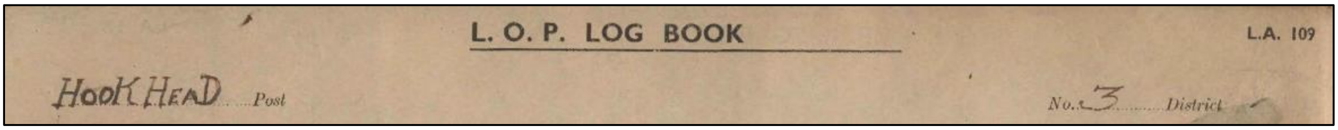
LOP (Look Out Post) Logbook – Hook Head

Annex: **S**

Title page of document



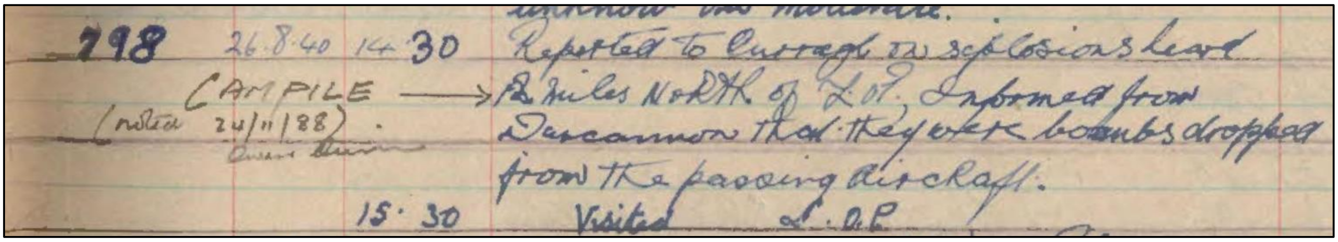
From 1-7-40 to 1-10-40.



L. O. P. LOG BOOK L.A. 109

HOOK HEAD Post No. 3 District

Relevant entry – 26th August 1940



298	26.8.40	14.30	Reported to Curragh explosions heard 12 miles NORTH of LOP. Informed from Duncannon that they were bombs dropped from the passing aircraft.
CAMPILE → (noted 24/11/88)			
		15.30	Visited L.O.P.

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

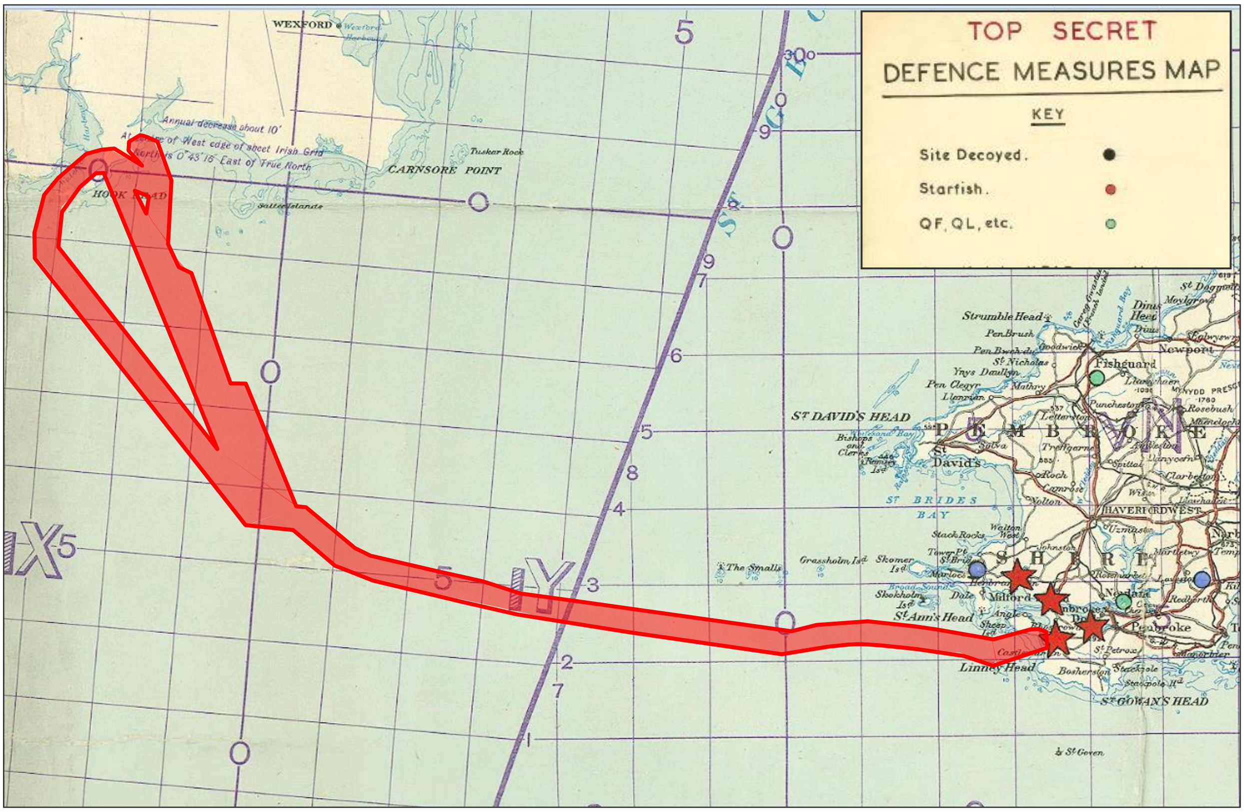
Client: **Intertek**

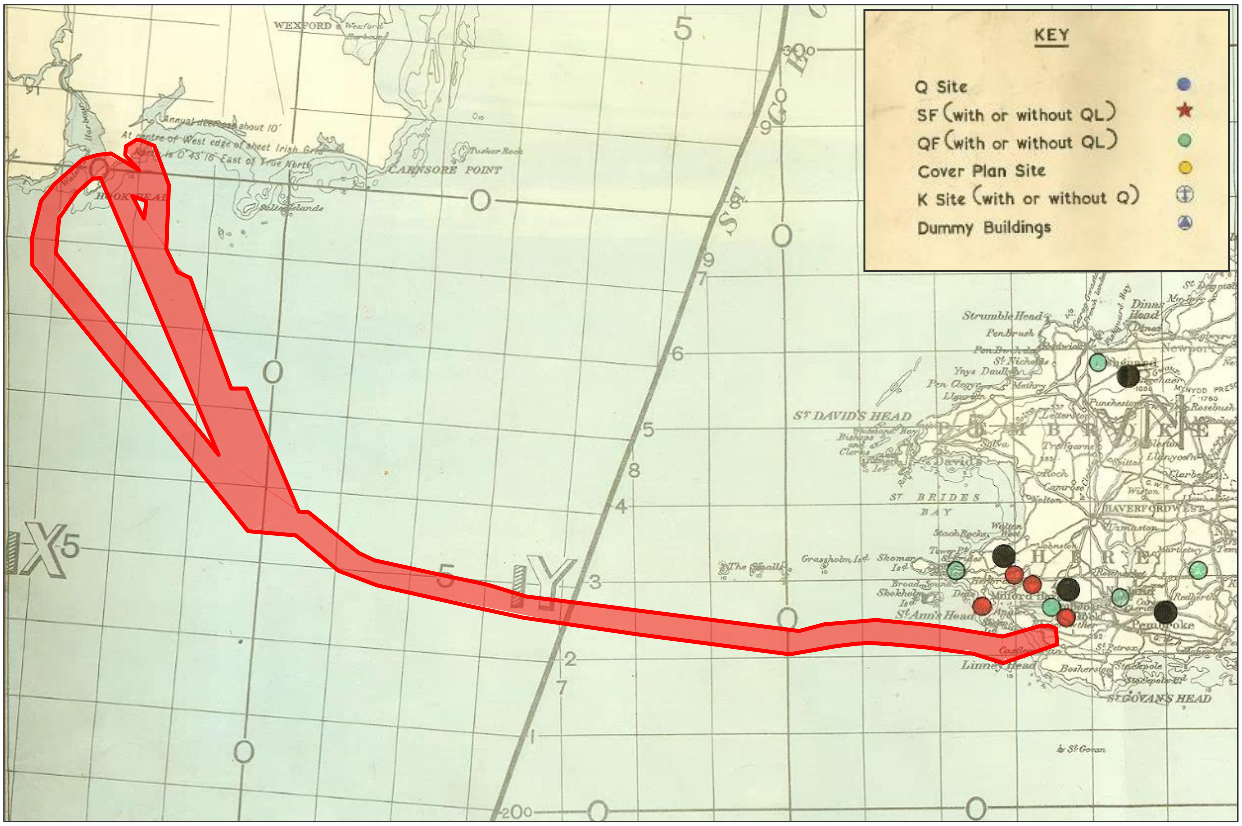
Project: **Greenlink**

Ref: **DA2985-01** Source: Defence Forces Ireland Military Archives

Decoy Site Mapping

Annex: **T**



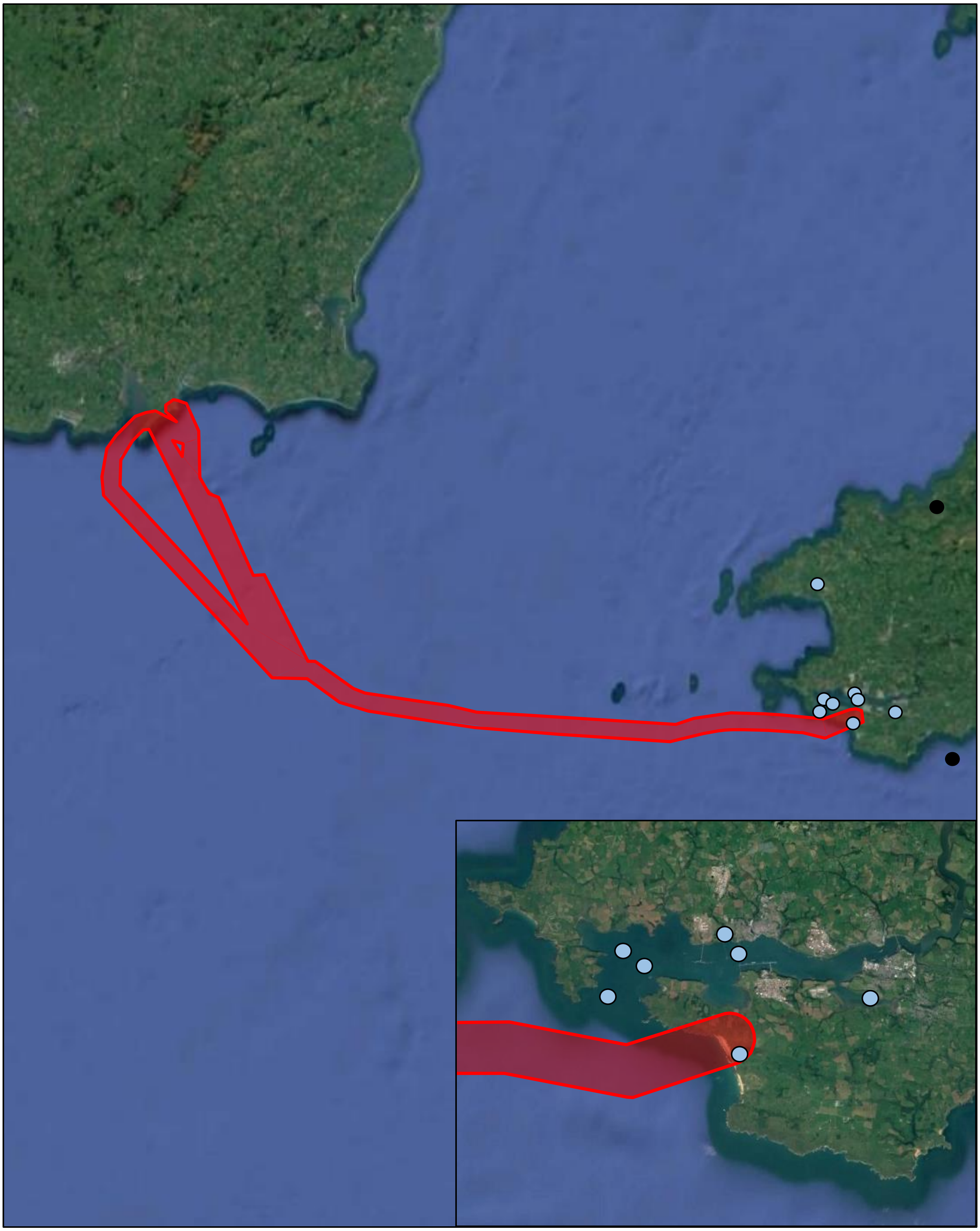


1ST LINE DEFENCE	Client: **Intertek**	**Approximate study area**
	Project: **Greenlink**	N
	Ref: **DA2985-01**	Source: The National Archives, Kew

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

OSPAR Munition Encounters

Annex: **U**



Key:

Conventional

Unknown

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Approximate study area

Project: **Greenlink**

N

Ref: **DA2985-01**

Source: OSPAR

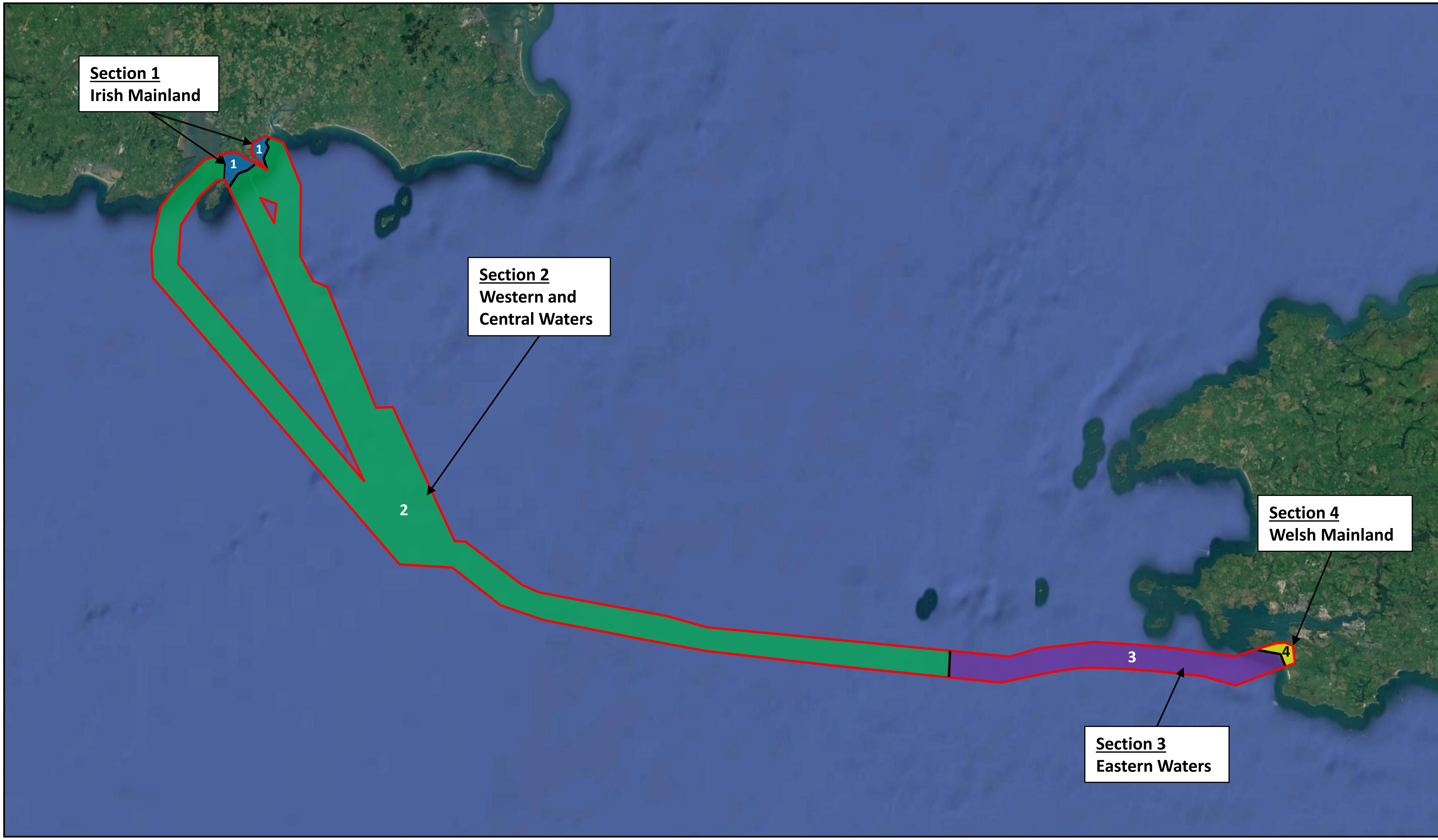
1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road
Hoddesdon
Hertfordshire
EN11 0EX
Tel: 01992 245020

www.1stlinedefence.co.uk

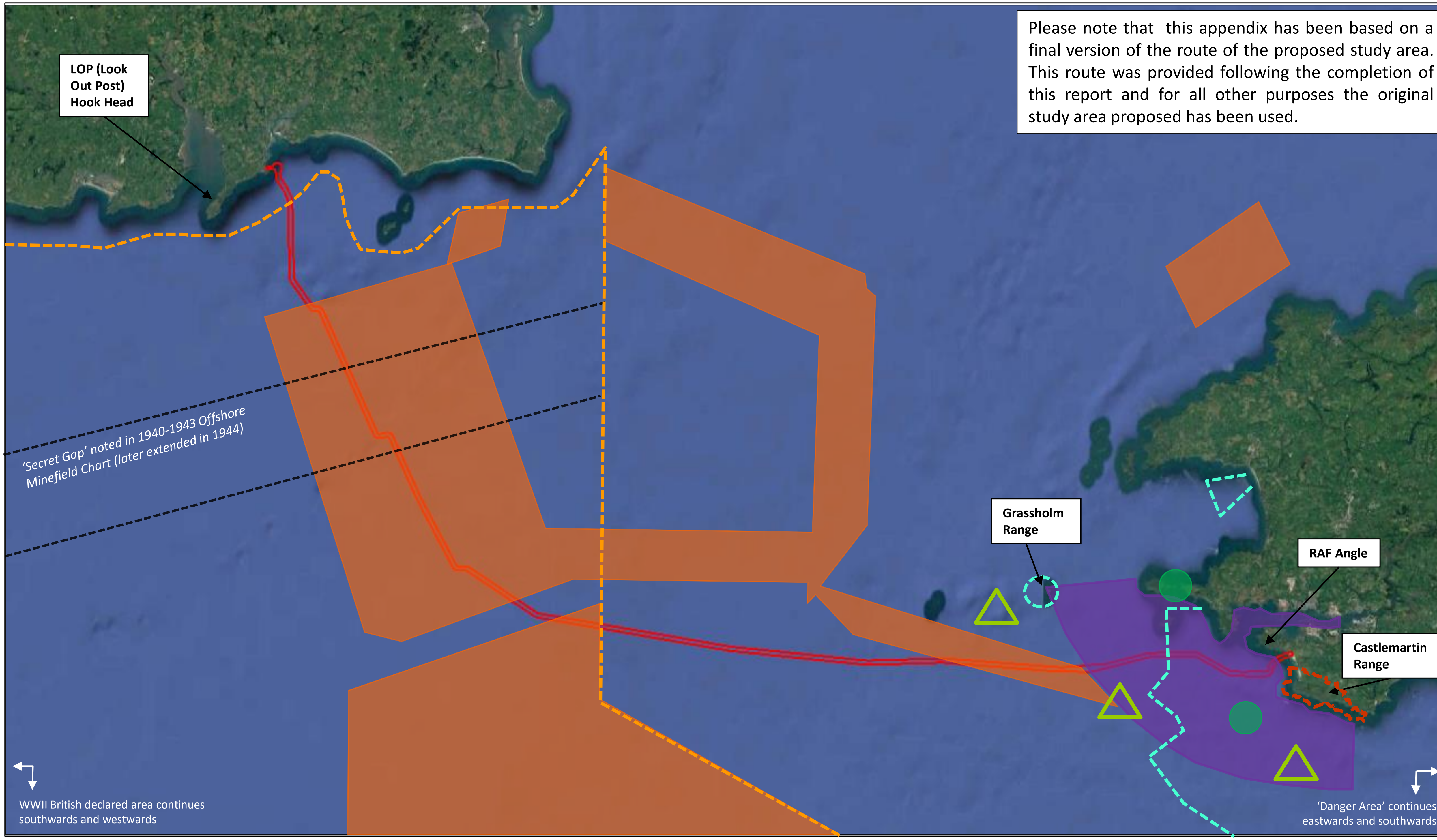
1ST LINE DEFENCE

Sections of Study Area



1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 446 974

Client:	Intertek	Approximate study area	N
Project:	Greenlink		
Ref:	DA2985-01	Source:	1st Line Defence



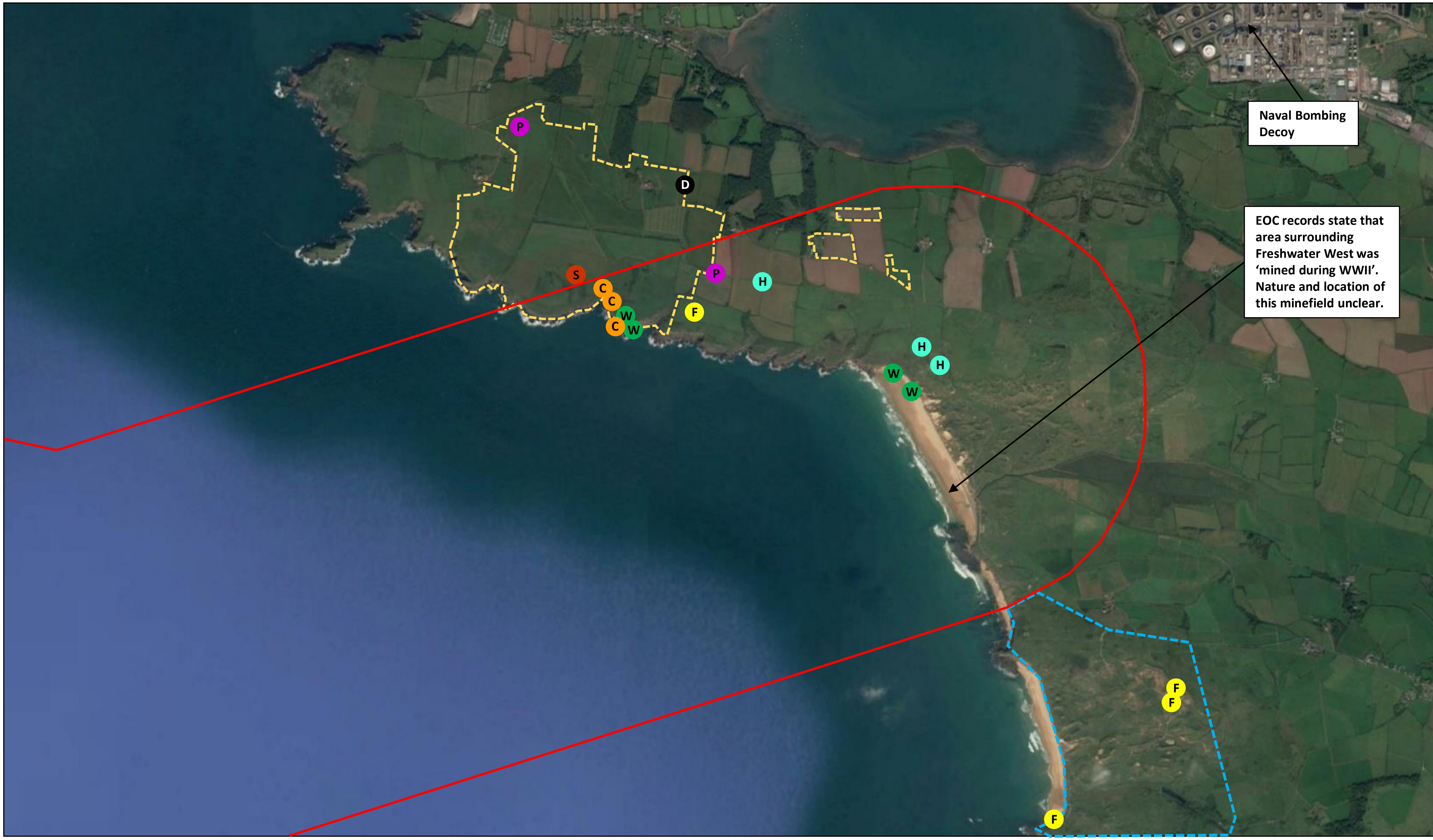
Key:

- Reported WWI German Minefield. *Not geographically accurate. Extents based on historical literature and recorded wrecks caused by WWI German mines.*
- WWII British Minefield
- WWII Enemy Minefield
- WWII British Declared Areas
- Extent of WWII Armament 'Danger Area' Associated with Training
- Recorded Munitions Dumpsite
- **Approximate study area**

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 446 974

Client:	**Intertek**
Project:	**Greenlink**
Ref:	**DA2985-01**
Source:	1st Line Defence

N



Key:

C	Coastal observation point
H	HAA battery
S	Small arms range
D	Defended building/battle HQ
W	Weapon pit
P	Pillbox
F	Field gun emplacement

Extents of:

RAF Angle

Castlemartin Naval Aviation Bombing Range

1ST LINE DEFENCE
Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 446 974

Client:	**Intertek**	**Approximate study area**
Project:	**Greenlink**	
Ref:	**DA2985-01**	Source: 1st Line Defence

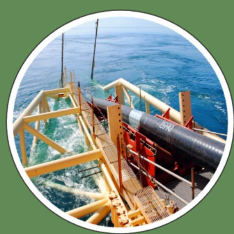
GREENLINK
MARINE ENVIRONMENTAL IMPACT ASSESSMENT REPORT- IRELAND

APPENDIX K

Magnetic Fields and the Induced Voltages caused by the Greenlink HVDC Circuit

P1975_R4500_RevF1
July 2019

Greenlink Interconnector
- connecting the power markets
in Ireland and Great Britain



Greenlink
INTERCONNECTOR

Magnetic Fields and the Induced Voltages caused by the Greenlink HVDC Circuit

Date: 2 May 2019

Introduction

This document accesses the effect that the Greenlink HVDC circuit would have on the existing telecom cables that it runs parallel to or crosses. There are two locations where the Greenlink circuit run parallel to or crosses the existing telecom cables ESAT1 and Solas and these are shown in Figure 1 or 2. In both locations the distance between the Greenlink circuit and the telecom cables are considerable (i.e. 650 m) and both cable crossings are at right-angles.

Figure 1: *Greenlink Cable crosses the ESAT1 cable at KP 102.5.*
Minimum distance where the circuits run parallel is greater 650m

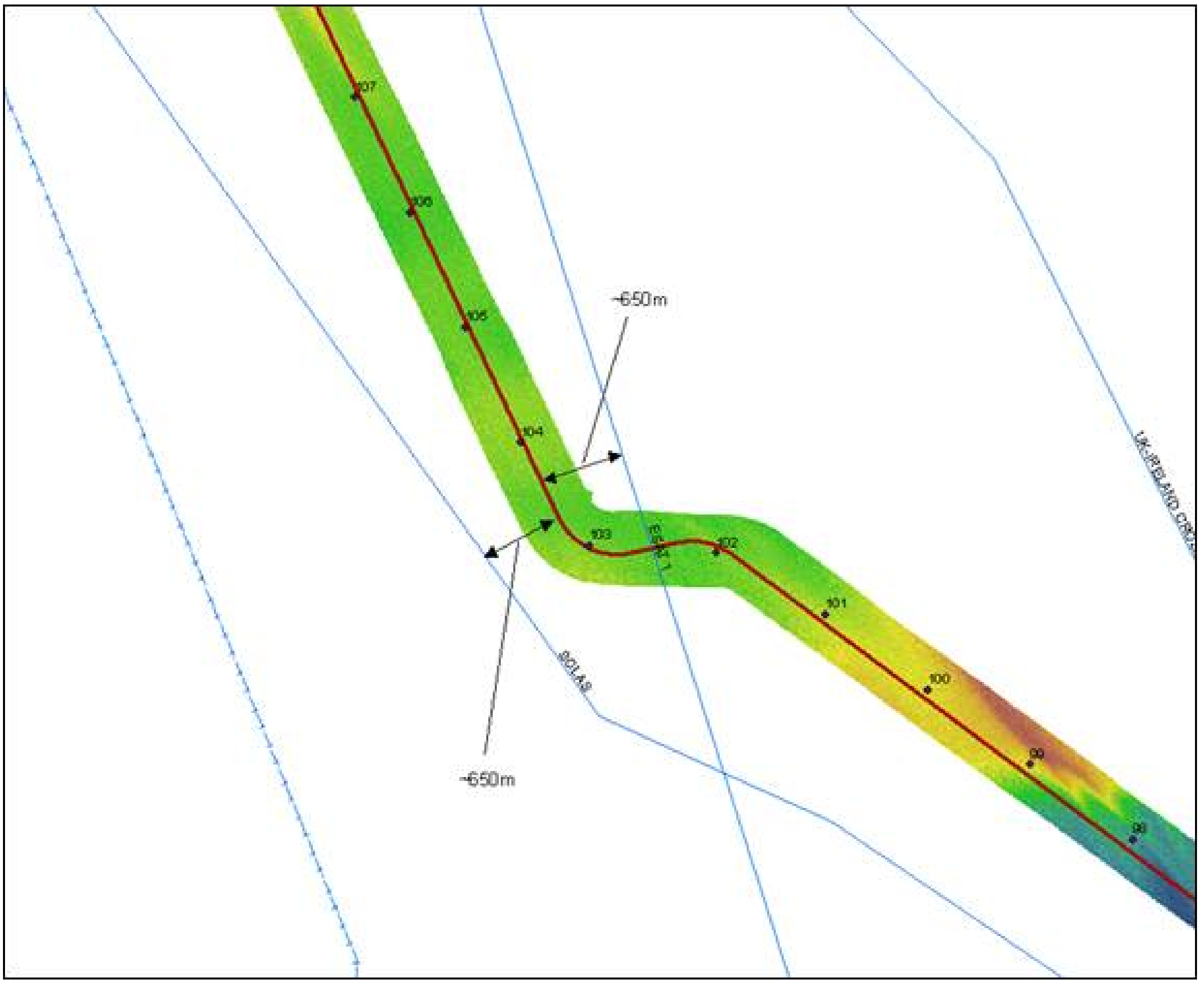


Figure 2: Greenlink Cable crosses to Solas Cable at KP 121.6
Minimum distance where the circuits run parallel is greater 650m

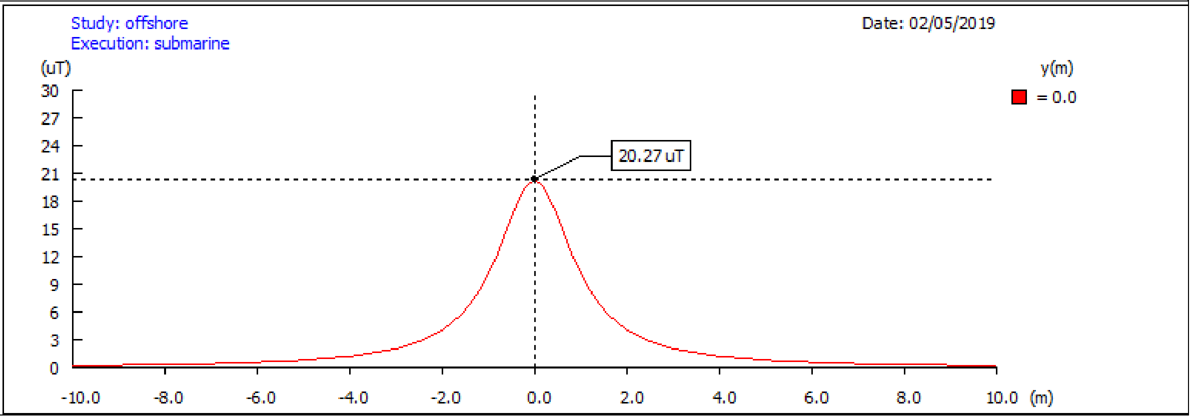
Magnetic Field and Induced Voltages

Power cables with electrical current flowing in the conductor would produce a magnetic field. It is feasible that a changing magnetic field produced by a power cable can induce a voltage / current into a telecom cable with metallic components. For a voltage to be induced into the metallic components of a telecom cable the following must occur.

- There must a rapidly changing magnetic field from the power circuit (due to changing electrical currents in the power cable).
- The power circuit must run parallel to the telecom cable for a long distance (i.e. many km).
- The distance between the power cables and the telecom cable is close (i.e. a few metres).

The Greenlink circuit is a direct current (DC) circuit and magnetic field produced by each cable is equal and opposite. With cables bundled together under normal operating conditions the magnetic fields produced by each cable tends to cancel each other out. The resultant magnetic field is very low (i.e. approx 21 micro-Tesla on the seabed immediately above the cables) and within 10 metres from the power circuit the resultant magnetic field is negligible. Please refer to diagram in Figure 3 showing the resultant magnetic field under the maximum load conditions.

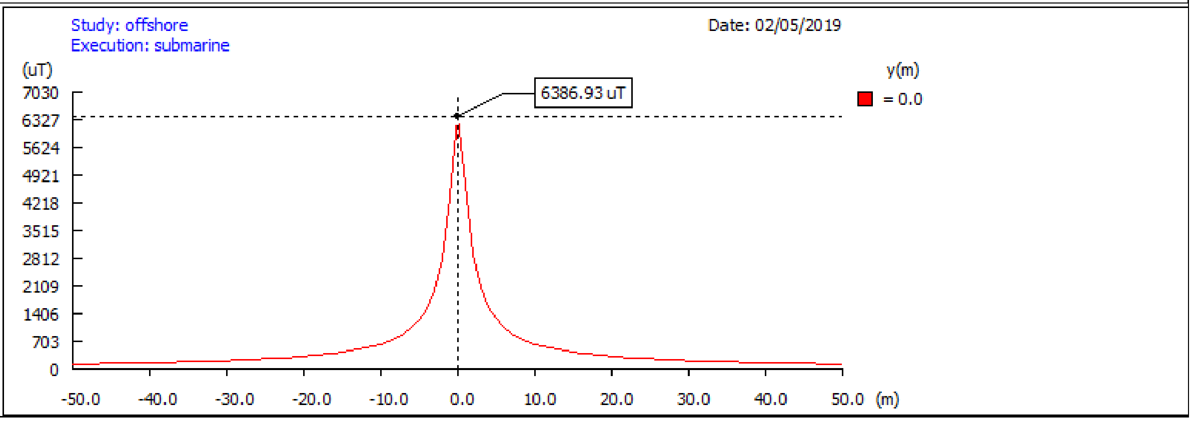
Figure 3: Greenlink Circuit, Magnetic field under full load condition



Please note, for DC circuits under normal operating conditions the magnetic field is stable (i.e. not rapidly changing) and therefore the induced voltages in the parallel telecom cables would be negligible.

Fault currents, which can occur once or twice in the lifetime of the circuit, do produce a rapidly changing high magnetic field. However, even this magnetic field would become negligible within 50 metres (please refer to Figure 4).

Figure 4: Greenlink Circuit, Magnetic field under fault condition



Therefore, even under fault conditions, because of the very large distance between the parallel telecom cables and the Greenlink circuit (i.e. 650 m), induced voltages would be negligible.

Where the Greenlink circuit would cross the existing telecom cables, the cables would cross at right-angles (to minimise parallelism) and therefore at crossing locations the voltages induced into the telecom cables would be zero even under fault conditions.

Conclusion

The Greenlink cable would induced negligible voltages into the parallel telecom cables.

V.J.Barry

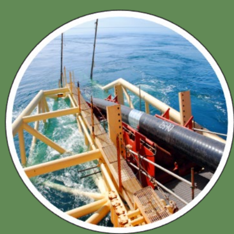
GREENLINK
MARINE ENVIRONMENTAL IMPACT ASSESSMENT REPORT- IRELAND

APPENDIX L

Welsh and Irish Landfall Final Selection Report

P1975_R4500_RevF1
July 2019

Greenlink Interconnector
- connecting the power markets
in Ireland and Great Britain



Greenlink
INTERCONNECTOR

CONTENTS

1. INTRODUCTION

Intertek Energy & Water Consultancy Services (Intertek) has been appointed by Greenlink Interconnector Limited (Greenlink) to provide a range of marine consultancy and engineering services related to the Greenlink Interconnector.

Greenlink proposes to develop an electricity interconnector, which will allow transfer of power between the high voltage grid systems of the UK and the Republic of Ireland. The power would be able to flow in either direction at different times, depending on the supply and demand in each country. Greenlink will connect to the UK National Grid system at Pembroke substation in Pembrokeshire, Wales and to the Irish network at Great Island substation in County Wexford, Ireland.

Greenlink will use high voltage direct current (HVDC) technology to link the two power systems. As both national electrical systems use high voltage alternating current (HVAC) supply, convertor stations will be located near each substation to convert the HVAC electrical supply to HVDC.

Greenlink emerged as a separate interconnector project from the Greenwire renewable energy input project, proposed by Element Power. It was awarded an interconnector licence in GB by Ofgem on 10 February 2015. Element Power had previously commissioned a study to identify suitable DC cable landfall locations in Pembroke, Wales for Greenwire. This, as well as a new study specifically commissioned for Greenlink, have been used to identify suitable landfall locations in Pembroke, Wales and County Wexford, Ireland. The studies are:

- JP Kenny (2012) Greenwire Part 2a: South Wales Landfall Options Report (*224729-00_Part 2a - South_Wales_Landfalls_Technical_Note_R2.pdf)*
- Intertek (2016) Greenlink Interconnector Project Landfall Selection Report (*P1975_RN3926_Rev4.pdf)*

These documents conclude that of the options investigated, two landfalls are most feasible on the Welsh coast and four landfalls are most feasible on the Irish coast. Copies of these reports, containing the detailed methodology and assessment for the landfall locations, can be found in Appendix A and B of this report.

This report summarises the studies and details the subsequent consultation with stakeholders that has led to the selection of the final landfall options in Wales and Ireland.

- Wales: **Freshwater West**
- Ireland: **Boyce's Bay** and **Baginbun Beach**

2. WELSH LANDFALL

2.1 Introduction

JP Kenny (2012) undertook a desktop study for the Greenwire project that identified eight potentially suitable landfall locations in Pembrokeshire, Wales. These were Broad Haven, Freshwater West, Tenby South Beach, Dale, Whitesands, Abereiddy LF, Aber Mawr 1 & 2 and Strumble Head.

Table 2-1 summarises the landfall assessments detailed in the desktop study. The two preferred options, as identified in the report were:

- **Broad Haven;** and
- **Freshwater West.**

Table 2-1 Summary of landfall selection

Landfall	JP Kenny conclusions	Intertek comment
Freshwater West (preferred)	Advantages: ▪ It has the shortest onshore route of all options under consideration; ▪ Technically straightforward; ▪ The nearshore route avoids the firing range; ▪ Sandy foreshore with favourable nearshore beach profile; ▪ Reasonable onshore access. Disadvantages: ▪ Proximity to firing range; ▪ Proximity to Milford Haven harbour entrance; ▪ Shore crossing and working area likely to be through dunes to public carpark and subsequently be likely be subject to environmental restrictions; ▪ Evidence of land movement in the slope behind dunes leading up to the public access road; ▪ Potential for rock to be encountered in the nearshore (slate and conglomerate exposed on the beach at low tide at far Northern end of beach), areas of rock identified on admiralty chart.	Intertek agrees that this is a good choice for the Greenlink Interconnector to landfall. The greatest advantage of using this location as the preferred landfall option is that is it shortest route to the connection point with no technical challenges. It is also south of the haven and therefore avoids a harbour crossing. The offshore route does not avoid the firing range but consultation with the MoD has resulted in permission to route within the Castlemartin military area thus eliminating this as a routing constraint and potential disadvantage. Using HDD will also eliminate the disadvantages posed by the environmental restrictions behind the beach. The major disadvantage of using this landfall is the potential risk the firing range will have in the operation and maintenance phase of the cables life; however, this isn't thought to be significant as the cable lies on the northern edge of Castlemartin firing range.
Broad Haven (preferred)	Advantages: ▪ The nearshore route can avoid the firing ranges; ▪ Sandy foreshore (with some exposed rocks at northern end); ▪ Nearshore geology on the admiralty chart is mostly sand, muds and gravels; ▪ Favourable beach profile; ▪ Onshore routing is constructible. Disadvantages: ▪ It necessitates a technically challenging but feasible crossing of Milford Haven (~3km); ▪ Broad Haven is a high value recreational amenity area and it is probable that the permit construction window will exclude the summer months; ▪ Desire to avoid laying the cable along the seafront and through the town where possible; ▪ Admiralty chart indicates some areas of rock in the nearshore; ▪ Crossing under seawall is required if routing at the northern end of Broad Haven (not a major concern); ▪ Storm water culvert at the northern end of the beach may impact on northern shore crossing route options.	Intertek also agrees that Broad Haven is a good choice for the Greenlink Interconnector to landfall. The beach profile is very favourable from a construction perspective. At the time of the desktop study, the major attraction of this landfall selection was that it avoids the Castlemartin firing range entirely. Subsequent discussions with the MoD has meant that the firing range is no longer a constraint, and therefore avoidance of the area no longer outweighs the disadvantage that the technically challenging crossing of Milford Haven poses to reach the connection point from this landfall.

Landfall	JP Kenny conclusions	Intertek comment
Broad Haven South (Not selected)	Broad Haven South is within the Castlemartin Firing range and as such should not be considered further unless other more favourable options are excluded. Points of note for Broad Haven South: ▪ Steep walking path access to down to the beach from the carpark (stairs, ~100m, up to 30deg slope); ▪ Landfall construction will likely require an HDD into carpark to avoid open cut on the steep slope; ▪ Tourist information boards identify several bird species local to the area including guillemot, razorbill and the area is also a nesting zone for Chough (Britain's rarest crow); ▪ Rocks offshore (visible, castle rock), and also small breaking waves to the west of castle rock; ▪ Sandy beach; ▪ High tourist amenity and visual landscape value; ▪ Significantly longer offshore route than Freshwater West.	Although Castlemartin firing range is no longer considered a constraint, an offshore route to this landfall would require traversing more of the active area. In addition, the offshore route would be approximately 10 km longer than one routing to Freshwater West. Only HDD would be feasible at this location.

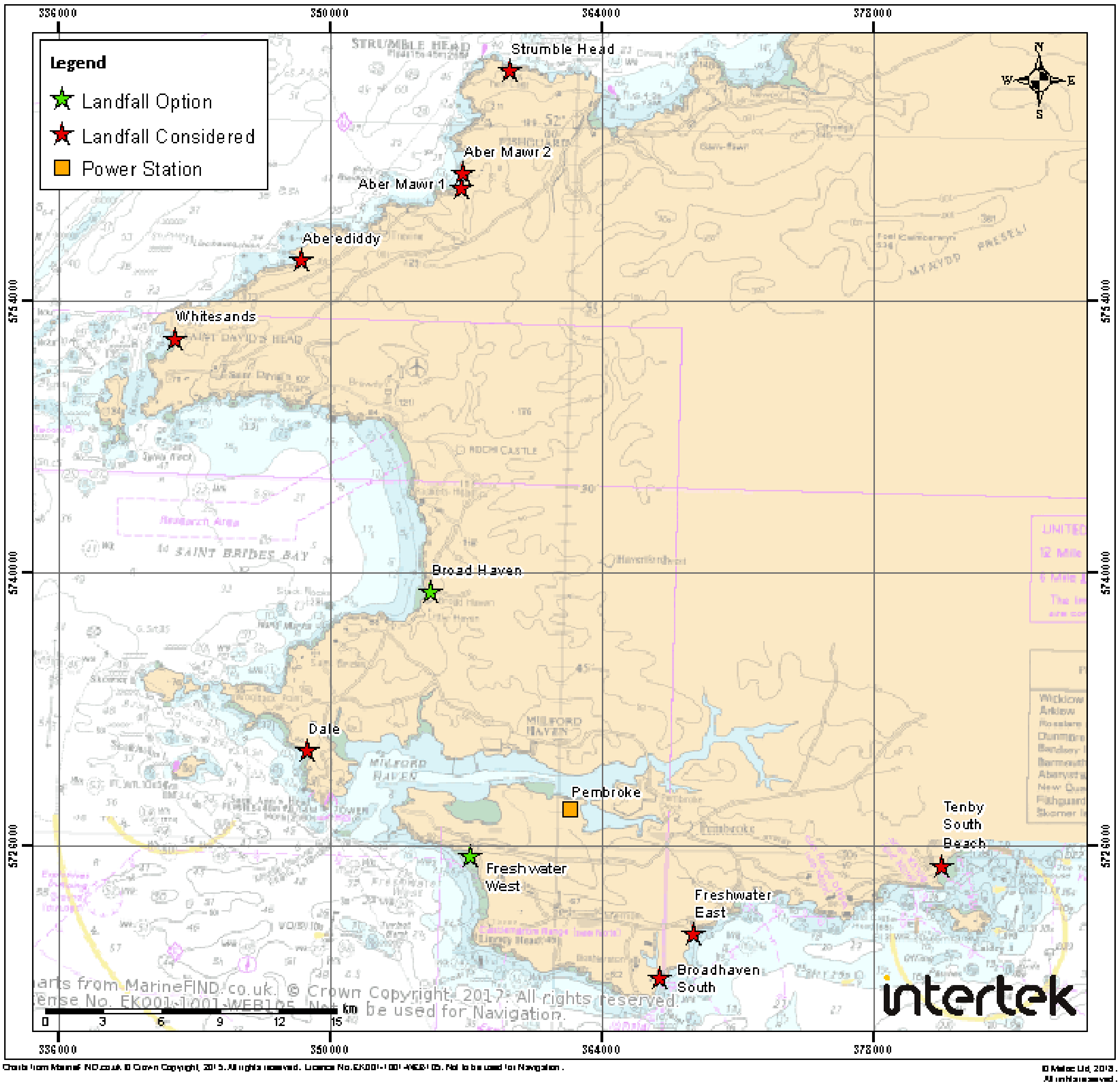
Freshwater East
(Not selected)
	Freshwater East is within the Castlemartin Firing range and as such should not be considered further unless other more favourable options are excluded.
	Points of consideration for Freshwater East:
	▪ Gently sloping beach with gravel/pebbles/cobbles overlying sand;
	▪ Admiralty chart indicates gravels and sands in the nearshore;
	▪ The main access to the beach is from a car-park located approximately 20m to 50m from the beach at close to it's southern extent:
	  ▪ One walking path passes through small dunes (1-3m high) onto beach;
	  ▪ Another concreted footpath provides access alongside a small stream to the beach;
	▪ Difficult onshore route to the southwest:
	  ▪ Tight narrow roads, small stream with one-way narrow bridge (4 to 5m long bridge at the beach access location);
	  ▪ A two-lane road runs from the public access, at the southern end of the beach, towards the north. As soon as it exits the beach the road rises steeply and then run along the top of the slope approximately 300m behind the beach and estimated at over 30m high. Residential properties are located at the top of this steep bank along the length of the beach. There are also some walking access tracks down the slope to the beach and farm access which may be able to be improved for onshore cable construction up the slope;
	▪ There are mooring buoys for small watercraft at the southern extent of the beach and buoys marking the boat speed zones;
	▪ Significantly longer offshore route than Freshwater West.
		Castlemartin firing range is no longer considered a constraint. However, the main factor to discount this landfall location is that the offshore route length would be approximately 15 to 20 km further than Freshwater West, and whereas the route to Freshwater West traverses the edge of the Firing Range a more direct path through the active area would be required to reach this landfall.

Landfall	JP Kenny conclusions	Intertek comment
Tenby South Beach (Not selected)	A landfall at Tenby South Beach can be routed to narrowly avoid the Castlemartin Firing range. However, it is the longest offshore route, is a popular tourist area and has a long onshore route. Points of consideration: ▪ Sandy beach, admiralty chart indicates sand and shells in the nearshore area; ▪ Golf course runs behind most of the beach except at the southeastern end; ▪ Any landfall would likely be located at the SE end of beach, near new apartment blocks to avoid the golf course; ▪ There are other cables making landfall at the SE end of beach for which proximity agreements would need to be negotiated; ▪ Offshore, the cable would be routed between Caldey Island and Woolhouse rocks.	Castlemartin firing range is no longer considered a constraint but the added offshore cable route length (30km) and the additional asset proximity agreements has discounted this landfall location. The offshore cable route would also have to be engineered between Caldey island and Wales mainland which would represent a permanent risk to the cable during installation and the operation and maintenance phase with regards to anchor strike. An additional navigational risk assessment, specific to this location may be necessary.
Dale (Not selected)	The option to the west of Dale town is a difficult landfall, due to geology, topography and access issues, and therefore is not preferable.	Intertek agrees with the assessment.
Whitesands (Not selected)	Whitesands appears technically feasible from a landfall construction viewpoint. Observations regarding the Whitesands landfall are noted below: ▪ Sandy beach with rock outcrops at northern extent, although rock noted in the nearshore on the admiralty chart; ▪ Exit from a beach landfall could be through to the public car-park (approximately 40m x 120m); ▪ From the car-park a narrow single lane road climbs up in a moderately steeply manner (no parking available on the road); ▪ Adjacent to the access road at the top of the slope leading down to the beach is the St David's City Golf Course (entrance approximately 700m from the beach). The golf course extends to within 100m of the beach, on the southern side of the access road and south of the public car-park; ▪ The beach has a high recreational amenity value and is a prominent surfing location; ▪ The onshore route ~25km longer than that to Broad Haven but correspondingly the offshore route is shorter; ▪ Most of the onshore main access road is suitable except for narrow congested sections through St David's and Solva town. It may be possible for alternative onshore routes to be proposed. However, the feasibility of the onshore route and the potential for public opposition due to the high recreational amenity value would need to be further investigated if this option is to be considered further.	Due to the length & challenges of the onshore route and the potential for public opposition Intertek did not consider this landfall further.

Landfall	JP Kenny conclusions	Intertek comment
Abereiddy LF (Not selected)	Abereiddy is a small beach located to the northeast of Whitesands and the town of St David's. The landfall comprises the following features: ▪ Exposed bedrock to the west of the beach; ▪ To the east the foreshore comprises pebbles overlying sand; ▪ A small (<2m) high concrete seawall is the sea defence for the public carpark which runs along the beachfront (~30m x 120m long); ▪ Admiralty chart indicates shells and pebbles are present in the nearshore. The water depth increases quickly to ~25m at the end of the inlet approximately 400m offshore; ▪ Beach is used for access to the nearby "blue lagoon", a disused slate quarry which has been infilled with seawater through a breach in the outer wall. This lagoon is a popular location for tourism activities that include coasteering; ▪ Road access is generally suitable except for the final access to the beach which is approximately 4 to 5m wide. Much longer onshore route than Broad Haven.	The landfall study carried out by JP Kenny is inconclusive as to why this landfall was not selected. From an offshore perspective this landfall is a similar length to Freshwater West and poses minimal routing restrictions offshore. However, the approach to the beach consists of 2km of rock and potential reef (within the Pembrokeshire Marine Special Area of Conservation) and installation would be technically challenging e.g. extended HDD, rock cutting through potentially protected feature. In addition, as this area is a popular location for tourism, this option was discounted.
Aber Mawr 1 & 2 (Not selected)	Aber Mawr 1 and 2 are gravel/pebble beaches located north of Abereiddy. Both beaches are similar in terms of geology. Access is difficult with no public road to the beaches. The Pembrokeshire coastal path network passes right across both beaches. The admiralty chart identifies the nearshore geology as gravels and pebbles. Access to both beaches is difficult: ▪ The public road is only one lane wide for the last 500-800m; ▪ For Aber Mawr 1, construction access would be very challenging as behind the beach is a wetland/marsh area extending for approximately 500m; ▪ For Aber Mawr 2, construction access could be built alongside the coastal walking path whichleads at a moderate slope down the cliff, southwest towards the beach. This may require some adjacent landowner permissions.	Access to both beaches would be extremely difficult, therefore these landfalls were not selected.
Strumble Head (Not selected)	Strumblehead was not accessed during the site visit as there was no public access available to the beach. It is the most northerly landfall that was identified as part of the desk top review. The location identified is a small inlet at the end of small valley to beach. The aerial view indicates a sandy foreshore but with rocks offshore. The beach is located approximately 500m from the public road and therefore landowner agreement would be required for construction and cable routing.	The lack of access at the landfall site excluded it from further consideration as a landfall option.

*Reference: JP Kenny (2012) Greenwire Part 2a: South Wales Landfall Options Report

Figure 2-1 Map of Preferred Welsh Landfall Locations



2.2 Broad Haven

This landfall north of Milford Haven comprises of a flat sandy foreshore with minimal offshore routing restrictions.

The onshore route would be to the east, just north of Broad Haven Town. The route would then turn south towards Milford Haven; where a crossing across the estuary would be required to run from Venn Farm on the northern side of the Haven to a location on the southern side.

While crossing the estuary is technically challenging, options may include horizontal directional drilling (HDD) or tunnelling to be near the power station. The total length of the proposed crossing is approximately 3km.

2.3 Freshwater West

Landfall options to the south of Milford Haven are all severely restricted due to the presence of Castlemartin and Manorbier firing ranges; actively used for military practice. The nearshore route can be positioned just outside the Castlemartin firing range by positioning at the northern end of the beach.

The shore crossing at Freshwater West would extend through sand dunes approximately 3m high at the northern extent. The sand dunes are environmentally sensitive areas and installation through this area would require environmental permitting. The landfall construction method may be restricted to an HDD option to avoid disturbance to the dunes.

Due to the proximity to both the firing range and Milford Haven harbour mouth it is possible that substantial cable burial depth would be required to provide sufficient protection to the cable.

One of the most attractive characteristics of this landfall location is that it has the shortest onshore route to the converter substation and tie in point.

2.4 Landfall Selection – Freshwater West

Of the two options, initially Freshwater West was less preferential because offshore constraints meant that sections of the marine cable route enter the Castlemartin firing range Sea Danger Area. Routing within the vicinity of the range was thought to be not feasible or at the very least problematic. However, consultation with the MoD in late 2013 and early 2014 (see Appendix C, minutes 14/01/2014) with respect to Freshwater West being a potentially landfall, indicated that routeing within the Castlemartin firing would be permitted. Further discussions with the MoD throughout 2016 and 2017 (see Appendix C, minutes 4 May 2017), determined that the co-location of a submarine cable and the military firing range was possible, from the MoD perspective. Subsequent, detailed discussions with the MoD have culminated in a letter agreeing protocols for access to the Sea Danger Area (10 July 2017, Appendix C).

Elements of the Broad Haven landfall such as onshore cost, route length, and the technically difficult challenges associated with engineering a crossing of Milford haven e.g. HDD or tunnelling under, have led to Freshwater West being given higher preference than Broad Haven. Overall Freshwater West is likely to be less challenging, and once the MoD confirmed that routeing through the Castlemartin Firing Range will be possible, this led to its selection as the preferred landfall.

Preferred Welsh Landfall Selection:

- **Freshwater West,** Pembrokeshire, Wales

3. IRISH LANDFALL

3.1 Introduction

Intertek was appointed by Element Power Ireland in 2015 to undertake a landfall assessment for the Greenlink Interconnector for the landfall in Ireland. A desk-based study identified ten possible sites, of which eight were visited and assessed in 2015. These were; Rathmoylan Cove, Boyce's Bay, Sandeel Bay, Carnivan Bay, Baginbun Beach, Dollar Bay, Booley Bay, Newtown Beach, Bannow beach and Cullenstown Beach. After site visits four preferred options were identified in report P1975_RN3926_Rev4 (Appendix B), namely:

- Baginbun Beach;
- Booley Bay;
- Boyce's Bay; and
- Sandeel Bay.

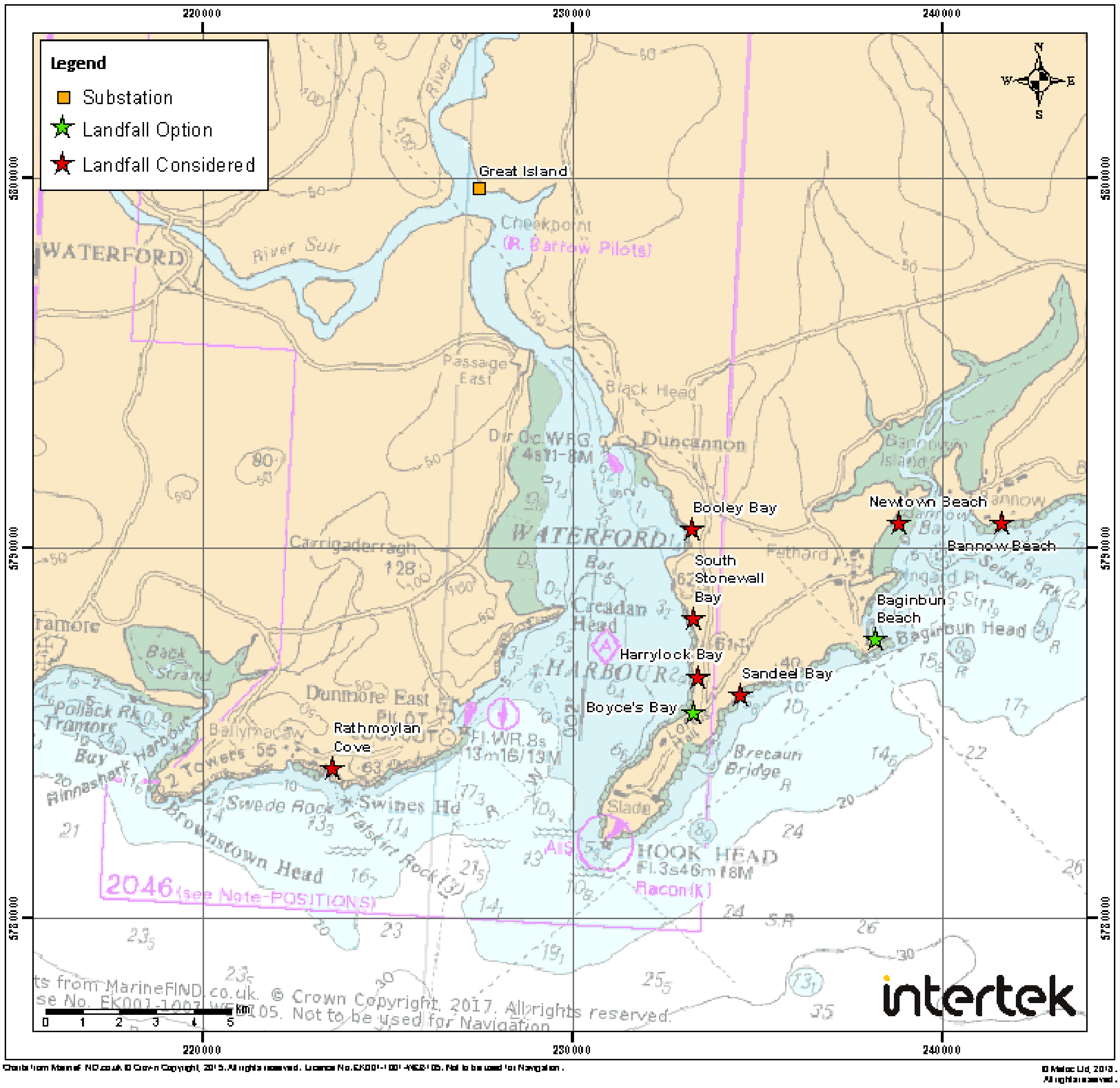
Table 3-1 shows the weighted score criteria outlined in P1975_RN3926_Rev4.

Table 3-1 Weighted Ranking for each Landfall Site

Description	Baginbun Beach	Bannow Beach	Booley Bay	Boyce's Bay	Carnivan Bay	Cullenstown	Dollar Bay	Sandeel Bay
Vessel Access	1.28	0.80	0.96	1.12	1.28	0.8	0.8	0.48
Beach Composition	1.12	0.42	1.12	1.12	0.7	0.7	1.12	0.7
Amenity Impact	0.7	0.20	0.5	0.5	0.5	0.2	0.6	0.2
Environmental Constraints	0.4	0.70	0.3	0.6	0.2	0.7	0.3	0.2
Exposure	0.72	0.16	0.56	0.48	0.16	0.16	0.56	0.24
Working/Site area	0.56	0.56	0.48	0.24	0.64	0.64	0.24	0.56
Coastal Erosion	0.56	0.32	0.56	0.56	0.16	0.16	0.56	0.48
Obstructions & Existing infrastructure	0.64	0.48	0.56	0.56	0.56	0.56	0.56	0.48
Access to beach	0.30	0.24	0.54	0.48	0.42	0.42	0.3	0.42
Cable engineering & protection requirements	0.36	0.18	0.36	0.36	0.42	0.42	0.36	0.36
Overall cable length	0.36	0.24	0.42	0.36	0.42	0.42	0.42	0.54
Total Weighting	**7.00**	**4.30**	**6.36**	**6.38**	**5.46**	**5.02**	**5.82**	**4.66**

Source: P1975_RN3926_Rev4

Figure 3-1 Map of Preferred Irish Landfall Locations



3.2 Baginbun Beach

Baginbun Beach is located to the north of Carnivan Bay on the Baginbun peninsula. It lies within the Hook Head Special Area of Conservation (SAC) but the cable would have less distance in the SAC than at alternative sites such as Sandeel Bay.

The beach faces north east, has excellent access for vessels and is eastward facing protecting the site from prevailing wind conditions. Offshore, lobster / crab pots were observed indicating fishing activity in the area.

Surrounding the beach are heavily vegetated cliffs of moderate height (< 15 m) with only minor signs of erosion on the northern side of the beach. Height and apparent stability would suggest HDD would be possible but would require appropriate geological assessment and survey of ground conditions for confirmation.

3.3 Sandeel Bay

Sandeel Bay is located to the south of the Baginbun peninsula on the east of the Hook peninsula. Sandeel bay lies within the Hook Head SAC and is close to Hookless Village / Sandeel Bay Cottages, a popular holiday resort.

The cliffs surrounding the beach are approximately 10 - 15 m in height with small localised areas of erosion and landslip. There is a rock outcrop to the south of the bay. The beach gradient is shallow but demonstrates large amounts of seaweed and debris. There also appears to be sediment zonation indicative of sediment sorting associated with high-energy condition.

The site would not be suitable for open-cut trenching due to the volume of rock and the seawall approaching the path. HDD may be suitable but geotechnical data assessment would be required to confirm suitability.

Initially, the landfall was not considered a 'preferred' option as the offshore environmental constraints were considered too significant. Following consultation with the National Parks & Wildlife Service (NPWS) (09 December 2015, Appendix D), it was concluded that installing a cable through a SAC could potentially be possible provided that works do not adversely affect the integrity of the protected site and its conservation objectives. In the interest of achieving the most direct offshore cable route, Sandeel Bay was reinstated as a potential landfall location, despite the relatively low score in assessment.

3.4 Boyce's Bay

This landfall location lies on the west coast of the Hook Peninsula, within the Port of Waterford harbour limits. The site is located outside the Hook Head SAC, but it falls within a proposed Natural Heritage Area (NHA). The beach faces the south west making it an exposed site, given the prevailing south-westerly weather conditions. Due to the nature of the 5 and 10 m depth contours, the types of vessel that can reach the beach may be restricted, increasing the chances of requiring anchored barges. The beach extends further north along the coastline for approximately 2 km but a rock outcrop to the north of the site prevents vehicles from passing to the additional coastline and beach.

The beach itself is gently sloping with evidence of a storm berm and seaweed debris on the upper reaches of the beach. The typical slope angle was 2.4° from the cliff to the water. The beach was approximately 200m wide, with approximately 157 m of rock to the south of the beach. Fossils were observed on rock outcrops on the side of the bay.

The surrounding cliffs and headland are high with one large derelict property at the top, close to the dairy farm; this is possibly a heritage site and would require confirmation prior to establishing the location for an HDD point. The surrounding cliffs are densely vegetated with grasses and scrub but there are many indicators of instability and slope movement. Portions of the cliffs were identified as suitable for HDD up to the main track, pending further geotechnical assessments and ground investigation.

3.5 Booley Bay

Booley Bay is approximately 5 km north of Boyce's Bay, within the Port of Waterford harbour limits. Like Boyce's Bay, the landfall faces the west and is moderately exposed to the prevailing south-westerly wind conditions. The beach is approximately 205 m wide and 113 m from the cliff to the water's edge shortly before low water. The beach is predominately flat (0.2°) with fine, water-saturated sand. A storm berm was observed at the upper reaches of the beach.

The surrounding headland is dominated by vegetated cliffs to the north and south, both sides demonstrated low levels of coastal erosion with minor evidence of disruption by landslides.

Adjacent to the access road and track was a freshwater riverine input, surrounded by unmanaged vegetation. The river water flows directly onto the beach where the water flow is diverted along the upper reach of the beach to the southern rock outcrop where it is forced towards the sea by rocks. Options for installation would include HDD and open-cut trenching.

It is likely that the flow of freshwater onto the beach would make keeping a trench open difficult and may risk exposure of the cable during adverse weather conditions.

Consultation with the Port of Waterford was undertaken on 09 March 2016 (Appendix E). At the meeting the Harbour Master advised the Booley Bay landfall be dropped from further consideration. A 100m wide corridor (marked on Admiralty Chart) is dredged at Duncannon approximately 3-4 times a year, to stop the shipping channel from silting up. The offshore approach to the landfall would intersect this area risking both the ports activities and the cable.

3.6 Landfall Selection - Baginbun Beach & Boyce's Bay

Due to the level of dredging at Duncannon, the Booley Bay landfall would be inadvisable; both the cable and the dredging would be put at risk if this landfall was progressed. Therefore, Booley Bay was discounted from any future assessments.

At the nearshore area of the Sandeel Bay landfall, the cable route would transect an area which has been identified to have abundant rocky reef sections which would complicate and increase installation costs. This coupled with the environmental considerations associated with the nearshore and onshore areas has meant that this location has been discounted.

Baginbun Beach has been selected as the preferred Irish landfall location as it yields the shortest overall cable route length and meets the requirements the other landfall options fall short on.

Boyce's Bay has been selected as an alternative for investigation should the proposed geophysical survey identify substantial issues which could result in a route to Baginbun Beach not being feasible. The Port of Waterford has expressed concerns that the proposed route to Boyce's Bay enters the shipping channel passing Hook headland. They have not granted permission for the route to extend into the central channel where there are potentially deeper Holocene sediments. Instead, their preference is for the cable to be routed as close to the headland as possible. A compromise, whereby the route follows the edge of a mapped outcrop to the east of the channel centre, has been proposed. However, this area may have a veneer of sediment overlying rock which would increase installation costs.

Baginbun Beach is the selected landfall for survey. However, should preliminary geophysical survey results identify any issues, a reconnaissance survey of the route to Boyce's Bay has been proposed as an alternative option.

Preferred Irish Route Selection:

- **Baginbun Beach,** Wexford, Ireland. Note that Baginbin is the preferred landfall but is still yet to be selected.

APPENDIX A

Welsh Landfall Report

Experience that Delivers

jp kenny

Client:

ARUP CORK for Element Power

Project Name:

GREENWIRE

Document Title:

Part 2a: South Wales Landfall Options Report

Document Number:	Document Type:
05-4004-02-G-3-001	TECHNICAL NOTE
Client Document Number:	Number of pages:
	40

02	27-07-12	Updated with comments	LM	SB	RGB	RGB	
01	20-07-2012	Issued for comment	LM	SB	RGB	RGB	
Rev	Date	Reason for Issue	Prep. By	Chk. By	App. By	QA	Client Approval

COMMENTS SHEET		
REVISION	**DATE**	**COMMENTS**
R02	31/07/12	Minor comments by Client (Arup) have been incorporated. Document is now to form a standalone report embedded within a larger document.

GUIDELINES ON USE OF REPORT

(1) This report and the assessments carried out in connection with the report (together the "Services") were compiled and carried out by JP Kenny Limited ("JPK") with the skill and care ordinarily exercised by a reasonable surveyor/engineering specialist at the time the Services were performed taking into account the limits of the scope of work as required by the preliminary nature of the assignment.

(2) Other than that expressly contained in paragraph 1 above, JPK provides no other representation or warranty whether express or implied, in relation to the Services.

(3) The passage of time may result in changes (whether natural, man-made or otherwise) in site conditions, while changes of technology, methods of analysis, economic conditions or regulatory or other legal provisions could render the report inaccurate or unreliable. Therefore the information contained herein should not be relied upon after a period of 1-year from the date of this report.

(4) The observations, recommendations and conclusions in this report are based solely upon the Services which were provided pursuant to the Preliminary Engineering scope of work. JPK shall not liable for the existence of any condition, the discovery of which would require performance of additional services not otherwise contained in the agreed scope of work.

Table of Contents

Index of Tables

Index of Figures

1.0 OVERVIEW

1.1 Project Description

Element Power is developing the Greenwire project which will involve the export of 3 GW of renewable energy from Ireland to the UK via dedicated HVDC cables.

The project comprises a number of wind farms in the Irish midlands, an AC underground cable collector system for gathering wind generated electrical power and transmitting it to a high voltage AC - DC converter station (also in the Irish midlands), two HVDC underground cable routes to the east coast of Ireland, a subsea HVDC cable across the Irish Sea to Wales, HVDC underground cables in Wales to new DC – AC converter stations and connections to the United Kingdom transmission system.

Agreement has been reached with the UK National Grid for two tie-in locations at Pentir in North Wales and Pembroke in southwest Wales. Therefore there are two export HVDC cable routes likely to proceed:

- Northern Route (up to 2.5 GW): from the Dublin area to a North Wales landfall, tie-in to the National Grid at Pentir in northern Wales;

- Southern Route (up to 2.5 GW), from the Rosslare area to a South Wales landfall, to tie-in to the National Grid at the 400kV Pembroke substation on the southern side of Milford Haven,

At the time of writing this report, the number of cables, cable properties and the total capacity of the system have not been confirmed. It is likely that each cable route will include 2 HVDC cables as well as a fibre-optic cable (it might be noted that reference to cable in the rest of this report is to this array of cables). This initial assessment does not consider specific HVDC cable design parameters. However it does consider working area requirements and constructability issues at a macro level.

Element Power has appointed Arup (with J. P. Kenny) to assist them with the preliminary engineering of the onshore and subsea elements of the project.

The purpose of this report is to present the findings of a preliminary assessment of landfalls in South Wales.

1.2 Scope of Work

The scope of work for this technical note is limited to the evaluation of landfall options in south Wales and it includes:

- An initial desk top assessment to identify possible landfalls

- Results of a site visit to possible landfall locations to confirm suitability

- Identification of the extent of Castle Martin firing range activities

- Determination of the physical constraints to near offshore routing and installation, for example rock out-crops, excessive sea bed slopes, sand waves and coastline stability.

Landfall evaluation matrices using the information described in this report are included in Appendix B.

1.3 Limitations

The findings of this report are based on a desktop study and site walkover only and, at this stage, the project has limited technical definition. For any of the proposed landfall options, it will be necessary to obtain additional data and information to finally confirm that the landfall location is suitable.

1.4 Geodesy

All co-ordinates quoted are referenced to the WGS 84 datum.

2.0 ABBREVIATIONS

HDD	Horizontal Directional Drilling
HVDC	High Voltage Direct Current
EP	Element Power
GW	Gigawatt
JPK	J P Kenny
UK	United Kingdom
UXO	Un-exploded ordnances

3.0 SUMMARY OF SOUTH WALES LANDFALL OPTIONS

3.1 South Wales Landfall Options

J P Kenny has identified eight potentially suitable landfall locations for the HVDC cable in Pembrokeshire, South Wales as part of a desk top review. A site visit to South Wales was undertaken by the ARUP Project Manager and a J P Kenny Civil Engineer from the 19th to 21st June 2012 to assess landfall options and subsequent onshore routing from the landfalls to the Pembroke substation.

This technical note summarises the observations of the site visit to South Wales; and presents the advantages and disadvantages of the preferred landfall options.

The location of the Castle Martin and Manorbier firing ranges presents challenges to a proposed cable route to the Southern landfall locations, and therefore locations both North and South of the Pembroke substation were investigated. Note that the Northern landfall options would require a subsea crossing of Milford Haven in order to tie-in to the substation on the southern side of the harbour.

Table 3-1 Potential Southern Wales Landfalls (WGS84 Datum)

LANDFALL LOCATION	AREA	LATITUDE	LONGITUDE
Southern Side of Milford Haven			
Freshwater Bay (North End Broomhill Burrows) preferred southern option	South of Milford Haven	51° 39.789'N	5° 3.956'W
Broad Haven South	South Pembroke	51° 36.466'N	4° 55.353'W
Freshwater East	South Pembroke	51° 38.715'N	4° 51.824'W
Tenby South Beach	South Pembroke	51° 40.028'N	4° 42.176'W
Northern Side of Milford Haven			
Broad Haven [preferred option]	Northwest of Milford Haven	51° 46.944’N	5° 6.210’W
Dale	Northwest of Milford Haven	51° 42.470’N	5° 11.229’W
Whitesands	North Pembroke	51° 53.742’N	5° 17.767’W
Abereiddy LF	North Pembroke	51° 56.182’N	5° 12.355’W
Aber Mawr 1	North Pembroke	51° 58.408’N	5° 4.902’W
Aber Mawr 2	North Pembroke	51° 58.161’N	5° 5.028’W
Strumble Head	North Pembroke	52° 1.523’N	5° 3.229’W

Figure 3-1 South Wales Landfall Options

3.2 Overview of Preferred Options

3.2.1 PREFERED NORTHERN OPTION : BROAD HAVEN

The preferred option north of Milford Haven is a landfall at Broad Haven Beach. The landfall is on a sandy flat foreshore with minimal offshore routing restrictions.

The admiralty chart indicates the offshore geological conditions to be sand/mud/gravel. However there is some exposed bedrock at the northern edge of the beach and a small seawall and stormwater culvert in the vicinity of the proposed landfall.

Onshore, there is a suitable route travelling out to the east just north of Broad Haven town. The onshore route would then turn south towards Milford Haven; where a subsea crossing would be required to run from Venn Farm on the northern side of the Haven across to the vicinity of the power station (total length approximately 3km).

While a crossing of the Haven will be technically challenging options include HDD, or tunnelling. Further studies would be needed to identify the optimal crossing methodology.

Therefore, subject to geophysical and geotechnical survey results there are no technical reasons not to situate the export cable landfall at Broad Haven.

Figure 3-2 Broad Haven

3.2.2 PREFERRED SOUTHERN OPTION: FRESHWATER BAY WEST

Landfall options to the south of the Haven (which would eliminate the need for a harbour crossing) are severely restricted due to the presence of the Castle Martin and Manorbier Firing Ranges which remain in active use for military practice.

The preferred landfall to the South of Milford Haven is at the Northern end of Freshwater Bay West. If the landfall is located at the Northern end of the beach the nearshore route can be positioned just outside the extent of the Castle Martin Firing Range (Refer to Appendix A)

The admiralty chart indicates the presence of rock in the nearshore area and areas of weathered slate and conglomerate were exposed at the northern end of the beach at low tide.

The shore crossing at Freshwater Bay would extend through sand dunes approximately 3m high at the northern extent. The sand dunes are environmentally sensitive areas that impose environmental permitting constraints. The landfall construction method may be restricted to an HDD option in order to avoid disturbance to the dunes.

Due to the proximity to both the firing range and the harbour mouth it is likely that substantial cable burial depth would be required in order to provide protection to the cable (in the order of approximately 4m) from ordnance and anchor dragging. This could be provided by rock dumping a surface laid cable or trenching and backfilling. However, the burial depths of power cables are limited due to the burial providing additional thermal insulation.

The most advantageous factor of selecting this landfall is that it has the shortest onshore route to the converter station and National Grid tie-in point. In order to select this landfall a detailed unexploded ordnance survey would be required to locate any stray munitions on the seabed in the area of the proposed cable route. If this landfall option is to be further considered early consultation should be sought with the Ministry of Defence.

Due to the proximity to the firing range and harbour mouth, further studies (in addition to the usual surveys required at any landfall location) will be needed to determine the effects of ordnance, anchors and thermal insulation in order to prove the feasibility of this landfall.

Figure 3-3 Freshwater Bay West (North end)

4.0 LANDFALLS NORTH OF MILFORD HAVEN

4.1 Broad Haven (Preferred Option)

4.1.1 SUMMARY

The preferred option north of Milford Haven and most favoured option overall is a landfall at Broad Haven Beach, located within St. Bride's Bay to the northwest of Milford Haven. The landfall is on a sandy flat foreshore with minimal offshore routing restrictions.

A landfall at Broad Haven would result in an offshore route distance from Rosslare, Ireland of an estimated 106km and an onshore route from Broad Haven to the northern side of Milford Haven of approximately 16km. A further ~3km crossing of the harbour would be required to connect to the converter station.

Onshore, there is a suitable route inland from the Northern landfall at Broad Haven travelling east just north of Broad Haven town. The large public car park at ~100m from beach could provide a working area for the northern exit. This onshore route to the north is proposed in order to avoid routing causing construction disturbance along the seafront road. The onshore route would then travel south towards Milford Haven; where a subsea crossing would be required to run from Venn Farm on the northern side of Milford Haven across to the national grid tie-in point.

Subject to geophysical and geotechnical surveys and the limitations described in Section 1.3 there are no technical reasons not to situate the export cable landfall at Broad Haven.

4.1.2 ADVANTAGES

The advantages of a Broad Haven landfall location are:

- The nearshore route can avoid the firing ranges;
- Sandy foreshore (with some exposed rocks at northern end);
- Nearshore geology on the admiralty chart is mostly sand, muds and gravels;
- Favourable beach profile;
- Onshore routing is constructable.

4.1.3 DISADVANTAGES

The less favourable aspects of locating the landfall at Broad Haven are:

- It necessitates a technically challenging but feasible crossing of Milford Haven (~3km);
- Broad Haven is a high value recreational amenity area and it is probable that the permit construction window will exclude the summer months;
- Desire to avoid laying the cable along the seafront and through the town where possible;
- Admiralty chart indicates some areas of rock in the nearshore;
- Crossing under seawall is required if routing at the northern end of Broad Haven (not a major concern);
- Stormwater culvert at the northern end of the beach may impact on northern shore crossing route options.

.

Figure 4-1 Crossing Option at Northern end of Broad Haven

Figure 4-2 Potential crossing location at Southern end of Broad Haven

Figure 4-3 Further view of Northern end of Broad Haven beach

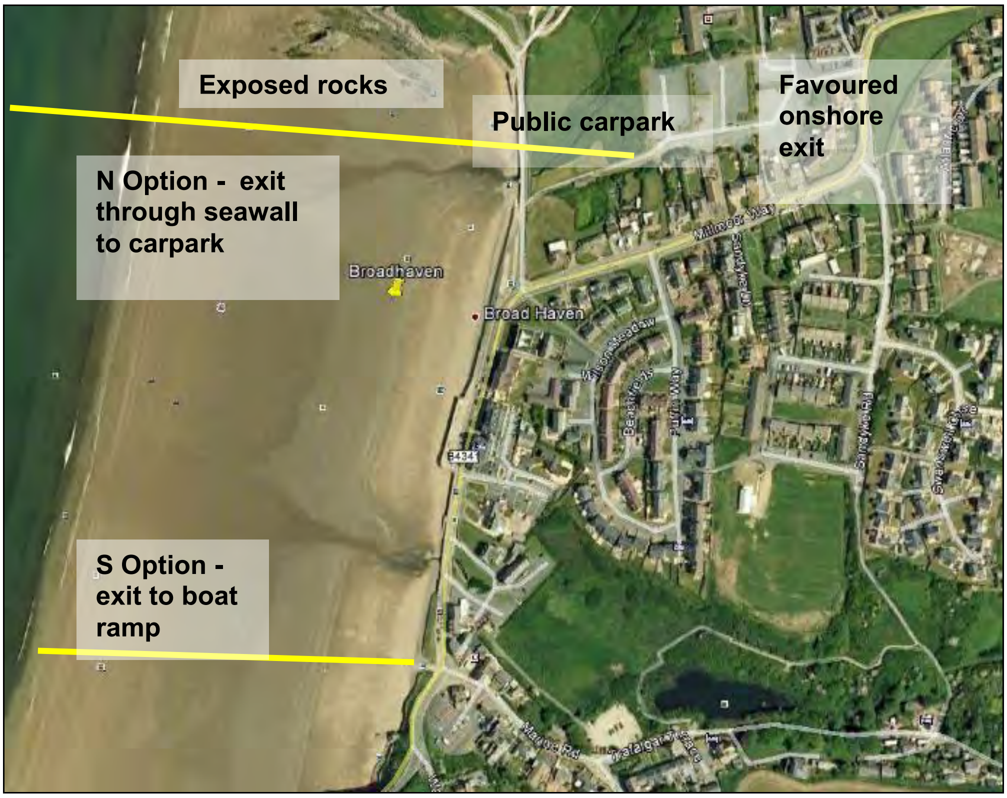


Figure 4-4 Satellite (Google Earth) view of Broad Haven beach

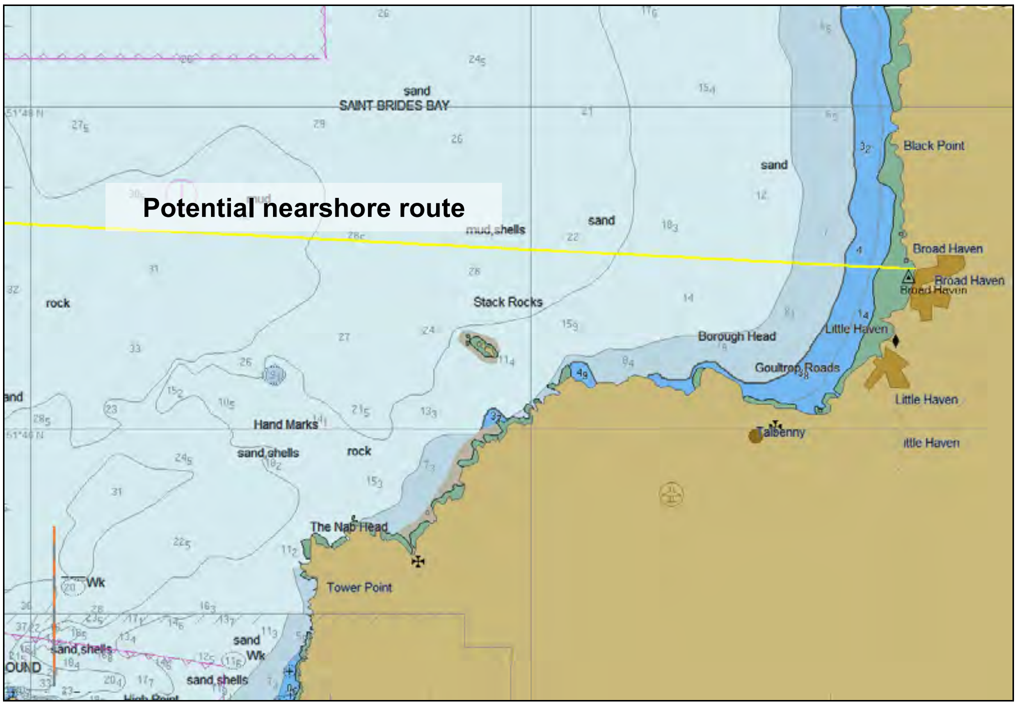


Figure 4-5 Admiralty Chart, Broad Haven

4.2 Newgale

Newgale beach is also located within St Brides Bay, just north of Broad Haven. This landfall was not considered a feasible option because a section of the nearshore is designated as an environmental testing area. Therefore it is highly unlikely that any offshore construction activities would be permitted.

4.3 Dale

The option to the west of Dale town is a difficult landfall, due to geology, topography and access issues, and therefore is not preferable.

Points for consideration:

- Located towards southern end of the peninsula, approximately 3km from Milford Haven harbour entrance;
- Admiralty chart indicates a rocky nearshore;
- Beach on western side of the coast has a only a small strip of sand, with exposed rocks visible both on the beach and just offshore;
- Small ~3-4m bank at the lowest point upon exiting the beach to the valley (farmland);
- Onshore access is difficult, public road is narrow and travels past Dale castle along the top of a steep bank, at some height above the beach. No road access to beach;
- Better access could be gained along the base of the valley from the town on the eastern side of the peninsula. This access would require a crossing agreement with farmer for access of construction equipment through the valley;
- The beach area on the eastern side of the peninsula is used for local moorings;
- This location would result in a longer harbour crossing of Milford Haven than that from Venn farm further to the east.

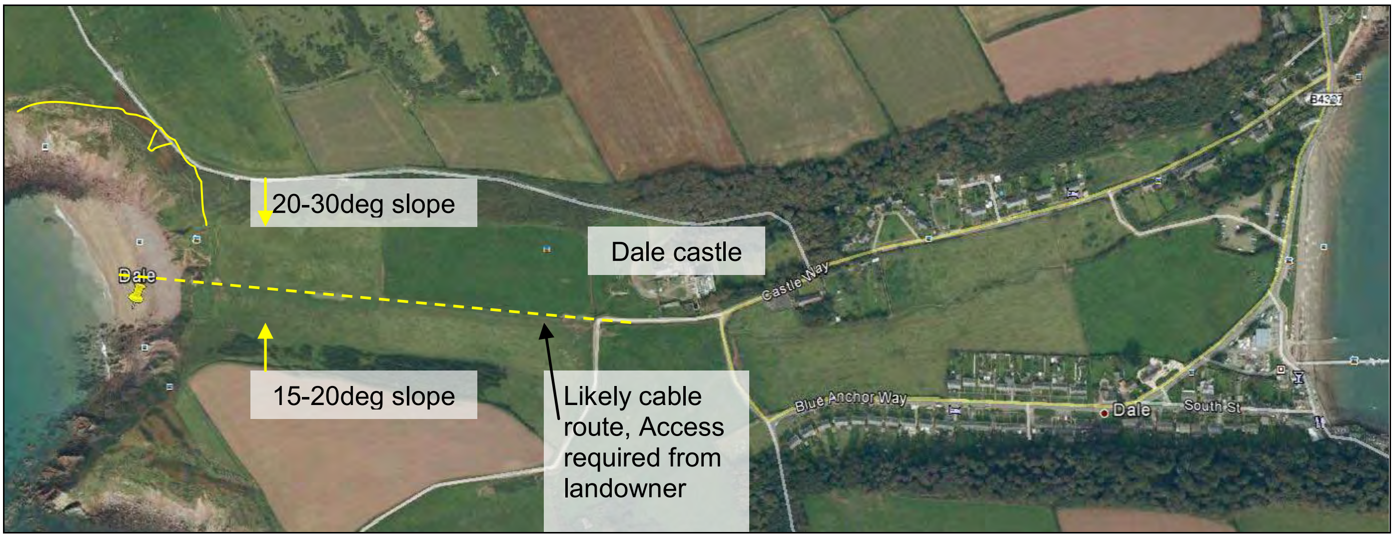


Figure 4-6 Landfall Option (to the left) with Dale Township (to the right)

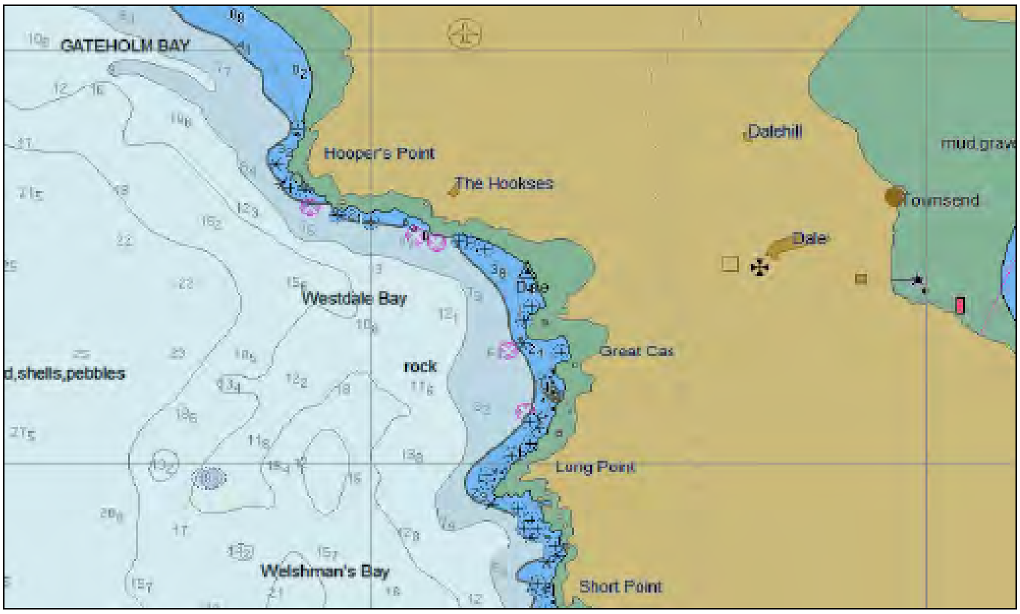


Figure 4-7 Admiralty Chart for Dale

Figure 4-8 View of Dale Landfall

4.4 Options Further North

4.4.1 OVERVIEW

Beaches further to the North of Broad Haven were identified as potential options as part of the desktop study, however these options should be considered only as fall-back options to be further evaluated if obstacles are encountered with a landfall at Broad Haven or Freshwater West. This is due generally to the less favourable landfall conditions, longer onshore routes and difficulties with accessing the northern beaches, often via single lane narrow roads. It might be noted that all northern routes will require a crossing of Milford Haven.

Figure 4-9 Northernmost Landfall Locations

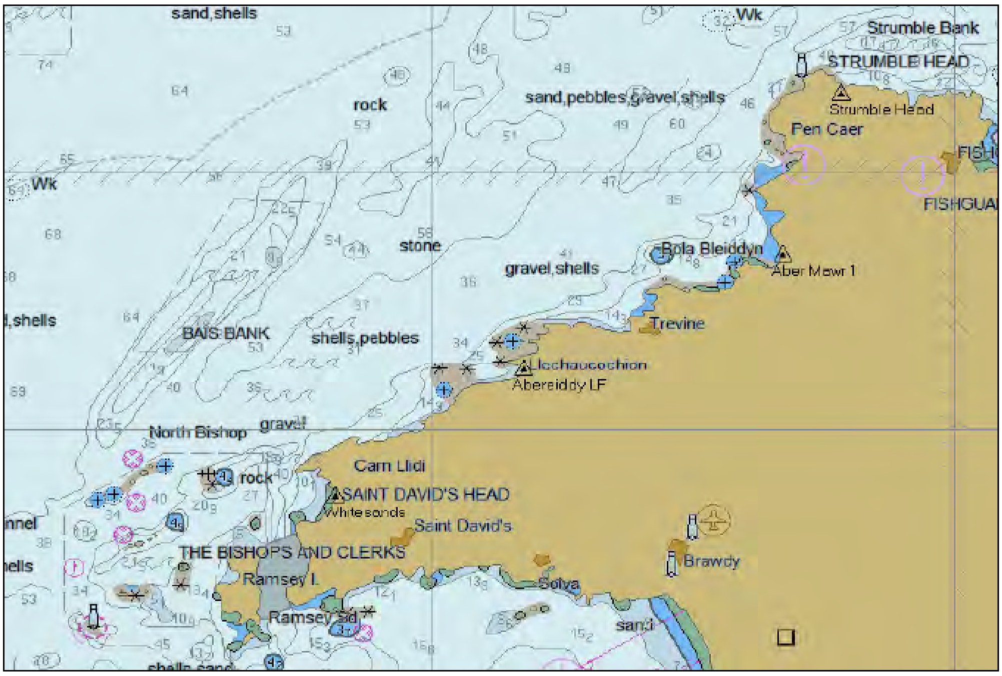


Figure 4-10 Admiralty Chart, Far North Options

4.4.2 WHITESANDS

Whitesands appears technically feasible from a landfall construction viewpoint.

Observations regarding the Whitesands landfall are noted below:

- Sandy beach with rock outcrops at northern extent, although rock noted in the nearshore on the admiralty chart;
- Exit from a beach landfall could be through to the public car-park (approximately 40m x 120m);
- From the car-park a narrow single lane road climbs up in a moderately steeply manner (no parking available on the road);
- Adjacent to the access road at the top of the slope leading down to the beach is the St David's City Golf Course (entrance approximately 700m from the beach). The golf course extends to within 100m of the beach, on the southern side of the access road and south of the public car-park;
- The beach has a high recreational amenity value and is a prominent surfing location;
- The onshore route ~25km longer than that to Broad Haven but correspondingly the offshore route is shorter;
- Most of the onshore main access road is suitable except for narrow congested sections through St David's and Solva town. It may be possible for alternative onshore routes to be proposed.

However the feasibility of the onshore route and the potential for public opposition due to the high recreational amenity value would need to be further investigated if this option is to be considered further.

Figure 4-11 Whitesands Beach, view from the South

4.4.3 ABEREIDDY

Abereiddy is a small beach located to the northeast of Whitesands and the town of St David's. The landfall comprises the following features:

- Exposed bedrock to the west of the beach;
- To the east the foreshore comprises pebbles overlying sand;
- A small (<2m) high concrete seawall is the sea defence for the public carpark which runs along the beachfront (~30m x 120m long);
- Admiralty chart indicates shells and pebbles are present in the nearshore. The water depth increases quickly to ~25m at the end of the inlet approximately 400m offshore;
- Beach is used for access to the nearby "blue lagoon", which is a disused slate quarry which has been infilled with seawater through a breach in the outer wall. This lagoon is a popular location for tourism activities that include coasteering;
- Road access is generally suitable except for the final access to the beach which is approximately 4 to 5m wide. Much longer onshore route than Broad Haven.

Figure 4-12 Abereiddy Beach, looking towards the North

4.4.4 ABER MAWR 1 & ABER MAWR 2

Aber Mawr 1 and 2 are gravel/pebble beaches located north of Abereiddy. Both beaches are similar in terms of geology and difficult access with no public road to the beach. The Pembrokeshire coastal path network passes right across both beaches. The admiralty chart identifies the nearshore geology as gravels and pebbles.

Access to both beaches is difficult:

- The public road is only one lane wide for the last 500-800m;
- For Aber Mawr 1, construction access would be very challenging as behind the beach is a wetland/marsh area extending for approximately 500m;
- For Aber Mawr 2, construction access could be built alongside the coastal walking path which leads at a moderate slope down the cliff, southwest towards the beach. This may require some adjacent landowner permissions.

Figure 4-13 Aber Mawr 1, looking towards the Northwest

Figure 4-14 Aber Mawr 2, looking towards the Southwest

4.4.5 STRUMBLE HEAD

Strumblehead was not accessed during the site visit as there was no public access available to the beach. It is the most northerly landfall that was identified as part of the desk top review. The location identified is a small inlet at the end of small valley to beach. The aerial view indicates a sandy foreshore but with rocks offshore.

The beach is located approximately 500m from the public road and therefore landowner agreement would be required for construction and cable routing.

The admiralty chart identifies the nearshore geology as sand, pebbles, gravels and shells.

5.0 LANDFALLS SOUTH OF MILFORD HAVEN

5.1 Firing Range Restrictions

Landfall options to the south of Milford Haven (which would eliminate the need for a harbour crossing) are severely restricted due to the presence of the Castle Martin and Manorbier Firing Ranges which remain in active use for military practice. Refer to Appendix A for a Figure indicating the extent of the firing ranges.

In order to select any of the landfalls presented that are located south of Milford Haven, a detailed unexploded ordnance (UXO) survey would be required to locate any munitions present along the proposed cable route. Impact ballistic studies would also be needed to identify the level of protection the cable requires (burial depth and armouring) from future firing range activities. If a southern landfall option is to be further considered, early consultation should be sought with the Ministry of Defence.

5.2 Freshwater Bay West (Preferred Southern Option)

5.2.1 SUMMARY

The preferred landfall to the south of Milford Haven is at the northern extent of Freshwater Bay West. If the landfall is located at the northern end of the beach the nearshore route can positioned just outside the extent of the Castle Martin Firing Range.

The admiralty chart indicates the presence of rock in the nearshore area and areas of weathered slate and conglomerate were exposed at the northern end of the beach at low tide.

A landfall at Freshwater Bay West would result in an offshore route distance from Rosslare, Ireland of an estimated 117km and an onshore route of approximately 8km. This is a similar overall distance to the Broad Haven route.

The shore crossing at Freshwater Bay would extend through sand dunes. The dunes increase substantially in height further to the south and are part of an SAC and SSSI. Environmental permitting constraints that are likely could restrict the landfall construction method to an HDD option in order to avoid disturbance to the dunes.

Due to the proximity to both the firing range and the Milford Haven harbour mouth it is likely that substantial cable burial depth would be required in order to provide protection to the cable (in the order of approximately 4m subject to detailed analysis). This could be provided by rock dumping a surface laid cable or trenching and backfilling. However, the burial depths of power cables are limited due to the cover over the cable providing additional thermal insulation which is detrimental to cable performance.

The most advantageous factor of selecting this landfall is that it has the shortest onshore route to the converter station at Pembroke.

5.2.2 ADVANTAGES

The favourable points of this landfall are:

- It has the shortest onshore route of all options under consideration;
- Technically straightforward;
- The nearshore route avoids the firing range;
- Sandy foreshore with favourable nearshore beach profile;
- Reasonable onshore access.

5.2.3 DISADVANTAGES

- Proximity to firing range;
- Proximity to Milford Haven harbour entrance;
- Shore crossing and working area likely to be through dunes to public carpark and subsequently be likely be subject to environmental restrictions;
- Evidence of land movement in the slope behind dunes leading up to the public access road;
- Potential for rock to be encountered in the nearshore (slate and conglomerate exposed on the beach at low tide at far Northern end of beach), areas of rock identified on admiralty chart.

Figure 5-1 Freshwater West, Northern end of beach.

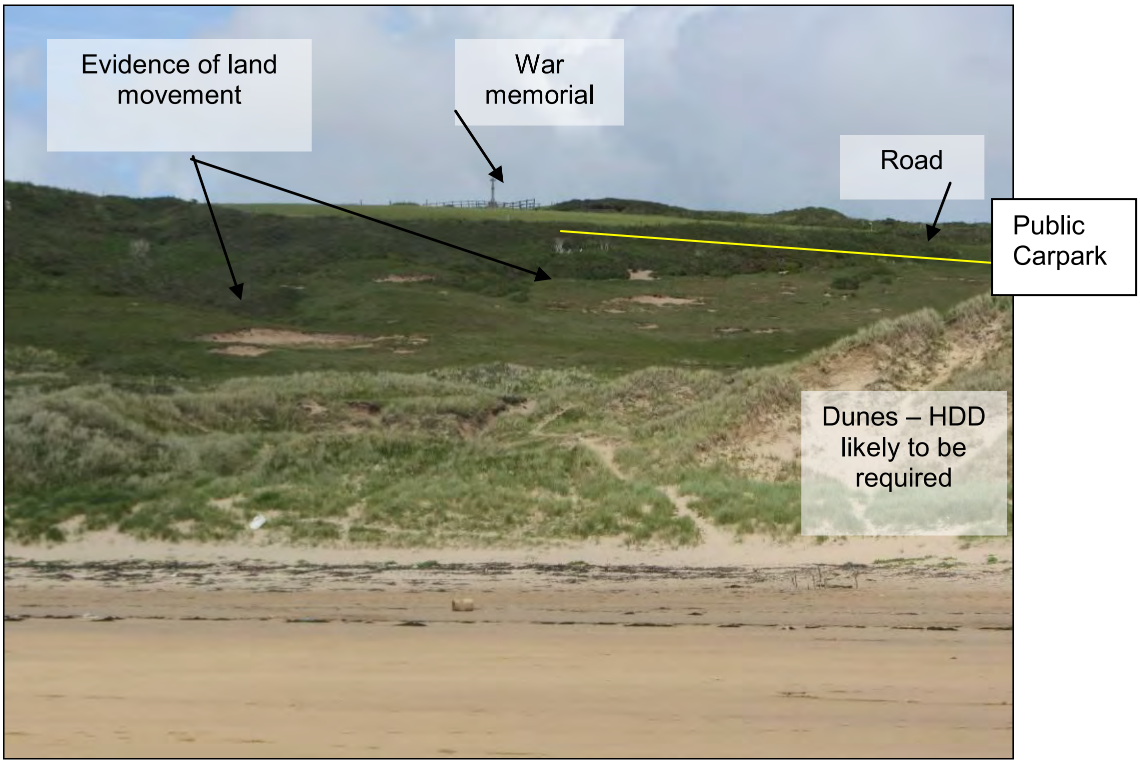


Figure 5-2 HDD exit behind dunes, to carpark

Figure 5-3 View looking towards the NW at Freshwater West Beach

Figure 5-4 Freshwater West, Public access to Beach

5.3 Broad Haven South

Broad Haven South is within the Castle Martin Firing range and as such should not be considered further unless other more favourable options are excluded.

Figure 5-5 Broad Haven South, Public access to Beach

Points of note for Broad Haven South:

- Steep walking path access to down to the beach from the carpark (stairs, ~100m, up to 30deg slope);
- Landfall construction will likely require an HDD into carpark to avoid open cut on the steep slope;
- Tourist information boards identify several bird species local to the area including Guillimots, Razorbills and the area is also a nesting zone for Britain's rarest crows named Cloughs;
- Rocks offshore (visible, castle rock), and also small breaking waves to the west of castle rock;
- Sandy beach;
- High tourist amenity and visual landscape value;
- Significantly longer offshore route than Freshwater West.
- Would require UXO surveys

5.4 Freshwater East

Freshwater East is within the Castle Martin Firing range and as such should not be considered further unless other more favourable options are excluded.

Figure 5-6 Freshwater East, looking south-east

Points of considerations for Freshwater East:

- Gently sloping beach with gravel/pebbles/cobbles overlying sand;
- Admiralty chart indicates gravels and sands in the nearshore;
- The main access to the beach is from a car-park located approximately 20m to 50m from the beach at close to it's southern extent:
    - One walking path passes through small dunes (1-3m high) onto beach;
    - Another concreted footpath provides access alongside a small stream to the beach;
- Difficult onshore route to the southwest:
    - Tight narrow roads, small stream with one way narrow bridge(4 to 5m long bridge at the beach access location) ;

- A two lane road runs from the public access, at the southern end of the beach, towards the north. As soon as it exits the beach the road rises steeply and then run along the top of the slope approximately 300m behind the beach and estimated at over 30m high. Residential properties are located at the top of this steep bank along the length of the beach. There are also some walking access tracks down the slope to the beach and farmbike access which may be able to be improved for onshore cable construction up the slope;
- There are mooring buoys for small watercraft at the southern extent of the beach and buoys marking the boat speed zones;
- Significantly longer offshore route than Freshwater East;
- Would require UXO studies.

Figure 5-7 View of Freshwater East looking North; note steep slope to the West

5.5 Tenby South Beach

A landfall at Tenby South Beach can be routed to narrowly avoid the offshore firing range. However it is the longest offshore route, is a popular tourist area and also has a long onshore route.

Points of consideration:

- Sandy beach, admiralty chart indicates sand and shells in the nearshore area;
- Golf course runs behind the majority of the beach except at the southeastern end;
- Any landfall would likely be located at the SE end of beach, near new apartment blocks in order to avoid the golf course;
- There are other cables making landfall at the SE end of beach for which proximity agreements would need to be negotiated;
- Offshore, the cable would be routed between Caldey Island and Woolhouse rocks;
- Due to proximity to the firing ranges UXO studies would be required.

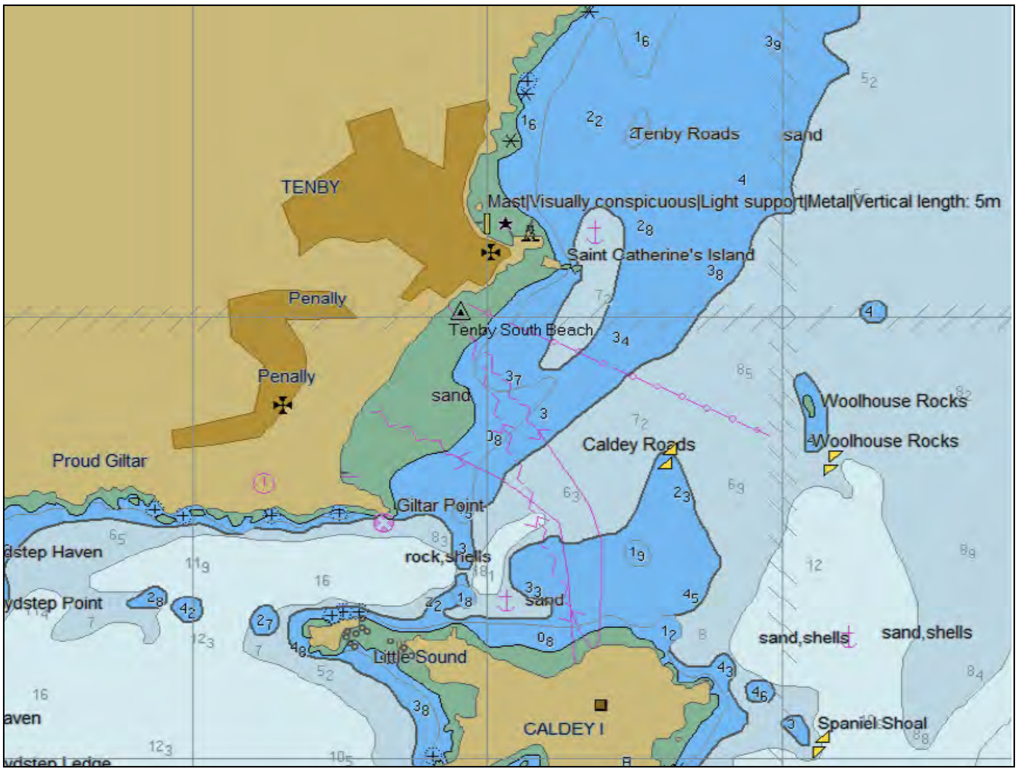
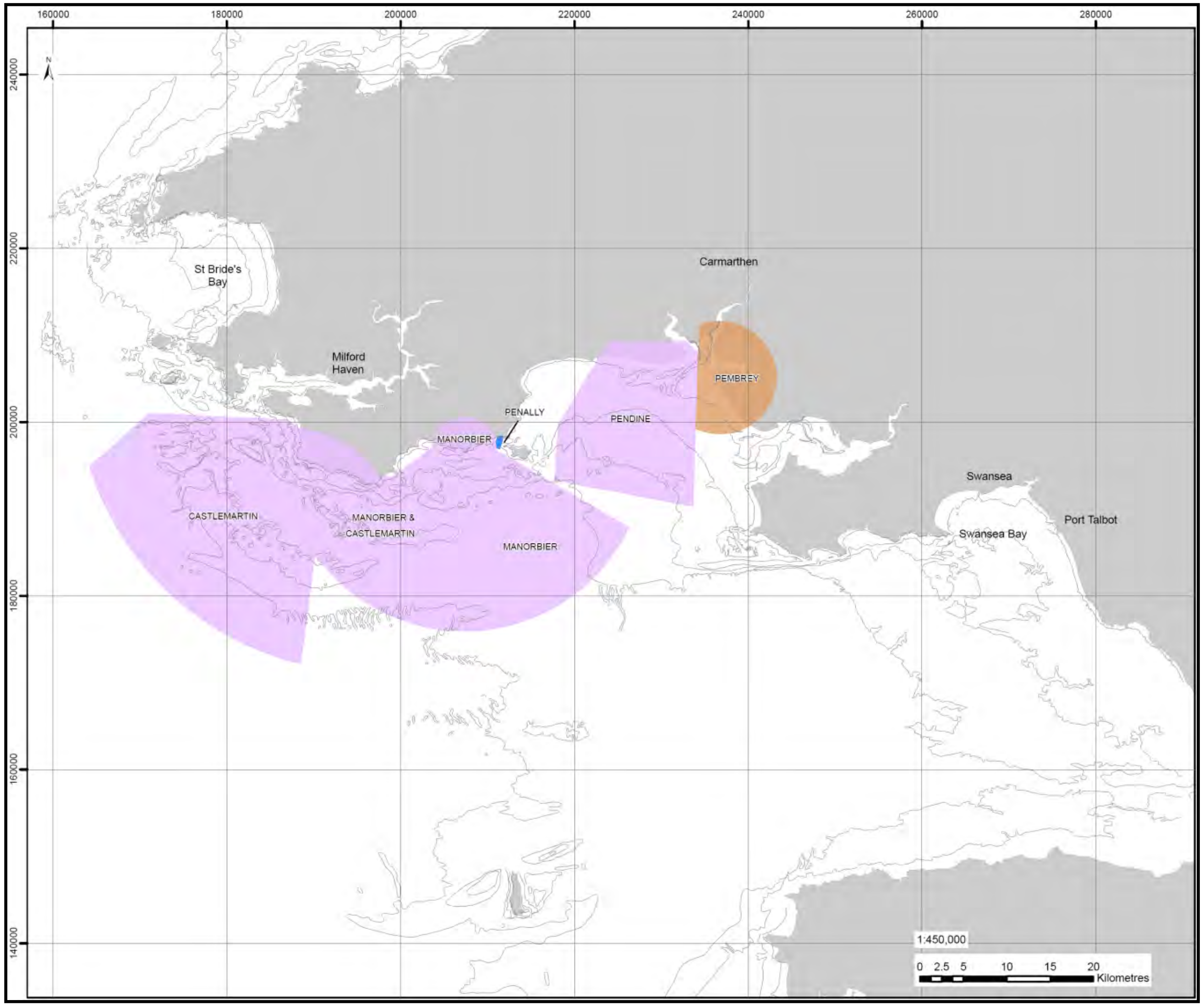


Figure 5-8 Admiralty Chart for Tenby South Beach

Figure 5-9 View of Tenby South Beach towards the Southwest

Appendix A:
Castle Martin and Manorbier Firing Ranges



A 1: Pembroke Range Limits

Appendix B:
Landfall Evaluation Matrices

A Technical Evaluation of the two landfalls is below. The Criteria are evaluated in terms of the colour coding below.

Favourable
Slightly Favourable
Neutral
Slightly Unfavourable
Unfavourable
Fatal Flaw

Category	Broad Haven	Freshwater West
Environment		
Biophysical Environment		
Natura 2000/ Habitats Directive (SPA. SAC)	Pembroke Marine SAC offshore	Pembroke Marine SAC offshore, Limestone Coast of South Wales SAC, Castle Marine Coast SPA
Not designated, contains habitats directive annex 1 habitat or annex 2 species	to be evaluated	to be evaluted
SSSI/NHA not part of SPA or SAC	Newgale to Little Haven SSSI at coast between high tide and low tide level	Broomhill Burrows SSSI
Other designations	Pembroke Coast National Park (St Brides Bay Heritage Coast excludes Broad Haven Beach); marine monitoring area	Pembrokeshire Coast National Park, South Pembrokeshire Heritage Coast
Historical Environment		
Archaelogical and Cultural Heritage	2 concrete defences cubes at the beach	Weapons pit at freshwater west, gun emplacement at Freshwater West; war memorial adjacent to road overlooking the beach.
Wrecks	No charted wrecks	No charted wrecks
Physical Environment		
Onshore Topography	Flat beach, flat - gently sloping behind beach to carpark.	Flat beach. Moderate steep slope behind beach up to public carpark and road. Limited Flat working area.
Onshore Hydrology/Pollutants	Unknown. Stormwater culvert at the N end of beach.	Unknown.

Category	Broad Haven	Freshwater West
Nearshore Geology	Sand/mud/gravel. Some exposed rocks on the beach.	Admiralty chart shows areas of rock in the nearshore, exposed bedrock at Northern end of the beach.
Offshore Route Geology	Majority is sand/mud/gravel. Some areas of rock past the headlands, may be possible to route around.	Rock/gravels/sand.
Offshore Features	None identified.	Harbour entrance.
Nearshore Bathymetry	Favourable	Favourable
Coastal Erosion	Seawall along the beach may effect erosion processes. Unknown.	Unknown.
Meteocean Conditions	Within standard design envelopes.	Higher currents around harbour entrance

Human Factors

Built Environment

Wellheads, platforms etc	No offshore structures.	No offshore structures.
Firing range/UXO/PEXA zones	Outside firing range	On edge of firing zone, UXO survey required
Dredging & Dredge Dumping	To be evaluated	To be evaluated
Adjacent landfalls	SW culvert	None identified

Category	Broad Haven	Freshwater West
Public Utilities/Pipelines/Windfarms/ Other uses	May be considered for future developments	May be considered for future developments
Structures at landfall	Small seawall up to 2m high. Boat ramp at S End of beach, SW culvert at N end.	None
Human Activity		
Shipping	Anchors within St Brides Bay	Close to harbour mouth with shipping activities that include large LNG tankers etc.
Commercial Fishing	to be evaluated	to be evaluated
Adjacent land use - Residential & Commerical Properties	Adjacent to local Broad Haven properties. Carpark area should be available for construction	Farmland
Public Safety and Impact on Community Amenities/Facilities Onshore - Beach Use	Local and tourist use year round.	Local use year round.
Public Amenities Offshore - recreational fishing, boating, yachting, moorings, marinas, navigation buoys	Boat ramp at Southern end of the beach providing access for recreational users.	Minimal
Public Interest in Project	Landfall in tourist area, potentially in or adjacent to town	Landfall in area with environmental designations
Noise & Vibration at Landfall	Landfall works may generate construction noise/vibration disturbance due to proximity to local residents if not managed correctly.	HDD/beach works may generate minimal vibrations and construction noise, but no residential dwellings nearby
Visual Effects	No permanent effects, temporary only during	No permanent effects, temporary only during

Category	Broad Haven	Freshwater West
	construction	construction
Engineering and Economic Factors		
Design and Construction Complexity	Broad Haven landfall is reasonably simple with no notable design challenges identified.	Degree of complexity due to sand dunes environmental considerations, but resolvable by industry standard design and construction methods
Overall Construction Cost	May be able to do an open cut at the landfall	Likely to require HDD under sand dunes
No./type Offshore Crossings	No pipeline or cable crossings	No pipeline or cable crossings
Site Access/ROW/Temp Works Area	Public carpark at N end of beach. Good public road access.	Narrower road access to within 300m of beach. Flat works area will need to be constructed behind sand dunes.
Logistics	Easy access to existing infrastructure. Landfall within /near to existing town/city.	Moderate access to existing infrastructure. Landfall within 10km of existing town/city.
Land acquisition	To be evaluated - ARUP?	To be evaluated - ARUP?
Tie in to onshore PL	Tie-in OK but long onshore route and 2 additional tie-ins from Milford Haven crossing.	Simple tie-in, close to substation

End Of Document

APPENDIX B

Irish Landfall Report

GREENLINK INTERCONNECTOR PROJECT

LANDFALL SELECTION REPORT

Report Reference. P1975_RN3926_Rev4

Issued 8 February 2016

Intertek
Exchange House
Liphook
Hants GU30 7DW
United Kingdom

Tel: +44 (0) 1428 727800
Fax: +44 (0) 1428 727122

E-mail: energy.water.info@intertek.com
Web Site: www.intertek.com

Co-financed by the European Union
Connecting Europe Facility

DOCUMENT RELEASE FORM

Title:	GREENLINK INTERCONNECTOR PROJECT LANDFALL SELECTION REPORT
Client:	ELEMENT POWER IRELAND
Report Reference:	P1975_RN3926_REV44
Date of Issue:	8 February 2016

		Hard Copy	***Digital***
Distribution:	ELEMENT POWER IRELAND	No: --	PDF
	Intertek Energy & Water Consultancy Services	No: --	PDF
	ARUP	No: --	PDF
Prepared By:	Emma Pidduck / Jillian Hobbs / Paula Daglish / Sheila O'Sullivan		

Project Manager:	Authoriser:
afarley	afarley
Anna Farley	Anna Farley

Rev No	***Date***	***Reason***	***Author***	***Checker***	***Authoriser***
Rev 0	13/11/15	Original	ELP/JH	APA/EH	CJM
Rev 1	19/11/15	Incorporating Arup assessment	SOS	APA	CJM
Rev 2	21/12/15	Final comments following consultation	ELP	APA	CJM
Rev 3	08/01/16	FINAL	SOS	EH	ALF
Rev 4	08/02/16	FINAL – incorporating Clients comments	SOS	EP	ALF

COPY NUMBER: (applies to hard copies only)

Intertek Energy & Water Consultancy Services is the trading name of Metoc Ltd, a member of the Intertek group of companies

Co-financed by the European Union
Connecting Europe Facility

SUMMARY

Intertek Energy & Water Consultancy Services (Intertek) and Arup have been commissioned, to provide a landfall assessment and study for the proposed HVDC Greenlink Interconnector between Great Island substation in Ireland and Pembroke substation in Wales. The Greenlink Interconnector is a CEF funded project between Ireland and Wales.

The objective of the study is to establish the optimal landfall locations from a marine and onshore perspective for further survey. Site visits to pre-determined landfall locations in Ireland were conducted. Arup conducted a landfall site visit on 15 October 2015 in Ireland. Intertek and Arup conducted joint landfall site visits on 28-29 October 2015 in Ireland. In Ireland, 10 sites were identified of which 4 were visited on the initial Arup visit and 8 were visited on the joint visit, ensuring all options were visited. Site visits were not required for Wales during this phase. The landfall location was previously determined as part of a Welsh landfall assessment process, which included a number of site visits, for the Greenwire project. The Welsh landfall selected is at Freshwater West in Pembrokeshire.

Prior to the visits in Ireland, potential landfall sites were identified using both publicly available and purchased data, and Intertek and Arup ranked each site independently from an offshore and onshore perspective, respectively. The most suitable sites were selected for site visits. Following the site visits, the landfalls were ranked in order of preference by each consultant. Of the 10 sites visited, 3 have been proposed for further investigation; namely Booley Bay, Baginbun Beach and Boyce's Bay on the Hook Head Peninsula, based on their high initial ranking score.

Following a consultation with the National Parks & Wildlife Service (NPWS), it was concluded that installing a cable through a Special Area of Conservation (SAC) could potentially be possible provided that the works would not adversely affect the integrity of the protected site and its conservation objectives. In the interest in achieving the most direct offshore cable route, Sandeel Bay was reinstated as a potential preferable landfall location, despite the relatively low initial ranking score.

In conclusion, Booley Bay, Baginbun Beach, Boyce's Bay and Sandeel Bay have been identified as potential preferable landfall locations and will all be subject to further investigations, including site assessments and stakeholder consultations.

Following detailed site assessments and stakeholder consultations the final landfall selection will be completed and a further Revision of this report will be issued.

Co-financed by the European Union
Connecting Europe Facility

CONTENTS

Co-financed by the European Union
Connecting Europe Facility

TABLES

Co-financed by the European Union
Connecting Europe Facility

FIGURES

Co-financed by the European Union
Connecting Europe Facility

ABBREVIATIONS

HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
MLW	Mean Low Water
NHA	Natural Heritage Area
NPWS	National Parks & Wildlife Services
SAC	Special Area of Conservation
SPA	Special Protection Area
TJP	Transition Joint Pit

Co-financed by the European Union
Connecting Europe Facility

1 INTRODUCTION

Intertek Energy & Water Consultancy Services (Intertek) has been appointed by Element Power Ireland to provide a range of marine consultancy & engineering services related to the Greenlink Interconnector.

Arup has been appointed by Element Power Ireland to complete all onshore consultancy and engineering services related to the Greenlink Interconnector.

This report details the selection of suitable landfall locations from an offshore and onshore perspective including the methodology of assessment. This report outlines the methodology and chosen landfall locations before recommending landfalls for further investigation.

This report provides a qualitative analysis of landfalls using a set of criteria established to find an optimum site. There is no quantitative way to measure the suitability of each landfall.

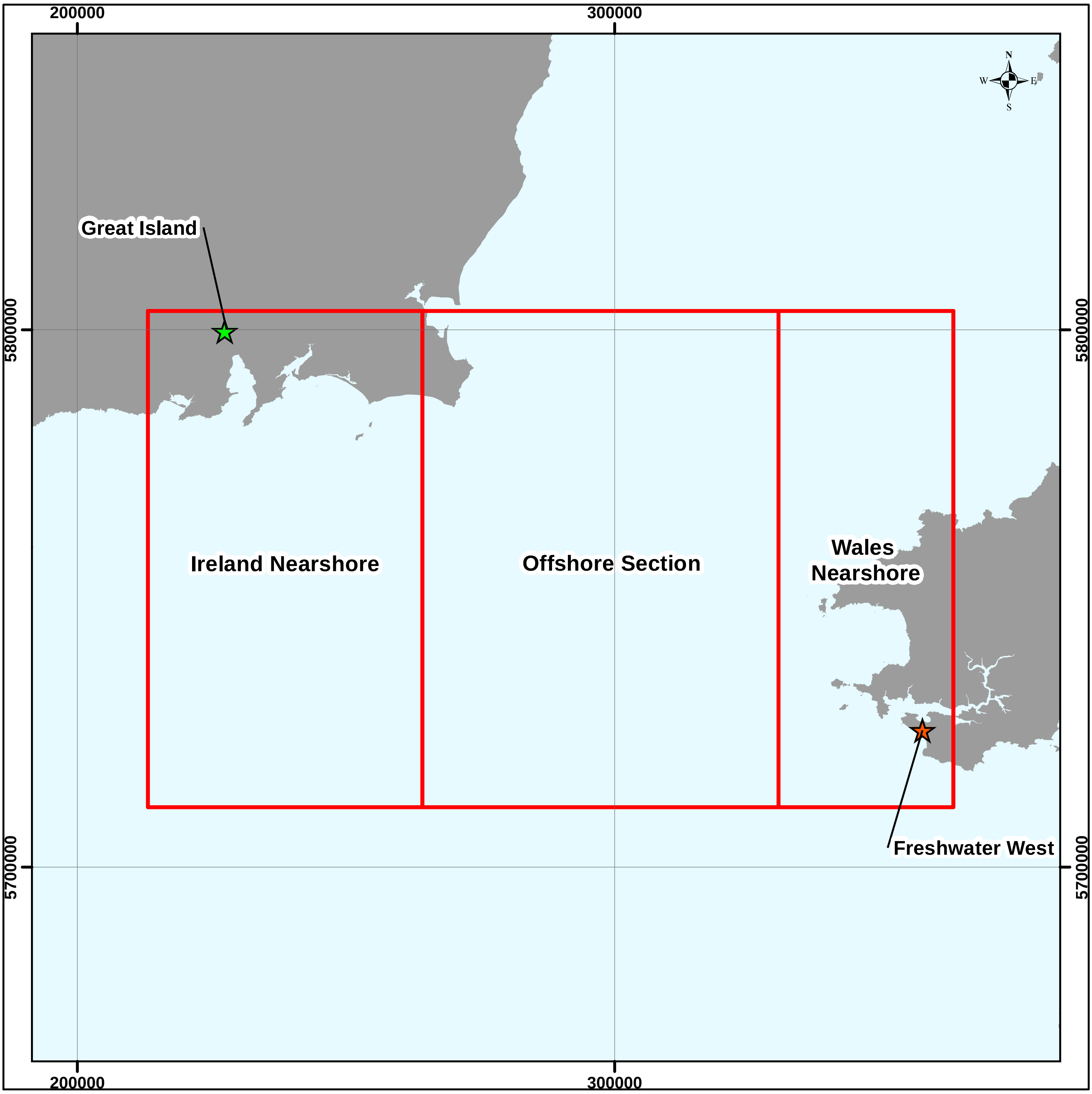
1.1 BACKGROUND

The Greenlink Interconnector is a dedicated interconnector to be constructed between UK and Ireland to connect the two electricity markets; linking the UK National Grid with EirGrid’s Irish network. The EU has selected the Greenlink project for funding under the Connecting Europe Facility (CEF). Greenlink has also been included as an EU Project of Common Interest, as well as being shortlisted for assessment by Ofgem for a Cap and Floor Regulatory Regime and application granted for an Interconnector Licence with Ofgem.

It is proposed, for technical reasons that Greenlink will connect to the National Grid system at Pembroke substation in Pembrokeshire, Wales and to the Irish network at Great Island substation in Co. Wexford, Ireland. Convertor stations will be located near each substation to convert the HVAC electrical supply in both countries to HVDC which will be the electrical system to be used in the Greenlink interconnector.

Figure 1-1 demonstrates the study area for the landfall site selection, including the offshore and nearshore sections of the route. The landfall location for the Wales grid connection has already been identified and is marked in **Figure 1-1**.

Co-financed by the European Union
Connecting Europe Facility



Legend

- Freshwater West
- Great Island
- Study Area

NOTE: Not to be used for Navigation

Greenlink Interconnector Cable

Figure 1-1: Proposed study area for the landfall site selection including the offshore and nearshore sections of the route.

Date	Monday, October 19, 2015 12:34:02
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	OSOD, OSI
File Reference	J:\P1975\Mxd\Figures\ Fig1_1_Overview.mxd
Created By	Ian Charlton
Reviewed By	Emma Langley
Approved By	Emma Pidduck

Valued Quality. Delivered.

km
0 10 20 30 40 50

2 METHODOLOGY

Factors to be considered in the identification of a cable landfall site include: the type of beach (with an optimal landfall site characterised by a wide, gently sloping sandy beach area in front of low lying land); good onshore and offshore access; alternative access available for landowners; a suitable lay-down area; minimal existing service ducts or cables; stable cliffs or gradual sloping access; and minimal environmental restrictions (e.g., the presence of protected archaeological or ecological sites or protected species could result in consenting issues, seasonal restrictions, or installation methodology restrictions).

The general selection of the potential landfall locations had previously been made on the basis of the proximity to Great Island substation which will be the connecting point to the existing Irish electrical transmission infrastructure, giving an approximate region in which to obtain data to use in analysing the constraints. For the nearshore region, publicly available and purchased data and mapping were acquired in order to identify landfall locations that comply with the constraints identified in **Table 2-1**.

Table 2-1: Criterion used to identify suitable landfall locations
Note: weighting is indicative only and subject to further review

Parameter	Ideal	Acceptable	Measure	Weighting
Vessel Access	10 m water depth contour is < 500 m from MLW mark. Approaches clear of all dangers. Minimal rock outcropping. No inshore fishing or anchoring.	10 m depth contour < 1 km from MLW mark. Identified dangers must provide sufficient sea room to allow for navigation of vessels/barges. Inshore fixed fishing gear, yacht anchorage, fish farming if clear of cable route.	Pre-visit: Chart 10 m depth contour and MLW to identify areas greater than 1 km and exclude. Use Admiralty charts to exclude marked anchorages. Site-visit: Conduct visit during spring tide to identify any hidden obstructions/dangers and assess accessibility by vessels. Look for indications of fishing.	16%
Beach composition – including nearshore seabed geology.	Gently shelving beach & approaches. Greater than 2 m cover. Stable beach level.	Gently shelving beach with less than 1 m sediment cover; pebbles and boulders acceptable if they can be excavated. Rock seabed provided the profile will not cause cable suspensions.	Pre-visit: Identify areas of sandy beach with low cliffs. Site-visit: measure beach gradient with GPS and assess sand coverage.	14%
Environmental Constraints	No environmental sites such as Special Areas of Conservation (SAC), Special Protection Area (SPA), offshore wrecks, onshore protected archaeological structures or historic estates/demesnes in the vicinity of the landfall and access road.	Installation in the vicinity of archaeological sites and/or through proposed ecological protected sites where no alternatives are available and with proper consideration of environment and minimising installation disruption to the proposed sites.	Pre-visit: Identify landfall locations not within environmental constraints. Site-visit: Observe local signage and tourist information.	10%
Amenity Impact	Least impact on local community and amenities	Multiple access roads to site; no local businesses (cafes, etc.); minimal disruption to	Pre-visit: Identify landfall locations away from major towns and tourist hotspots.	10%

Co-financed by the European Union
Connecting Europe Facility

Parameter	Ideal	Acceptable	Measure	Weighting
		water-users.	Site-visit: Look for indications of beach use such as dog-walking, surfing, swimming, etc.	
Exposure – weather and currents	Sheltered from prevailing weather with currents not exceeding 1 knot.	Partial shelter from prevailing weather with currents not exceeding 2 knots.	Pre-visit: Identify prevailing conditions & find locations that would be sheltered. Use tide-maps/currents to assess strength of flow. Site-visit: Look for signs of turbulent, fast-flowing water.	8%
Working / Site Area	Access via primary roads, no improvements needed and hard standing available for plant. Preferable to avoid ports or busy beaches.	Access via a regional road or track, with ability to upgrade if required. Space available to build hard standing.	Pre-visit: Map access roads Site-visit: Check accessibility and confirm space available.	8%
Obstructions & Existing Infrastructure	No cables or pipelines in area. Good drainage along access road to landfall.	Landing offers sufficient space to achieve adequate separation (to be defined according to cable specifications and cable installation requirements).	Pre-visit: Identify all existing cables/pipelines and avoid, if possible. Site-visit: Look for indications of previous cables, obvious infrastructure, etc.	8%
Coastal Erosion	Landfall location with stable headland/cliffs. Minimal evidence of erosion.	Small signs of cliff erosion; no rock slides.	Pre-visit: Use of public data/journal articles to identify areas where coastal protection has been installed. Site-visit: Observe condition of cliffs during site visit. Document evidence of erosion.	8%
Access to the Beach	Wide road for vehicular access (including heavy plant machinery, etc.) with minimal slope. Public road with alternative for local users.	Single track road with hedges/walls that can be re-established if required. Gentle slope. Tarmac/concrete that can be re-established if required.	Pre-visit: Identify landfalls with access by public roads where alternatives would be viable. Site-visit: Measure gradient and width of track; identify surrounding properties/users.	6%
Cable engineering & protection requirements	Cable can be directly buried on beach and offshore. Area for installation of transition joint pit (TJP).	Cable can be protected with split pipe and pinned to seabed, if required. Large flat area of beach for TJP or empty field where conditions can be returned to normal.	Pre-visit: Identify sheltered areas to reduce risk of erosion or high sediment transport. Identify landfalls with sufficient area to install TJP. Site-visit: Examine sediment type, evidence of underlying rock, etc.	6%
Overall cable length	Shortest overall cable length from Great Island Convertor Station to Freshwater West Landfall in Wales	Cable length not significantly greater than shortest overall cable length from Great Island Convertor Station to	Pre-visit: Map overall cable distance taking identified constraints into account. Site-visit: Examine onshore	6%

Co-financed by the European Union
Connecting Europe Facility

Parameter	Ideal	Acceptable	Measure	Weighting
		Freshwater West Landfall in Wales	and offshore access point constraints modifying route.	

At each location, digital photographs were taken of the actual beach and foreshore areas together with the approaches and surroundings of each site. Photographs taken were marked using in-camera GPS.

The site visits conducted by Intertek were timed to coincide with low water spring tides so that as much of the beach would be visible as possible. Tide times were taken from Cobh, a nearby port (Table 2-2).

Table 2-2: Tide times at Cobh harbour during the landfall assessments. Adjustments of approx. 1.5 h required for Waterford.

Tides at Cobh Harbour	Time:	Tide Height:
Wednesday 28th October 2015	0527	4.6 m
	1200	0.0 m
	1749	4.6 m
	2359	0.1 m
Thursday 29th October 2015	0022	0.0 m
	0610	4.6 m
	1244	0.0 m
	1833	4.5 m

A series of positional measurements of significant features were taken using a hand held GPS unit. The instrument quoted accuracies varying between +/- 4 m to 12 m during the field work. For ease of measurement and calculation, the logged GPS points have been converted to UTM Zone 29 on the ED 50 Spheroid. Consequently, all co-ordinates referred to in this report are in the grid format relevant to Ireland. Elevation measurements were also made with a hand held GPS, but the reader should be aware of the limitations of this method.

Following completion of the landfall visits, for each criterion listed below, the sites were given a score out of 10. The scores were averaged and then a weighting applied according to the relative importance of each criteria (**Table 2-1**).

Co-financed by the European Union
Connecting Europe Facility

3 STUDY AREA / SITE OVERVIEW

The location of the Irish landfall was pre-determined by the location of the grid connection at Great Island, Co. Wexford. The surrounding coastline within a 30 km radius was assessed using purchased and publicly available data.

As discussed in the methodology, the location of the landfall requires a compromise between onshore and offshore constraints, particularly in relation to achieving the shortest possible cable length and minimising project impacts. Alternative landing locations included along the Wexford coast (south-east Ireland), close to Rosslare and further up the east coast of Ireland.

Along the Wexford coast between the eastern edge of our identified study area (refer to Figure 1-1) and Cahore Point, approximately 40km up the east coast of Ireland, the full coastline is protected by environmental designations, including Special Areas of Conservation (SAC) and Special Protected Areas (SPA). These areas of designation are as follows: Ballyteige Burrow SAC, Saltee Islands SAC, Tacumshin Lake SAC, Carnsore Point SAC, The Raven SPA, Long Bank SAC and the Blackwater Bank SAC. Due to the potential for environmental impacts and subsea conditions offshore considered not suitable for cable installation these locations were not investigated further.

Further north along the east coast of Ireland, between Cahore Point and North of Courtown other potential landfalls were identified, from where a cable would not cross any onshore or nearshore designated sites.

However, these potential landfalls would significantly increase the length of onshore cable required and therefore create a significant potential for increased negative impact on the environment and people.

Much of the coastline of southern Ireland is dominated by steep cliffs interspersed with estuarine/riverine inputs and beaches. Within the Waterford, Wexford and Great Island area (identified study area – refer to Figure 1-1), the rock formation is predominately of the Palaeozoic era ranging from Cambrian to Devonian rock types including sandstone, shale and basalt with additional igneous volcanic rock [1]. The area is well-known for its fossil heritage [2, 3, 4] and similar to the south-east Ireland coast detailed above, much of the southern coastline is also protected by environmental designations. The following environmental protection sites were identified within the study area:

- Ballyteigue Burrow SPA
- Ballyteigue Burrow SAC
- Carnsore Point SAC
- Hook Head SAC
- Keeragh Island SPA & NHA
- Lower River Suir SAC
- River Barrow and River Nore SAC
- Saltee Islands SAC & SPA
- Tacumshin Lake SAC & SPA
- Tramore Back Strand SPA

Co-financed by the European Union
Connecting Europe Facility

- Tramore Dunes and Backstrand SAC

Hook Head is of both geological importance and provides important marine habitats including intertidal and subtidal moderate energy reef covering approximately 10,534 ha, vegetated cliff and large shallow inlets and bays. The reef habitat provides homes to rare and scarce species such as: sponge; hydroids; anemone; sea slug; sea squirt; red algae and kelp.

All activities within a European protected area, which may affect the conservation objectives of that site, will be subject to an Appropriate Assessment screening to qualify the significance of the impact. The project would need to demonstrate that it will not affect the integrity of the designated features. Seasonal and installation methodology restrictions on construction activities may also be applied to protect sensitive species, such as nesting, breeding or over wintering birds.

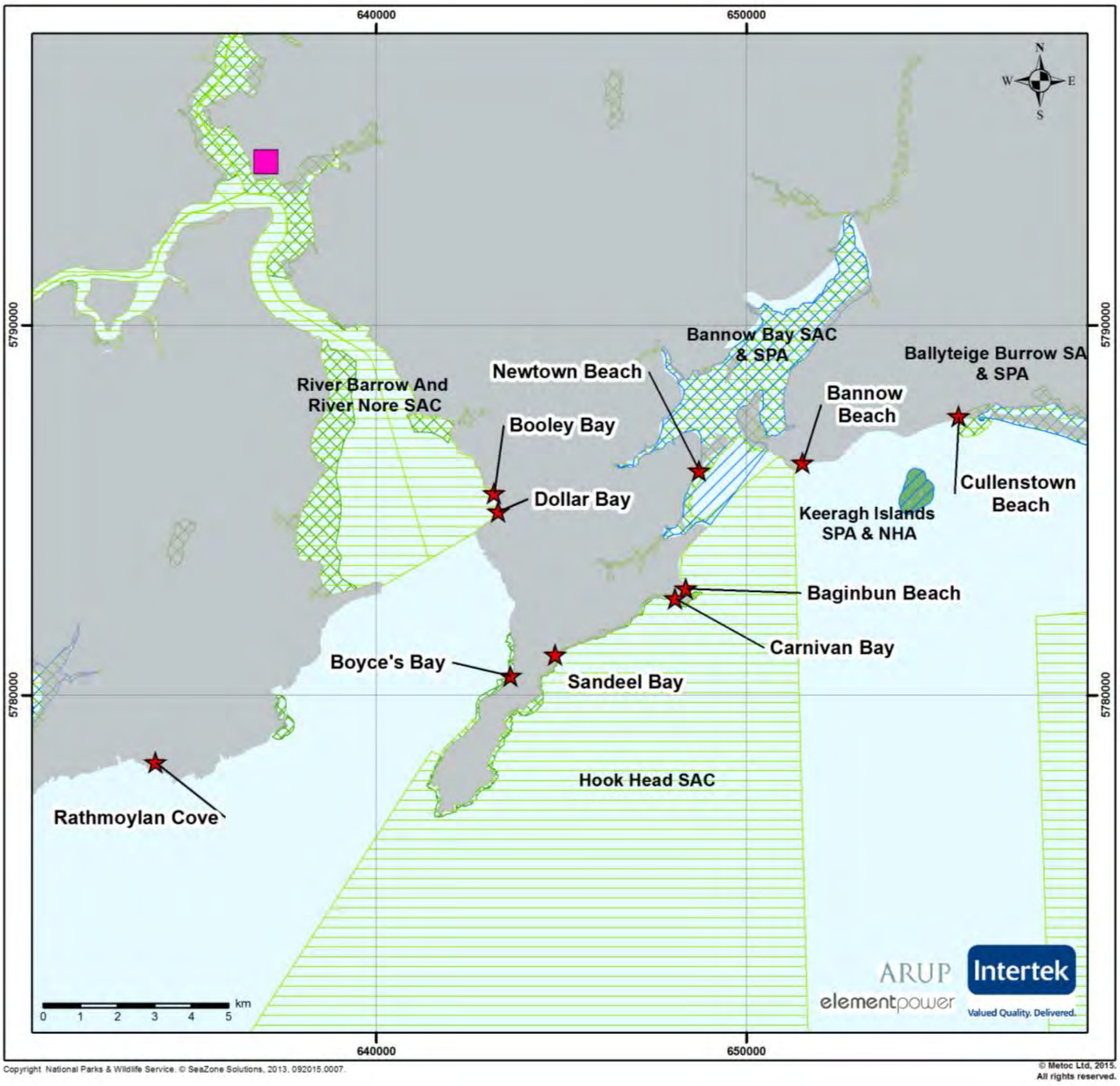
Using the methodology outlined in Section 2, 10 sites were identified as potential landfall visits, of which all 10 were visited.

This report details the results of site visits conducted on 15 October 2015 and on 28 – 29 October 2015 to coincide with spring low tide. Each site was assessed in line with the methodology and criteria presented in Section 2.

A total of 10 sites were identified prior to the site visits on 28-29 October 2015, of which 8 were assessed. The 10 sites are shown in **Figure 3-1**. Sites Rathmoylan Cove and Newtown Beach were visited on 15 October 2015 by Arup but were not visited as part of the site visits on 28-29 October 2015 as both were ranked unfavourable prior to this visit by the onshore and offshore consultant.

Co-financed by the European Union
Connecting Europe Facility

Figure 3-1: Ten proposed landfall sites on the Hook Peninsula within 30 km of the Great Island grid connection.



Co-financed by the European Union
Connecting Europe Facility

4 RATHMOYLAN COVE & NEWTOWN BEACH

4.1 RATHMOYLAN COVE

Rathmoylan Cove is located to the west of the River Nore estuary, across the estuary from all other potential landfall locations identified. It lies outside all SAC and SPAs identified in the area; however, to access the Great Island substation the River Barrow and River Nore SAC would be required to be crossed. To complete this crossing the onshore cable route would be required to traverse numerous areas of ribbon development and/or villages followed by a significant HDD crossing of the estuary with potential for significant ecological and human impacts.

Rathmoylan Cove is an exposed beach facing due south. There are cliffs surrounding the cove on both sides approx. 15 m in height showing evidence of deep erosion, exposing red sandstone geological features including a sea cave on the eastern edge of the cove. Rock protection is installed along the rear of the beach and there is also rock outcrop along the shoreline which was covered in seaweed (see **Figure 4-1 and 4-2**).

Offshore, fishing vessels were observed in the foreshore indicating fishing activity in the area. This is consistent with the location of the cove southeast of the fishing village of Dunmore East.

Birds were observed along the seashore including seagulls and oystercatchers.

Rathmoylan is accessed via a 'cul-de-sac' access road, approximately 4m wide and 350m in length. Three permanent private properties, numerous mobile holiday homes and agricultural landowner plots were identified off this access road with no alternative access.

The access road leads directly to the rear of the beach with space for approx. 2 vehicles with metal bollards preventing vehicular access onto the beach. The cove is quite small and space for heavy plant might be limited.

Figure 4-1: View of eroding cliffs from the rear of the cove looking east.

Figure 4-2: View of the shoreline looking south east including outcropping rock and birds.

From an offshore perspective, Rathmoylan Cove is a very exposed site that would likely limit the time that installation could take place. Additionally, the geology of the area indicates rock would further increase the difficulty of installation.   It would also increase the length of offshore cable required.

The geological features of the cove and the onshore route constraint of crossing the River Barrow and River Nore SAC ranked this landfall option as not suitable for further assessment and therefore has not been included in the final ranking and recommendation section of this report.

4.2 NEWTOWN BEACH

Newtown Beach is located to the north east of the Hook Head Peninsula, on the western side of the entrance to Bannow Bay. The landfall lies within the Bannow Bay SAC and SPA and would also require the cable to cross through the Hook Head SAC offshore. Bannow Bay SAC has a number of qualifying aspects including sandflats not covered by seawater at low tide and shifting dunes (see **Figure 4-3**) which would not be suitable for cable installation due to potential ecological impacts.

At the rear of the beach eroding vegetation on shallow cliffs is evident (see **Figure 4-4**). There was rock outcrop uncovered at low tide along the shoreline which was covered in seaweed. Birds were observed along the seashore including seagulls and oystercatchers.

Newtown Beach is accessed via a 'cul-de-sac' access road, approximately 3.5m wide and 50m in length. There are no properties or landowner plots with access from this access road. The access road leads directly to the rear of the beach with little space for vehicles. Private agricultural land runs parallel to the rear of the beach.

Figure 4-3: View from the rear of the beach looking north east.

Figure 4-4: View of the eroding vegetation at the rear of the beach.

The ecological significance and extremely shallow gradient of the beach ranked this landfall option as not suitable for further assessment and therefore, similar to Rathmoylan Cove, has not been included in the final ranking and recommendation section of this report.

Co-financed by the European Union
Connecting Europe Facility

5 BAGINBUN BAY LANDFALL

Baginbun Beach is located to the north of Carnivan Bay on the Baginbun peninsula. It lies within the Hook Head SAC but the cable would have less distance in the SAC than at alternative sites such as Sandeel Bay.

The beach faces north east and has excellent access for vessels. The distance from the 5 m and 10 m contours were 260 m and 1.4 km, respectively. The eastward facing beach is very sheltered from prevailing wind conditions and wave conditions during southerly winds on the day yielded wave heights of up to 0.3 m. Offshore, a number of lobster / crab pots were observed indicating fishing activity in the area.

Baginbun Beach is accessed via a 'cul-de-sac' access road, approximately 4m wide and 450m in length. Five private properties and approximately seven additional agricultural landowner plots were identified off this access road with no alternative access.

At the end of the access road there is space for approx. 3 vehicles and a gravel access track to the east leading to the beach. The parking space at the top could be used for the site construction units or the TJP. The access track is approximately 3.5m wide with grass verges/vegetation on either side of the path. On the hillside of the track there are 3 concrete drainage access points that exit onto the beach; likely freshwater drainage.

The potential onshore route from the Baginbun Beach access road to the R733/L4045 junction, southeast of Great Island, is approximately 12.8km along local roads or 12km along regional roads. The various onshore route options available to the Baginbun Beach access road require environmental constraints to be considered for each route.

At the bottom of the access track there is a seawall of approx. 1 m tall and less than half a metre wide. Additionally, the path is broken into pieces at the bottom and there is bed rock. The angle of the access path relative to the beach was approaching 90°, meaning that open cut trenching on the beach and up the path would not be possible without significant changes in direction for the cable.

Surrounding the beach are heavily vegetated cliffs of moderate height (< 15 m) with only minor signs of erosion on the northern side of the beach. Height and apparent stability would suggest HDD would be possible but would require appropriate geological assessment and survey of ground conditions for confirmation. At the base of the cliffs on the southern side, there were the remains of a large stepped concrete structure but with no indication of what it was. There was also a large letter 'C' installed on one of the cliff faces – possibly a beach monitoring station.

Co-financed by the European Union
Connecting Europe Facility

Figure 5-1: Start of access down to beach and parking spaces.

Figure 5-2: Grass verge on the beach side of the access track.

Figure 5-3: View of the access track from the beach looking north west.

Figure 5-4: View of the beach looking north west including cliffs and outcropping rock.

Figure 5-5: Unknown concrete stepped structures at the south end of Baginbun Beach.

Seaweed was observed on the upper reaches of the beach suggesting the tide reaches the sea wall. The centre of the beach showed no signs of seaweed or debris. Intertidal rock outcrops were covered in seaweed.

The gradient of the beach was flat (1.7°) and the sediment was generally uniformly distributed coarse sand with occasional whole or partial shells. Notably, there was very little man-made debris.

The beach was used by members of public during the visit; there were a number of people with fishing equipment on the beach and there were

Co-financed by the European Union
Connecting Europe Facility

advertising signs in the car park identifying the type of fish that could be caught on the beach (e.g. bass fishing).

There was very little evidence of birds nesting at the site; no foot prints on the sand but there were circling gulls.

Figure 5-6: One of the drainage access points identified on the upper slope.

Table 5-1: Protected sites within 5km of Baginbun Beach landfall

Site Name	Designation	Feature of conservation Interest	Distance from landfall
Hook Head	SAC	**Annex I habitats:** Large shallow inlets and bays Reefs Vegetated sea cliffs of the Atlantic and Baltic coasts	Within
Bannow Bay	SPA	**Annex II species that are the primary reason for selection of this site:** Light-bellied Brent Goose (*Branta bernicla hrota*), Shelduck (*Tadorna tadorna*), Pintail (*Anas acuta*), Oystercatcher (*Haematopus ostralegus*), Golden Plover (*Pluvialis apricaria*), Grey Plover (*Pluvialis squatarola*), Lapwing (*Vanellus vanellus*), Knot (*Calidris canutus*), Dunlin (*Calidris alpina*), Black-tailed Godwit (*Limosa limosa*), Bar-tailed Godwit (*Limosa lapponica*), Curlew (*Numenius arquata*) and Redshank (*Tringa totanus*).	1.9km to the north
Bannow Bay	Ramsar Site	**Internationally important wetland**	1.9km to the north
Bannow Bay	SAC	Estuaries, Mudflats and sandflats not covered by seawater at low tide, Annual vegetation of drift lines, Perennial vegetation of stony banks, Salicornia and other annuals colonizing mud and sand, Spartina swards (Spartinion maritimae), Atlantic salt meadows (Glauco-Puccinellietalia maritimae), Mediterranean salt meadows (Juncetalia maritimi), Mediterranean and thermo-Atlantic halophilous scrubs (Sarcocornetea fruticosi), Embryonic shifting dunes,Shifting dunes along the shoreline with Ammophila arenaria (white dunes) and Fixed coastal dunes with herbaceous vegetation (grey dunes)	3km to the north
Bannow Bay	pNHA		3km to the north

6 BANNOW BEACH LANDFALL

Bannow Beach is one of two sites not located on the Hook Head peninsula but lies on the coastline to the east. Bannow is a short distance away from Cullenstown Beach.

Bannow Beach is accessed via a 'cul-de-sac' access road, approximately 4m wide and 800m in length. Six private properties and numerous additional agricultural landowner plots were identified off this access road with no alternative access.

At the end of the access road there is parking space for approx. 2 vehicles and two gravel access tracks verge to the right, one leading down to the beach and one leading to a private property. The access track from the access road to the beach is via a reasonably straight broken track that would minimise cable bend angles if it were to be installed up the path.

The potential onshore route from the Bannow Beach access road to the R733/L4045 junction, southeast of Great Island, is approximately 19.5km along local and regional roads. The onshore route option to the Bannow Beach access road requires crossing of numerous bridges and culverts and all other environmental constraints to be considered.

Bannow Beach is an exposed beach facing almost due south and wave conditions during the south-easterly wind conditions yielded wave heights of approximately 1 m close to the shore. The beach was approx. 216 m wide and 51 m from cliff edge to the water at low tide.

The primary benefit of Bannow Bay was the short distance from the beach to the 5 m water depth contour: 1.1 km. This would allow cable vessels to get closer to the shore and reduce the requirement for cable transpooling or barges. The evident wave conditions and likely current conditions would limit the installation time frames.

Offshore, a number of lobster and crab pots were installed with several fishing vessels observed further offshore.

The beach itself was composed of large cobbles and stones with small patches of very coarse sediment and broken shells. The gradient of the beach was 8.6° and a large storm berm had formed approximately 10 m from the base of the cliff highlighting the energetic water conditions the beach is exposed to. Very large piles of rotting seaweed deposited on the beach right up to the edge of the cliff suggesting tides reach the base of the cliff, but only deposited during storm conditions.

Despite not being directly within an environmentally protected area, there were large numbers of birds on and around the cliffs, with evidence of nesting in crevices.

Bannow Beach landfall site is not located within any designated areas. It is within 5km of 5 other protected areas: Hook Head SAC, Bannow Bay SPA and Ramsar Site, Bannow Bay SAC, Bannow Bay pNHA.

The Bannow Beach landfall is adjacent to Hook Head SAC which is of both geological importance and provides important marine habitats. The Bannow Beach landfall location is approximately 1km from the Bannow Bay SPA and

Co-financed by the European Union
Connecting Europe Facility

Ramsar Site; it is possible that bird species from these protected sites are present around the landfall site overwinter.

Figure 6-1: Bannow Beach looking east at a rock outcrop and the vegetated cliffs.

Figure 6-2: Bannow Beach looking west towards the rock headland.

Figure 6-3: Bannow Beach access track to the beach - largely solid and composed of stones and turf.

Figure 6-4: Private property close to the access road down to the beach at Bannow Beach. In good condition and likely used regularly.

Table 6-1: Protected sites within 5 km of Bannow Beach.

Site Name	Designation	Feature of conservation Interest	Distance from Landfall
Hook Head	SAC	**Annex I habitats:** Large shallow inlets and bays Reefs Vegetated sea cliffs of the Atlantic and Baltic coasts	286m to west
Bannow Bay	SAC	**Annex I habitats:** Estuaries, Mudflats and sandflats not covered by seawater at low tide, Annual vegetation of drift lines, Perennial vegetation of stony banks, Salicornia and other annuals colonizing mud and sand, Spartina swards (Spartinion maritimae), Atlantic salt meadows (Glauco-Puccinellietalia maritimae), Mediterranean salt meadows (Juncetalia maritimi), Mediterranean and thermo-Atlantic halophilous scrubs (Sarcocornetea fruticosi), Embryonic shifting dunes,Shifting dunes along the shoreline with Ammophila arenaria (white dunes) and Fixed coastal dunes with herbaceous vegetation (grey dunes)	1km to the north west
Bannow Bay	SPA	**Annex II species that are a primary reason for selection of this site:**	1km to the north

Co-financed by the European Union
Connecting Europe Facility

Site Name	Designation	Feature of conservation Interest	Distance from Landfall
		Light-bellied Brent Goose (*Branta bernicla hrota*), Shelduck (*Tadorna tadorna*), Pintail (*Anas acuta*), Oystercatcher (*Haematopus ostralegus*), Golden Plover (*Pluvialis apricaria*), Grey Plover (*Pluvialis squatarola*), Lapwing (*Vanellus vanellus*), Knot (*Calidris canutus*), Dunlin (*Calidris alpina*), Black-tailed Godwit (*Limosa limosa*), Bar-tailed Godwit (*Limosa lapponica*), Curlew (*Numenius arquata*) and Redshank (*Tringa totanus*).	west
Bannow Bay	pNHA	Habitats and wildlife	1km to the north west
Bannow Bay	Ramsar Site	**Internationally important wetland**	1km to the north west

Co-financed by the European Union
Connecting Europe Facility

7 BOOLEY BAY LANDFALL

Approximately 5 km north of Boyce's Bay (see Section 8) is the Booley Bay landfall. Similar to Boyce's Bay, the landfall faces the west and is moderately exposed to the prevailing south-westerly wind conditions.

Booley Bay is further up the river estuary and therefore the distance from the 5 and 10 m depth contours increases to 3.9 and 6.5 km, respectively. This may restrict the types of vessels that can reach the site and increase the chances of requiring anchored barges. The beach was approximately 205 m wide and 113 m from the cliff to the water's edge shortly before low water. The beach was predominately flat (0.2°) with fine but water-saturated sand. A storm berm was observed at the upper reaches of the beach.

Booley Bay is accessed via a 'cul-de-sac' access road off the L4045, approximately 4m wide and 350m in length. One private property entrance was being constructed at the time of the site visit off this access road. Approximately five additional agricultural landowner plots were identified off this access road with no alternative access.

The potential onshore route from the Booley Bay access road to the R733/L4045 junction, southeast of Great Island, is approximately 5km along the L4045.

The end of the access road is blocked by two large boulders preventing permanent vehicular access down to the beach. These could be removed temporarily to provide access to the beach. An access track, approximately 50m in length, leads from the end of the access road down to the beach.

There is a small area to the north of the access track for parked vehicles (Figure 6-4). In the parking space at the time of the site visit, there was an activity school van and two surfers. Wave conditions offshore were approx. 0.9m and suitable for surfing – indicative of potentially difficult installation conditions during southerly wind conditions and less shelter than Boyce's Bay.

The surrounding headland was dominated by vegetated cliffs to the north and south (Figures 7-3 and 7-6); both sides demonstrated low levels of coastal erosion with minor evidence of disruption by landslides. Adjacent to the access road and track was a freshwater riverine input, surrounded by unmanaged vegetation. The river water flowed directly onto the beach where the water flow was diverted along the upper reach of the beach to the southern rock outcrop where it was forced towards the sea by rocks.

Options for installation would include HDD and open-cut trenching. It is likely that the flow of fresh water onto the beach would make keeping a trench open difficult and may risk exposure of the cable during adverse weather conditions. More information is required regarding the stability of sediment on the beach through an appropriate geological assessment and survey of ground conditions.

Co-financed by the European Union
Connecting Europe Facility

Figure 7-1: Freshwater outlet/river at Booley Bay - facing west-north-west.

Figure 7-2: The view of the access road from the beach - looking east.

Figure 7-3: Rock headland to the north of Booley Bay. Evidence of saturated sand.

Figure 7-4: A small parking area with activity school van and two surfers.

Figure 7-5: View from the access track down to Booley Bay landfall.

Figure 7-6: View of the rock headland and outcrop looking north-west.

Booley Bay landfall is located within the River Barrow and River Nore SAC and within 5km of the Hook Head pNHA (**Table 7-1**). The project would need to demonstrate that it will not affect the integrity of the River Barrow and River Nore SAC. It is policy of Wexford County Council to protect the pNHAs as if already designated.

Of particular note within the Booley Bay landfall was the presence of honeycomb reef worm (*Sabellaria alveolata)* on the intertidal rocks (**Figure 7-7**). This was also present in Dollar Bay. While not listed as part of the River Barrow and Nore SAC, it is a species that is sensitive to changes in sediment regime and physical disruption (including storm damage). Most of the intertidal rock at the site was covered but the extent offshore would need additional survey.

Co-financed by the European Union
Connecting Europe Facility

Figure 7-7: Honeycomb Worm Reef (*Sabellaria Alveolata*) on intertidal rocks at Booley Bay Landfall.

Table 7-1: Protected sites within 5km of Booley Bay landfall

Site Name	Designation	Feature of Conservation Interest	Distance from landfall
River Barrow and Nore	SAC	Annex I habitats: • Estuaries • Tidal Mudflats and Sandflats • Salicornia Mud • Atlantic Salt Meadows • Mediterranean Salt Meadows • Floating River Vegetation • Dry Heath • Hydrophilous Tall Herb Communities • Petrifying Springs* • Old Oak Woodlands • Alluvial Forests* Annex II Species: • Desmoulin's Whorl Snail (Vertigo moulinsiana) • Freshwater Pearl Mussel (Margaritifera margaritifera) • White-clawed Crayfish (Austropotamobius pallipes) • Sea Lamprey (Petromyzon marinus) • Brook Lamprey (Lampetra planeri) • River Lamprey (Lampetra fluviatilis) • Twaite Shad (Alosa fallax) • Atlantic Salmon (Salmo salar) • Otter (Lutra lutra) • Killarney Fern (Trichomanes speciosum) • Nore Freshwater Pearl Mussel (Margaritifera durrovensis) Waterford Harbour pNHA and Duncannon Sandhills pNHA are now within the boundaries of the SAC.	Within
Hood Head	pNHA	Large kittiwake (gull) colonies on several cliffs	3.9km to south

8 BOYCE'S BAY LANDFALL

Originally identified as Lumsdin Bay, this beach is actually called Boyce's Bay within Lumsdin Bay and lies on the west coast of the Hook Peninsula. The site is located outside the Hook Head SAC. It does, however, fall within a proposed NHA (pNHA).

The beach faces the south west making it an exposed site, given the prevailing south-westerly weather conditions. During the site visit, the forecast was south-southeast force 4 – 5 (13 – 24 knots) and apparent wave conditions at the site were insignificant (> 0.5 m) indicating a level of protection from the surrounding high cliffs and headland. The 5 and 10 m depth contours are 1.4 and 2.6 km, respectively. This may restrict the types of vessels that can reach the site and increase the chances of requiring anchored barges. The beach extends further north along the coastline for approximately 2 km but a rock outcrop to the north of the site prevents vehicles from passing to the additional coastline and beach.

Figure 8-1: Part of the Access Road to Boyce's Bay.

Figure 8-2: Wave conditions during F4-5 SSE weather.

Figure 8-3: Derelict house to the south of the access road.

Figure 8-4: Evidence of bird presence on the beach.

Boyce's Bay is accessed via a 'cul-de-sac' access road off the L4045 local road, approximately 4m wide and 350m in length with hedge and/or low brick walls on either side. Three private properties and a dairy farm yard and buildings were identified off the access road.

The three private properties consist of a derelict property at the junction with the L4045 local road **(see Figure 8-3)**, a farm house associated with the dairy farm and a private property called 'Lumsdin Lodge' on the southern side of the access path. Alternative accesses appear to be available, off the L4045 local road, to the dairy farm and associated farm house, and the derelict property.

Co-financed by the European Union
Connecting Europe Facility

The dairy farm yard and buildings are located on the northern side of the access track with fields located to both the north and south of the access road.

The potential onshore route from the Boyce's Bay access road to the R733/L4045 junction, southeast of Great Island, is approximately 10.5km along the L4045.

An access track, approximately 50m in length, leads from the end of the access road down to the beach. The access track to the beach is approx. 3 m wide composed of rough terrain, and has an established sea wall of good condition at the bottom. The sea wall is approximately 2 m high and 1.2 m wide at the base. It appears to have been built on solid bed rock with a similar composition to rock outcrops observed to the north and south of the beach (**Figure 8-1**).

The beach itself was gently sloping with evidence of a storm berm and seaweed debris on the upper reaches of the beach. The typical slope angle was 2.4° from the cliff to the water. The beach was approximately 200 m wide, with approximately 157 m of rock to the south of the beach. Fossils were observed on rock outcrops on the side of the bay (**Figure 8-6**).

Figure 8-5: A panoramic overview of Boyce's Bay looking west across the River Barrow and River Nore.

The surrounding cliffs and headland were tall with one large derelict property at the top, close to the dairy farm; this is possibly a heritage site and would require confirmation prior to establishing the location for an HDD point. The surrounding cliffs are densely vegetated with grasses and scrub but there are many indicators of instability and slope movement. Portions of the cliffs were identified as suitable for HDD up to the main track, pending further geotechnical assessments and ground investigation.

Co-financed by the European Union
Connecting Europe Facility

Figure 8-6: A fossil found on the rock outcrop at Boyce's Bay. Fossil appeared to be naturally coated in pyrite.

Boyce's Bay landfall is located within Hook Head pNHA. It is policy of Wexford County Council to protect the Hook Head pNHA as if already designated. The landfall site is also within 5km of two other protected areas: Hook Head SAC, River Barrow and Nore SAC (**Table 8-1**). Due to the proximity of the Hook Head SAC, the project would need to demonstrate that it will not affect the integrity of the site.

At Boyce's Bay the rough ground of the headland begins to give way to the sand and mud of the estuary. Kittiwake colonies may be present at the landfall site, however further information is required to identify if this location is of importance to this species. Wintering flocks of migratory birds are seen along the Barrow Estuary, 3.8 km north of the landfall and Annex II species may be present including resident otter, while sea and river lamprey, Atlantic salmon and shad may be migrating across the landfall approach area at certain times of the year.

Notably, two large seals were observed swimming adjacent to the beach and several gulls were present during the site visit (see **Figure 8-4** for bird footprints). A line of seaweed was observed within the surf zone of the beach possibly indicating rock and potential feeding grounds. Offshore (middle-estuary), a fishing vessel was operating the vicinity recovering a lobster/crab pot.

Co-financed by the European Union
Connecting Europe Facility

Table 8-1: Protected sites within 5km of Boyce's Bay landfall

Site Name	Designation	Feature of Conservation Interest	Distance from landfall
Hook Head	pNHA	Large kittiwake (gull) colonies on several cliffs	Within
Hook Head	SAC	Annex I habitats: • Large shallow inlets and bays • Reefs • Vegetated sea cliffs of the Atlantic and Baltic coasts Hook Head is of geological importance and provides important marine habitats including intertidal and subtidal moderate energy reef covering approximately 10,534 ha, vegetated cliff and large shallow inlets and bays. The reef habitat provides homes to rare and scarce species such as: sponge; hydroids; anemone; sea slug; sea squirt; red algae and kelp.	815m to the East
River Barrow and Nore	SAC	Annex I habitats: • Estuaries • Tidal Mudflats and Sandflats • Salicornia Mud • Atlantic Salt Meadows • Mediterranean Salt Meadows • Floating River Vegetation • Dry Heath • Hydrophilous Tall Herb Communities • Petrifying Springs* • Old Oak Woodlands • Alluvial Forests* Annex II Species: • Desmoulin's Whorl Snail (Vertigo moulinsiana) • Freshwater Pearl Mussel (Margaritifera margaritifera) • White-clawed Crayfish (Austropotamobius pallipes) • Sea Lamprey (Petromyzon marinus) • Brook Lamprey (Lampetra planeri) • River Lamprey (Lampetra fluviatilis) • Twaite Shad (Alosa fallax) • Atlantic Salmon (Salmo salar) • Otter (Lutra lutra) • Killarney Fern (Trichomanes speciosum) • Nore Freshwater Pearl Mussel (Margaritifera durrovensis)	3.8km to the north west

Co-financed by the European Union
Connecting Europe Facility

9 CARNIVAN BAY LANDFALL

Carnivan Bay is on the south side of the Baginbun peninsula and is separated from Baginbun Bay by private fields on the peninsula.

Carnivan Bay is accessed via a 'cul-de-sac' access road, approximately 3m wide and 350m in length. One private property and approximately four additional agricultural landowner plots were identified off this access road with no alternative access.

The potential onshore route from the Carnivan Bay access road to the R733/L4045 junction, southeast of Great Island, is approximately 12km along local roads. The onshore route option to the Carnivan Bay access road requires environmental constraints to be considered.

Along the Carnivan Bay access road there are two vista points located at the rear of the bay. The vista point at the end of the access road would be suitable for a construction site and associated containers.

At the end of the access road an access track verges to the right leading down to the beach and an additional access track continues straight ahead leading to private land. The access track down to the bay is heavily maintained with fencing and warning signs identifying a strong undertow current and eroding cliffs. The access track was very steep with three permanent metal bollards preventing vehicular access. The access track was a combination of gravel and concrete leading down to bedrock and large cobbles, with a seawall at the bottom.

The beach is large and flat. The site is very exposed to southerly wind conditions and weather conditions on the day yielded waves of approx. 1 m. The profile of the beach has a shallow gradient; wide and long with less than 2° of slope. Looking north from the water's edge, patches of stable vegetated cliff were observed in the centre with patches of exposed rock. Cliffs to the east and west demonstrate evidence of coastal erosion and more recent landslips (**Figure 9-6**).

The beach is a popular site with members of the public walking the cliff path and on the beach. The coast path is maintained with fencing along it.

The apparent instability of the cliffs and warning signs combined with the exposed beach make this site unsuitable for HDD without significant and extensive geotechnical survey to determine the ground conditions. Open cut trenching would be a possibility on the beach but the stability of the access path for installation would also need to be assessed.

As with Sandeel Bay and Baginbun Beach, Carnivan Beach is within an SAC, including an Annex I reef habitat.

Co-financed by the European Union
Connecting Europe Facility

Table 9-1: Protected sites within 5km of Carnival Bay landfall

Site Name	Designation	Feature of conservation Interest	Distance from landfall
Hook Head	SAC	**Annex I habitats:** Large shallow inlets and bays Reefs Vegetated sea cliffs of the Atlantic and Baltic coasts	Within
Bannow Bay	SPA	**Annex II species that are a primary reason for selection of this site:** Light-bellied Brent Goose (*Branta bernicla hrota*), Shelduck (*Tadorna tadorna*), Pintail (*Anas acuta*), Oystercatcher (*Haematopus ostralegus*), Golden Plover (*Pluvialis apricaria*), Grey Plover (*Pluvialis squatarola*), Lapwing (*Vanellus vanellus*), Knot (*Calidris canutus*), Dunlin (*Calidris alpina*), Black-tailed Godwit (*Limosa limosa*), Bar-tailed Godwit (*Limosa lapponica*), Curlew (*Numenius arquata*) and Redshank (*Tringa totanus*).	1.9km to the north
Bannow Bay	Ramsar Site	**Internationally important wetland**	1.9km to the north
Bannow Bay	SAC	Estuaries, Mudflats and sandflats not covered by seawater at low tide, Annual vegetation of drift lines, Perennial vegetation of stony banks, Salicornia and other annuals colonizing mud and sand, Spartina swards (Spartinion maritimae), Atlantic salt meadows (Glauco-Puccinellietalia maritimae), Mediterranean salt meadows (Juncetalia maritimi), Mediterranean and thermo-Atlantic halophilous scrubs (Sarcocornetea fruticosi), Embryonic shifting dunes,Shifting dunes along the shoreline with Ammophila arenaria (white dunes) and Fixed coastal dunes with herbaceous vegetation (grey dunes)	3km to the north
Bannow Bay	pNHA		3km to the north

Co-financed by the European Union
Connecting Europe Facility

Figure 9-1: Warning signs at base of cliff as you enter the beach.

Figure 9-2: Another warning and the metal bollards preventing vehicular access to beach.

Figure 9-3: The beach and cliffs looking east towards Baginbun Head.

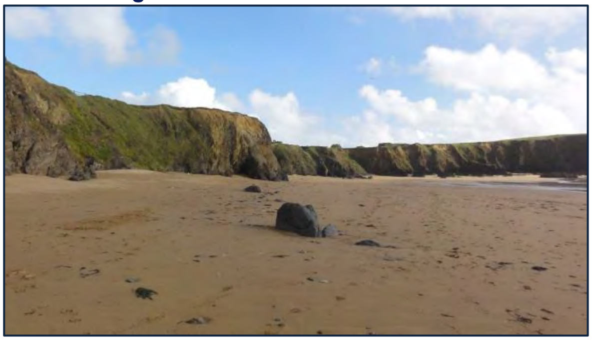


Figure 9-4: Wave conditions at the edge of the beach indicating the exposure.

Figure 9-5: Overview of Carnivan Bay looking east.

Figure 9-6: Evidence of loss of vegetation due to landslip.

Co-financed by the European Union
Connecting Europe Facility

10 CULLENSTOWN BEACH LANDFALL

Cullenstown beach is very large, exposed, south-facing beach east of Bannow Bay. The beach is heavily used by the public all year round and is a popular location for holiday homes.

Cullenstown Beach is accessed via a 'cul-de-sac' access road, approximately 4.5m wide and 260m in length. The village of Cullenstown, including numerous private properties, mobile holiday homes and businesses, is located on this access road with no alternative access.

The potential onshore route from the Cullenstown Beach access road to the R733/L4045 junction, southeast of Great Island, is approximately 19.1km along local and regional roads. The onshore route option to the Cullenstown Beach access road requires crossing of numerous bridges and culverts and all other environmental constraints to be considered.

At the end of the access road a 3.5m wide access track veers to the left leading down to the beach with a large car park with public conveniences, including outdoor showers at the rear of the beach. The carpark is height-restricted and coated in tarmac/concrete which would be suitable for practical construction works, but installation would interrupt the tourists and locals. There is a concrete sports structure likely used for bowls or hand ball. There were signs identifying dangerous bathing conditions due to the strong currents.

The beach is the largest of all visited with enormous variation in morphology from east to west. To the east, an environmentally protected estuary outlet was observed with extreme current flows shown by the turbulent waters. A spit of sand extended outwards along the estuary outlet with evidence of rip currents and an apparent offshore sediment bar where estuarine outlet meets tides and waves. This bar would likely cause problems during installation as indicates shifting sediments.

At the top of the beach, there were grass-covered dunes followed by a beach with heavy zonation of sediment; cobbles at the top, followed by finer gravel and then fine, saturated sand close to the water. The beach gradient was steep, particularly on the spit, where the sand was dry but completely unconsolidated.

The length of the beach was prohibitive for the installation of cable – vessel access would be tricky due to the sediment movement in the area and the shallow depth gradient.

There was some evidence of coastal protection associated with a tourist beach including rock protection on the western side of the beach. There was also evidence of landslides and little vegetation on the cliffs. To the west, there was a rock outcrop.

The was some seaweed likely deposited during storm conditions and also evidence of lobster pots on the beach and further offshore – it is suggested that fishing gear was debris dragged onto the beach, or storage by fisherman before use further offshore.

Co-financed by the European Union
Connecting Europe Facility

Figure 10-1: Sign at the top of Cullenstown Beach indicating dangerous bathing conditions to the east of the beach.

Figure 10-2: Car park and public conveniences at the top of the beach and evidence of vegetated sand dunes. Looking north.

Figure 10-3: View of the concrete sports structure, beach and rock protection. Looking west from the waters edge at Cullenstown Beach.

Figure 10-4: Estuarine outlet with turbulent water flowing towards the sea. Looking east from the spit towards the estuary.

Figure 10-5: Sand patches and breaking waves on an apparent offshore sediment structure.

Figure 10-6: Sand dunes and vegetated cliff structures. Looking east.

Cullenstown Beach Landfall is within Ballyteigue Burrow SAC and pNHA. It is within 5km of 6 other protected areas: Ballyteigue Burrow SAC, SPA and pNHA, Keeragh Islands SPA and NHA and Hook Head SAC.

Co-financed by the European Union
Connecting Europe Facility

Table 10-1: Protected sites within 5 km of Cullenstown Beach Landfall.

Site Name	Designation	Feature of conservation Interest	Distance from Landfall
Ballyteigue Burrow	SAC	**Annex I habitats that are a primary reason for selection of this site:** Estuaries Mudflats and sandflats not covered by seawater at low tide Coastal lagoons Annual vegetation of drift lines Perennial vegetation of stony banks Salicornia and other annuals colonizing mud and sand Spartina swards (Spartinion maritimae) Atlantic salt meadows (Glauco-Puccinellietalia maritimae) Mediterranean salt meadows (Juncetalia maritimi) Mediterranean and thermo-Atlantic halophilous scrubs (Sarcocornetea fruticosi) Embryonic shifting dunes Shifting dunes along the shoreline with Ammophila arenaria (white dunes) Fixed coastal dunes with herbaceous vegetation (grey dunes)	28.3m to the east
Ballyteigue Burrow	pNHA	Habitats and wildlife	28.3m to the east
Ballyteigue Burrow	SPA	**Overwinter:** Light-bellied Brent Goose (Branta bernicla hrota) Shelduck (Tadorna tadorna) Golden Plover (Pluvialis apricaria) Grey Plover (Pluvialis squatarola) Lapwing (Vanellus vanellus) Black-tailed Godwit (Limosa limosa) Bar-tailed Godwit (Limosa lapponica)	528m to the east
Keeragh Islands	SPA	Overwinter: Light-bellied Brent Goose (Branta bernicla hrota) Nationally Important breeding colony of Cormorant (206 pairs recorded in 1989), which is considered to be one of the largest in the country.	1.8km to the south west
Keeragh Islands	Ramsar	**Internationally important wetland**	1.8km to the south west
Keeragh Islands	NHA	The Keeragh Islands SPA is of ornithological importance as it has a Nationally Important population of breeding Cormorant. It retains potential for attracting breeding terns, species that are listed on Annex I of the E.U. Birds Directive, though none have been recorded since the 1970s.	1.8km to the south west
Hook Head	SAC	**Annex I habitats:** Large shallow inlets and bays Reefs Vegetated sea cliffs of the Atlantic and Baltic coasts	4.9km to the west

Cullenstown Beach landfall is located in close proximity to three European designated sites on a sand and shingle barrier beach. Ballyteigue Burrow SAC has a range of coastal habitats, including various types of sand dunes, salt meadows, and intertidal sand and mud flats. Former estuarine areas adjacent

Co-financed by the European Union
Connecting Europe Facility

to the site have been reclaimed as polders and are intensively managed for agriculture. This coastal site is of high ecological value for its range of coastal habitats, several being listed on Annex I of the E.U. Habitats Directive. It is a major site for wintering waterfowl, with an internationally important population of Brent Goose and a further six species with populations of national importance. Of particular note is that two of the species, Golden Plover and Bar-tailed Godwit, are listed on Annex I of the E.U. Birds Directive. Little Tern is also listed on Annex I of this Directive. Most of the site is designated as a Nature Reserve.

All activities within or adjacent to a European protected area, which may affect the conservation objectives of that site, will be subject to an Appropriate Assessment screening to qualify the significance of the impact. This will add time to the consent process. Seasonal and installation methodology restrictions on construction activities may also be applied to protect sensitive species, such as nesting, breeding or over wintering birds. The project would need to demonstrate that it will not affect the integrity of European protected features.

Co-financed by the European Union
Connecting Europe Facility

11 DOLLAR BAY LANDFALL

Dollar Bay Landfall is the next beach south of Booley Bay, separated by a rocky outcrop and short headland, and has similar characteristics to Booley Bay.

Similar to Booley Bay, Dollar Bay is accessed via a ‘cul-de-sac’ access road off the L4045, approximately 4m wide and 200m in length. No private properties were identified off this access road with no alternative access. Two field gates were located along the access road.

The potential onshore route from the Dollar Bay access road to the R733/L4045 junction, southeast of Great Island, is approximately 5.5km along the L4045.

A steep gravel track, approximately 50m in length at the end of the access road, lead down to coarse sand, pebbles and some cobbles at the top of the beach. The remainder of the beach was composed of fine, homogeneous sand with some evidence of water saturation close to the water’s edge.

As with Booley Bay, at the start of the track there were two large boulders placed to prevent vehicular access. These could be removed temporarily to provide access to the beach. On either side of the track were heavily vegetated cliffs with little sign of coastal erosion and no man-made sea defences. Rock headland and outcrops were found on the north and south of the bay.

The large headland to the south of Dollar Bay provides additional protection from the prevailing south-westerly weather conditions and the conditions during the site visit (F5 – 6 SE) yielded wave heights of approx. 1 m just offshore.

Similar to Booley Bay landfall, the rock outcrop separating Booley and Dollar Bay was covered with honeycomb reef worm (*Sabellaria alveolata)*. While not listed as part of the River Barrow and Nore SAC, it is a species that is sensitive to changes in sediment regime and physical disruption (including storm damage). Most of the intertidal rock at the site was covered but the extent offshore would need additional survey.

Dollar Bay landfall is located within the River Barrow and River Nore SAC and within 5km of the Hook Head pNHA (**Table 11-1**). The project would need to demonstrate that it will not affect the integrity of the River Barrow and River Nore SAC. It is policy of Wexford County Council to protect the pNHAs as if already designated.

Co-financed by the European Union
Connecting Europe Facility

Figure 11-1: The view of Dollar Bay from the access track (looking west).

Figure 11-2: The access track taken from mid-way down the path (looking east).

Figure 11-3: Honeycomb worm reefs on intertidal rock outcrop separating Dollar Bay and Booley Bay.

Figure 11-4: Dollar Bay landfall looking north west, including vegetated cliffs.

Table 11-1: Protected sites within 5 km of Dollar Bay Landfall.

Site Name	Designation	Feature of Conservation Interest	Distance from landfall
River Barrow and Nore	SAC	Annex I habitats: • Estuaries • Tidal Mudflats and Sandflats • Salicornia Mud • Atlantic Salt Meadows • Mediterranean Salt Meadows • Floating River Vegetation • Dry Heath • Hydrophilous Tall Herb Communities • Petrifying Springs* • Old Oak Woodlands • Alluvial Forests* Annex II Species: • Desmoulin's Whorl Snail (Vertigo moulinsiana) • Freshwater Pearl Mussel (Margaritifera margaritifera) • White-clawed Crayfish (Austropotamobius pallipes) • Sea Lamprey (Petromyzon marinus) • Brook Lamprey (Lampetra planeri) • River Lamprey (Lampetra fluviatilis)	Within

Co-financed by the European Union
Connecting Europe Facility

Site Name	Designation	Feature of Conservation Interest	Distance from landfall
		• Twaite Shad (Alosa fallax) • Atlantic Salmon (Salmo salar) • Otter (Lutra lutra) • Killarney Fern (Trichomanes speciosum) • Nore Freshwater Pearl Mussel (Margaritifera durrovensis) Waterford Harbour pNHA and Duncannon Sandhills pNHA are now within the boundaries of the SAC.	
Hood Head	pNHA	Large kittiwake (gull) colonies on several cliffs	3.9km to south

Co-financed by the European Union
Connecting Europe Facility

12 SANDEEL BAY LANDFALL

Sandeel Bay is to the south of the Baginbun peninsula on the east of the Hook peninsula. Sandeel bay lies within the Hook Head SAC and is close to Hookless Village / Sandeel Bay Cottages, a popular holiday resort.

Sandeel Bay is accessed via a ‘cul-de-sac’ access road off the local road network, approximately 4m wide and 500m in length. Three private properties with no alternative access were identified off the access road. A rear entrance to the Hookless Village/Sandeel Bay Cottages is also located off the access road.

The potential onshore route from the Sandeel Bay access road to the R733/L4045 junction, southeast of Great Island, is approximately 10.5km along local roads.

There is parking for approximately 4 cars at the southern end of the access road with an access path, approximately 3m wide, leading to the beach.

There is an area suitable for the construction site and possibly the TJP at the southern end of the access path at the rear of the beach. The access path appears to have irregular use by cars. At the end of the access path onto the beach is a grassy verge with large boulders of which some look like they have been placed for protection or are part of a previous structure that has been dismantled. These will likely require removal for vehicles to access the beach. There is also a seawall that is being used to stabilise the access path.

The cliffs surrounding the beach are approx. 10 - 15 m in height with small localised areas of erosion and landslip. There is a rock outcrop to the south of the bay; rock was covered in seaweed and molluscs, but there was no evidence of fossils. There are rocks within the surf zone with evidence of weed attached to rocks. Choppy sea offshore was also evident, with significant wave heights inshore.

The beach gradient is shallow but demonstrates large amounts of seaweed and debris. There also appears to be sediment zonation indicative of sediment sorting associated with high-energy conditions. Beneath the rocky upper shore, fine sand was evenly distributed. Seaweed and debris were observed to reach the base of cliffs. There was a recently-dead grey seal on beach and live seals were observed swimming offshore. Bird life was prominent (black birds, crows, gulls, etc.) and there was some evidence of birds nesting within cliff cracks.

The beach is used recreationally by members of public (dog-walking, building sand castles, etc.). It is possible the beach would be used for surfing as the wave conditions would be suitable under the appropriate weather conditions. However, there were no warning signs associated with use. There was no other infrastructure evident, including power lines, at the beach.

The site would not be suitable for open-cut trenching due to the volume of rock and the seawall approaching the path. HDD may be suitable but geotechnical data assessment would be required to confirm suitability.

Co-financed by the European Union
Connecting Europe Facility

Figure 12-1: Sandeel Bay looking to the north east from the end of the access track.

Figure 12-2: Rocky conditions at the base of the access road and evidence of sea defences.

Figure 12-3: Rock outcrop to the south of the east-facing beach.

Figure 12-4: Evidence of landslip and underlying rock.

Table 12-1: Protected sites within 5 km of Sandeel Bay

Site Name	Designation	Feature of conservation Interest	Distance from Landfall
Hook Head	SAC	**Annex I habitats:** Large shallow inlets and bays Reefs Vegetated sea cliffs of the Atlantic and Baltic coasts	within
Hook Head	pNHA	Large kittiwake (gull) colonies on several cliffs	within

Co-financed by the European Union
Connecting Europe Facility

13 RANKING & RECOMMENDATION

Following the site visit, each of the sites was ranked according to the parameters outlined in **Section 2**. **Table 13-1** demonstrates the results of the initial ranking and highlights the three preferred sites. As per the methodology outlined in Section 2, each criterion was given a score of 10 for each beach. The weighting was applied and the outcome of the initial ranking exercise was that the Baginbun Beach, Booley Bay and Boyce's Bay are the three preferable sites for further investigation. Following a consultation with the National Parks & Wildlife Service (NPWS), it was concluded that installing a cable through a Special Area of Conservation (SAC) could potentially be possible provided that the works will not adversely affect the integrity of the protected site and its conservation objectives. In the interest in achieving the most direct offshore cable route, Sandeel Bay was reinstated as a preferable landfall location, despite the relatively low score.

The four preferable landfall locations, Baginbun Beach, Booley Bay, Boyce's Bay and Sandeel Bay, are proposed for further investigations. Refer to Appendix A for an initial geotechnical assessment of the preferred landfall locations.

Following detailed route assessments and stakeholder consultations final landfall selection will be completed and Revision 5 of this report will be issued.

Co-financed by the European Union
Connecting Europe Facility

Table 13-1: Weighted ranking of each landfall site. Preferable sites are marked in green.
Note: weighting/ranking ansd scoring is indicative only and subject to further review

		Beaches - Scores out of 10								Beaches - Weighted Scores							
Description	**Weighting**	**Baginbun Beach**	**Bannow Beach**	**Booley Bay**	**Boyce's Bay**	**Carnivan Bay**	**Cullenstown**	**Dollar Bay**	**Sandeel Bay**	**Baginbun Beach**	**Bannow Beach**	**Booley Bay**	**Boyce's Bay**	**Carnivan Bay**	**Cullenstown**	**Dollar Bay**	**Sandeel Bay**
Vessel Access	16.00%	8	5	6	7	8	5	5	3	1.28	0.8	0.96	1.12	1.28	0.8	0.8	0.48
Beach Composition - including nearshore seabed geology.	14.00%	8	3	8	8	5	5	8	5	1.12	0.42	1.12	1.12	0.7	0.7	1.12	0.7
Amenity Impact	10.00%	7	2	5	5	5	2	6	2	0.7	0.2	0.5	0.5	0.5	0.2	0.6	0.2
Environmental Constraints	10.00%	4	7	3	6	2	7	3	2	0.4	0.7	0.3	0.6	0.2	0.7	0.3	0.2
Exposure	8.00%	9	2	7	6	2	2	7	3	0.72	0.16	0.56	0.48	0.16	0.16	0.56	0.24
Working / Site Area	8.00%	7	7	6	3	8	9	3	7	0.56	0.56	0.48	0.24	0.64	0.72	0.24	0.56
Coastal Erosion	8.00%	7	4	7	7	2	4	7	6	0.56	0.32	0.56	0.56	0.16	0.32	0.56	0.48
Obstructions & existing infrastructure	8.00%	8	6	7	7	7	5	7	6	0.64	0.48	0.56	0.56	0.56	0.4	0.56	0.48
Access to Beach	6.00%	5	4	9	8	7	4	5	7	0.3	0.24	0.54	0.48	0.42	0.24	0.3	0.42
Cable engineering & protection requirements	6.00%	6	3	6	6	7	9	6	6	0.36	0.18	0.36	0.36	0.42	0.54	0.36	0.36
Overall Cable Length	6.00%	6	4	7	6	7	4	7	9	0.36	0.24	0.42	0.36	0.42	0.24	0.42	0.54
	Total	**75**	**47**	**71**	**69**	**57**	**49**	**64**	**56**	**7.00**	**4.30**	**6.36**	**6.38**	**5.46**	**5.02**	**5.82**	**4.66**

14 OVERALL CABLE LENGTH

Separate marine and onshore route assessments are being completed for the Greenlink interconnector by Intertek (P1975_RN3929_Rev3) and Arup respectively. The initial route assessments identify possible cable routes based on a balance between length and environmental, technical and economic constraints.

The length of the currently identified preferable route for each landfall is summarised in Table 14-1 below. Marine Route Option A is common to all suitable landfalls and has been used for the below calculations.

Table 14-1: Overall approximate length of cable for each landfall site

Landfall	Approximate Offshore Length (km)	Approximate Onshore Length (km)	Overall Approximate Length (km)
Baginbun Beach	158.7	28.2	186.9
Booley Bay	165.5	20.3	185.8
Boyce's Bay	161.6	25.7	187.3
Sandeel Bay	156.7	25.9	182.6

Co-financed by the European Union
Connecting Europe Facility

15 REFERENCES

[1] – Geology of Ireland (2003), 1:1,000,000 scale. Geological Survey of Ireland. Composed by B. McConnell, S. Gatley & A. Sleeman.

[2] – McCoy, F. & Griffith, R. (1862). 'A Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland'.

[3] – Mitchell, W. I., Carlisle, H., Hiller, N. & Addison, R. (1972). 'A Correlation of the Ordovician (Co. Wexford) and Tramore (Co. Waterford)', *Proceedings of the Royal Irish Academy. Section B: Biological, Geological and Chemical Science.* Vol. 72.

[4] – Bruck, P. M. & Vanguestaine, M. (2005). 'An Ordovician age for the Muggort's Bay Lower Palaeozoic inlier, County Waterford, Ireland – the southernmost exposure of the Irish Caledonides'. *Geological Journal.* Vol. 40.

Appendix A Geotechnical Landfall Assessment

Co-financed by the European Union
Connecting Europe Facility

Technical Note

ARUP

50 Ringsend Road
Dublin 4
D04 T6X0
Ireland
www.arup.com

t +353 1 233 4455
f +353 1 668 3169

Project title	Greenlink Interconnector	Job number	246369-00
cc	Sheila O'Sullivan Ger Breen	File reference	4-03-03-04 (Draft 1)
Prepared by	Marie Fleming	Date	7 January 2016
Subject	Landfall Assessment – Geotechnical Considerations		

Technical Note

246369-00 7 January 2016

1 Introduction

A site walkover was carried out by Marie Fleming (Senior Engineering Geologist) on Thursday 26th November 2015 to access the geotechnical considerations of potential landfalls for the Greenlink Interconnector project.

The following landfall options were assessed:

- Boyce's Bay
- Booley Bay
- Baginbun Beach

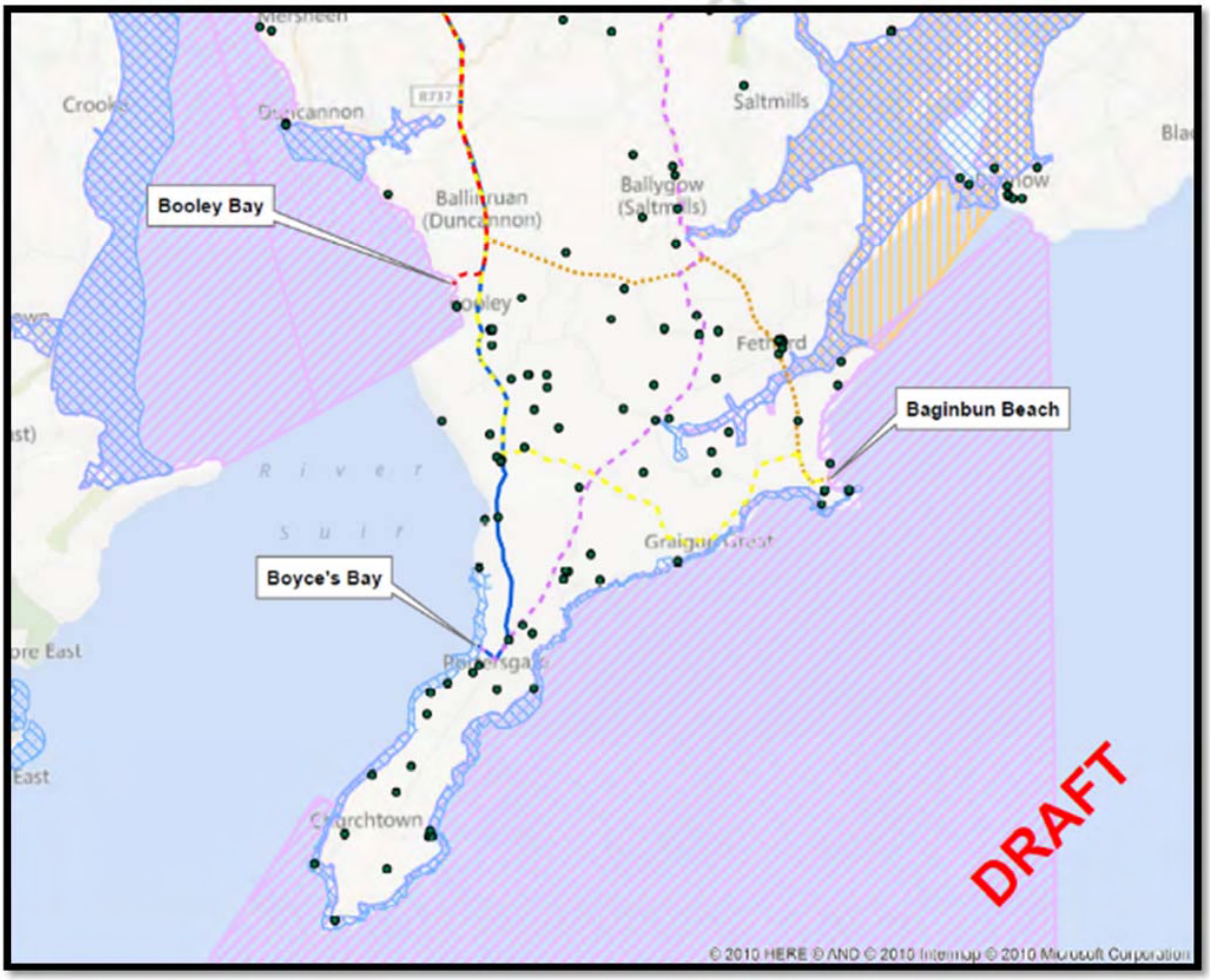


Figure 1: Landfall Sites Assessed

2 Regional Subsoil and Bedrock Geology

2.1 Subsoil Geology

The subsoil geology of the Hook Head area is dominated by a cover of glacial till intersected with alluvial sediments associated with rivers and streams. Where till is absent or subsoil cover is very thin, rock is present close to the surface or outcropping. Beach sediments are located along coastal areas.

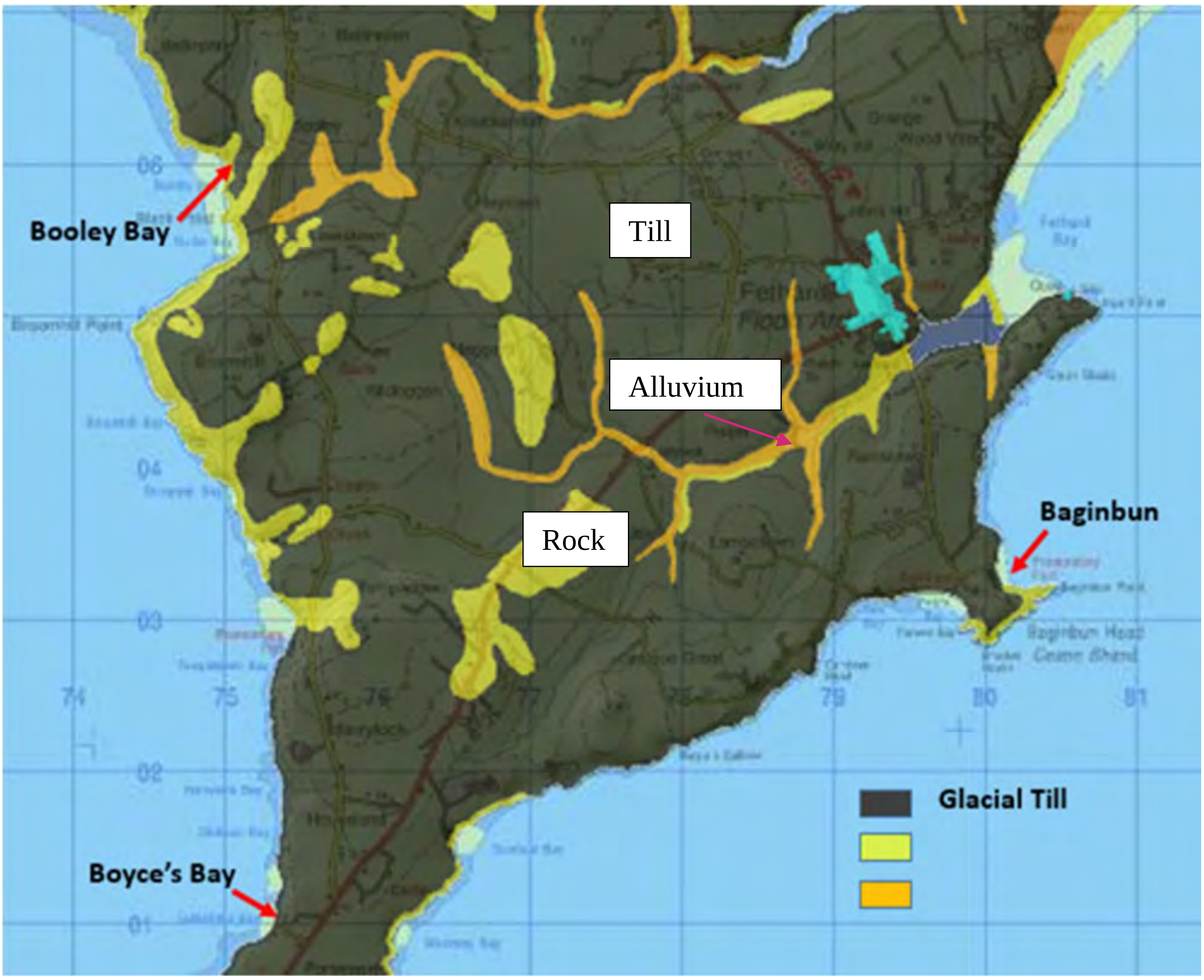


Figure 2: Extract from EPA subsoils mapping

2.2 Bedrock Geology

The Geological Survey of Ireland's (GSI) online mapping database was consulted to determine the regional geology at each location. Figure 2 indicates the underlying regional bedrock geology of the three sites visited.

Boyce's Bay is underlain by Upper Devonian to Lower Carboniferous Old Red Sandstone, sandstone, conglomerate and siltstone. The Porter's Gate Formation is indicated as outcropping in the Boyce's Bay area and is generally described as sandstone, shale and thin limestone.

Both Booley Bay and Baginbun Beach are underlain by much older Cambrian rocks described generally as Cambrian meta-sediments in the form of greywacke, slate and quartzite. These are also described by the GSI as grey to black mudstone with siltstone.

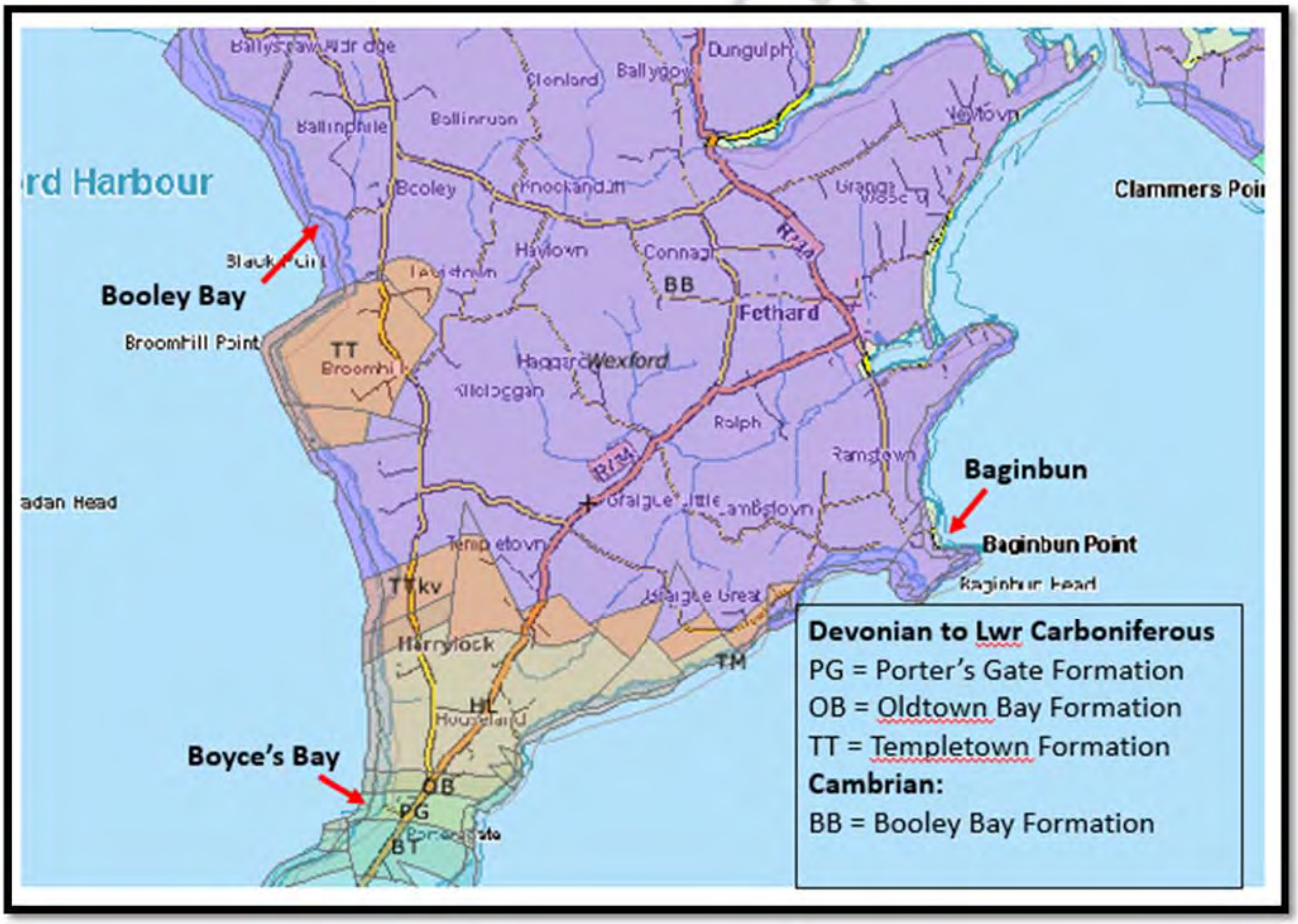


Figure 3: Bedrock Geology (extract from the 1:100,000 scale GSI map; www.gsi.ie)

2.3 Structural Geology

The regional structural geology of the area and at each landfall location is indicated on Figure 4.

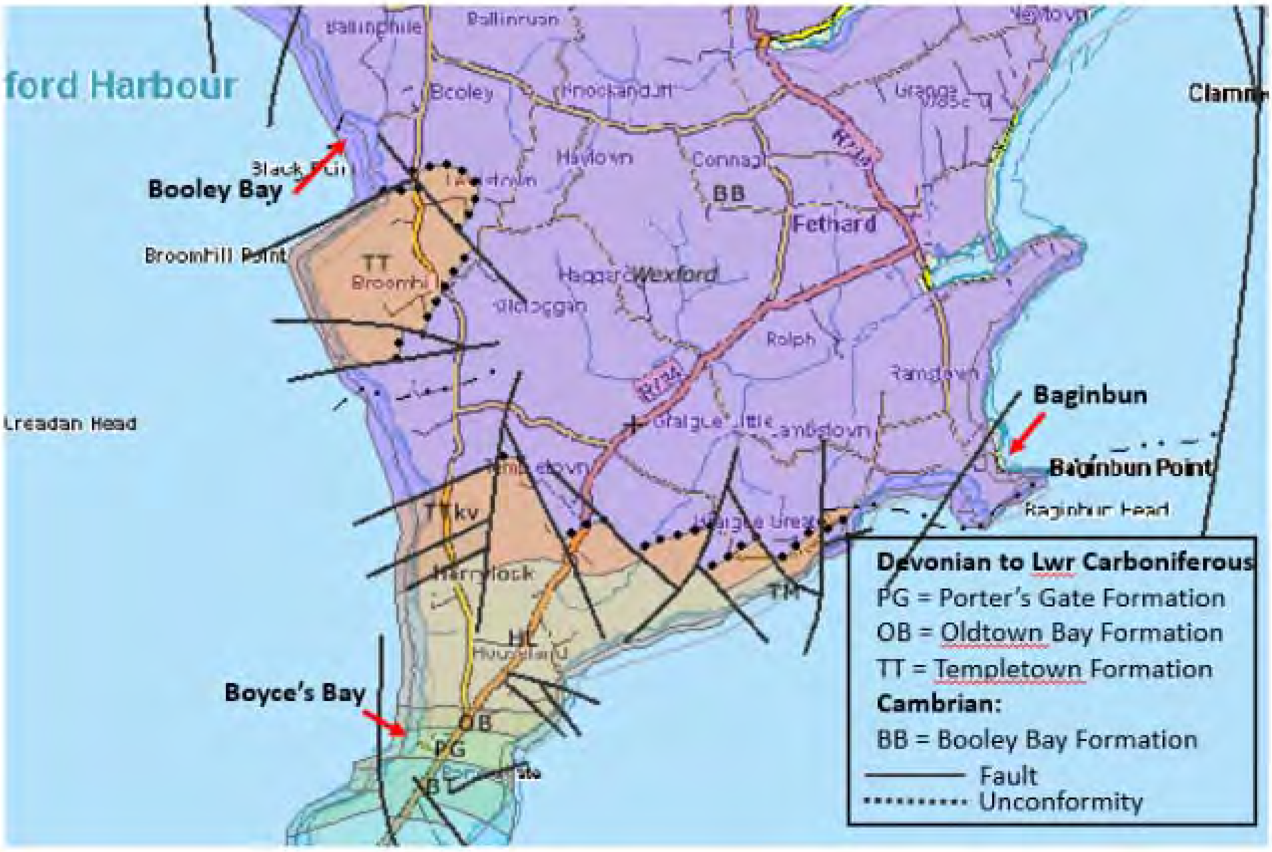


Figure 4: Structural Geology (extract from the 1:100,000 scale GSI map; www.gsi.ie)

2.4 Geological Heritage Areas

Geological Heritage Areas are designated as part of the Irish Geological Heritage Programme; a partnership with the (GSI) and the Department of Environment, Heritage and Local Government. The aim of the programme was to identify, document and protect the wealth of geological heritage in Ireland.

A review of the Geological Heritage Areas in the area has indicated that all three sites are potentially of geological interest as follows:

- Baginbun Head – Cambrian Stratigraphy – County Geological Site (CGS)
- Booley Bay - IGH 2-2: Occurrence of Ediacaran biota.IGH 4-40: Turbidite structures and Ediacaran- type faunas in the Upper Cambrian Booley Bay Formation of the Ribband Group (CGS recommended for Geological National Heritage Area)
- Boyce's Bay - Fossil plants, fossil spores, trace fossils - CGS, recommended for Geological National Heritage Area

The geological heritage audit of County Wexford is currently underway and is scheduled to finish by the end of March 2016. Preliminary consultation with the GSI has indicated that the fossil localities in Hook Head are rare, sensitive areas, and depending on the nature of the high voltage cable infrastructure, it will be a priority to ensure the minimum, if any, impact on the sites.

3 Site Walkover

3.1 Baginbun Bay

Baginbun Bay is underlain by Cambrian stratigraphy in the form of the Booley Bay Formation. The Booley Bay Formation is described by the GSI as comprising meta-sediments in the form of greywacke, slate and quartzite. These are also described by the GSI as grey to black mudstone with siltstone.

Northern Beach

The northern side of the beach is bounded to the west by coastal cliffs with bedrock outcropping in places along the beach but more frequently towards the shoreline as shown in Photo 1.

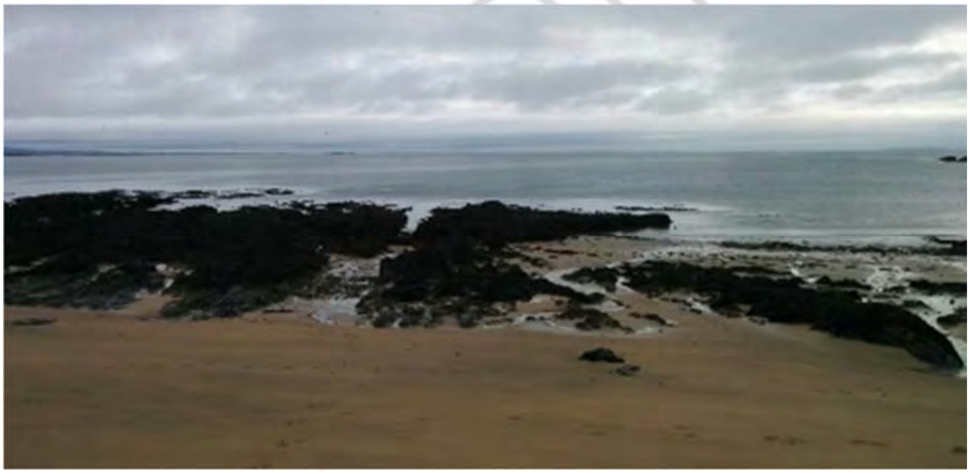


Photo 1: Outcropping rock

The cliffs are comprised of outcropping rock with a cover of 1 to 2.0m of overburden. While the cliffs are vegetated with grass and scrub in places, there is an abundance of unvegetated subsoil (potentially glacial till) towards the top of the slope as indicated in Photo 2.

Photo 2: Subsoil overlying bedrock

The slope morphology changes along the cliff with the greatest variability in the bedrock. Towards the crest of the slope the overburden is either standing at a steep to sub-vertical angle or is densely vegetated**.** Minor visual indicators of slope movement and shallow slumping of the subsoil material were observed along the slope as indicated in Photo 2 and Photo 3 below.

Photo 3: Subsoil overlying bedrock

The bedrock is highly variable along this section of beach ranging from the interlayered meta-sediments indicated in Photos 2 and 3 to more massive greywackes at the northern end of the beach as show on Photo 4.

Photo 4: North side of the Beach.

The structural geology at this location is highly complex manifested by the presence of regular minor folding and faulting visible along the rock faces (see Photo 5 for example). Bedding where present is sub-vertical to vertical.

Photo 5: Faulting visible on rockface (faultline shown in red)

Middle

The middle section of the beach is dominated by a public access track and a culverted land drain.

Southern Beach

The southern side of the beach has a number of geological features which are likely to require protection. Photo 6 is an example of chevron folding in the metasediments.

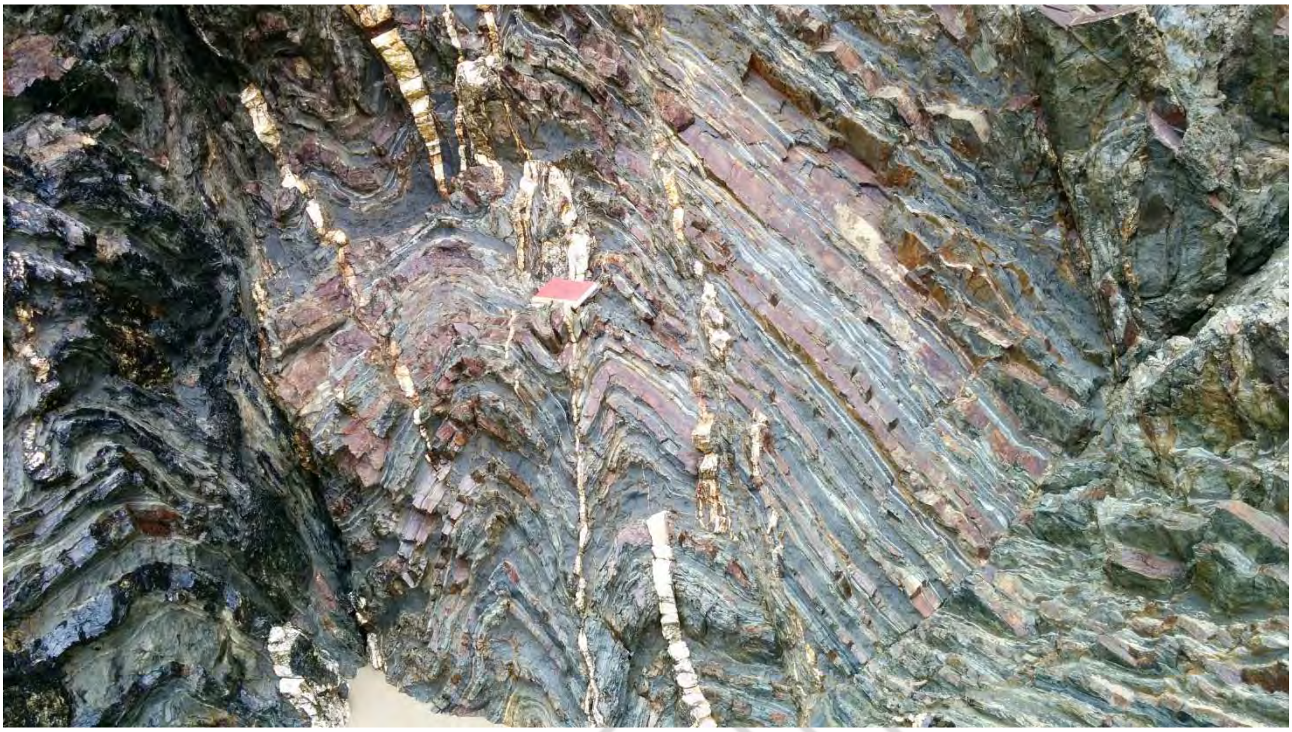


Photo 6: Chevron folding in interlayered meta-sediments.

A number of caves are also present at a number of locations along the cliff face in this location (see Photo 7).

Photo 7: Caves

Landfall potential

Based on the geological sensitivity of this area (as noted in Section 2.4), along with the restrictions due to public access *etc.*, horizontal directional drilling (HDD) is likely to be the optimum solution at this location.

An analysis of the fall required to accommodate the drilled section should be carried out to determine the optimum location for a HDD compound. The land adjacent to Baginbun Bay is predominantly agricultural land sloping towards the cliff with a number of residences in the area (including a Martello Tower towards the southern side of the area). There is potentially sufficient room in the field directly behind the northern half of the beach.

The depth of burial and the thermal resistivity of the surrounding bedrock and soil will be required for the detailed design of the cables for burial. Thermal resistivities that are too high can limit the ability of the cables to achieve rated transmission capacity.

3.2 Boyce's Bay

Boyce's Bay is underlain by Upper Devonian to Lower Carboniferous Old Red Sandstone, sandstone, conglomerate and siltstone. The Porter's Gate Formation is indicated as outcropping in the Boyce's Bay area and is generally described as sandstone, shale and thin limestone.

Limestone visibly outcrops along the southern end of the beach both at the base of the surrounding cliffs in this location and along the beach.

Photo 8: Access to Boyce's Bay with outcropping limestone

The surrounding cliffs at this location are comprised predominantly of subsoil of potentially glacial till. They are densely vegetated with grasses and scrub but there are many indicators of instability and slope movement as shown in Photo 9.

Photo 9: Soil slopes along Southern side of Boyce's Bay

Moving in a northerly direction along the beach, the outcropping rock becomes less frequent and the beach is bounded predominantly by soil slopes.

Photo 10: Looking North along Boyce's bay.

There is an abundance of slope failures visible along the slope. These failures appear to be progressive and predominantly shallow and are likely to have formed due to continual cliff recession due to over-steepening of the slope by erosion of the toe of the slope (Photo 11).

Photo 11: Slope failure along soil slopes.

Landfall potential

Due to the nature of the cliffs in this location and the tell-tale indicators of ongoing slope instability in this location, trenching is unlikely to be a viable option in this location. This along with the geological sensitivity of this area (as noted in Section 2.4), indicates that horizontal directional drilling (HDD) is likely to be the optimum solution at this location.

An analysis of the fall required to accommodate the drilled section should be carried out to determine the optimum location for a HDD compound. The land adjacent to Boyce's Bay is predominantly agricultural land sloping towards the cliff with a number of residences in the area including a derelict farmhouse adjacent to the top of the cliff. There is potentially sufficient room in the field directly behind the northern half of the beach.

The depth of burial and the thermal resistivity of the surrounding bedrock and soil will be required for the detailed design of the cables for burial. Thermal resistivities that are too high can limit the ability of the cables to achieve rated transmission capacity.

3.3 Booley Bay

Booley Bay Beach is underlain by Cambrian bedrock described generally as Cambrian meta-sediments in the form of greywacke, slate and quartzite. These are also described by the GSI as grey to black mudstone with siltstone.

The access to Booley Bay runs parallel to a freshwater river. On both sides of the river the area is dominated by vegetated headlands to the north and south (Photo 12).

Photo 12: Freshwater stream

Directly north of the river, the area is dominated by a small dune system which is densely vegetated. Minor instabilities, soil creep and shallow slides were observed on the cliff faces as indicated on Photo 13.

Photo 13: Minor instabilities

The dune system transitions into an area of outcropping rock and cliffs. Rockhead is irregular and a thin soil cover is generally present except in areas where depression in the rockhead have been infilled with subsoil material (Photo 14).

Photo 14: Rock outcrops showing variability of rock present

The geology is complex with interlayered meta-sediments and many structural features evident. (Photo 15)

Photo 15: Outcropping fold and adjacent areas of infill and instability

The southern side of Booley Bay is dominated by steeply dipping slate dominated meta-sediment with a thin soil cover vegetated with grass towards the top of the slope as shown on Photo 16:

Photo 16: Southern side of Booley Bay

Landfall Potential

There is the potential for access in this area via the public right of way but the presence of the water body in this location is likely to cause issues from both a construction and maintenance point of view as the channel morphology is likely to change over time which may lead to stability issues.

Trenching across the dune system may not be viable from an environmental point of view and may lead to further instability in this location. Based on the geological sensitivity of this area (as noted in Section 2.4) horizontal directional drilling (HDD) is likely to be the optimum solution at this location.

An analysis of the fall required to accommodate the drilled section should be carried out to determine the optimum location for a HDD compound. The landuse adjacent to Booley Bay is predominantly agricultural land. There is potentially sufficient room in these fields for a HDD compound.

The depth of burial and the thermal resistivity of the surrounding bedrock and soil will be required for the detailed design of the cables for burial. Thermal resistivities that are too high can limit the ability of the cables to achieve rated transmission capacity.

Technical Note

246369-00 7 January 2016

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Marie Fleming	Sheila O'Sullivan	Ger Breen
Signature			

APPENDIX C

Castlemartin Meeting Minutes

Anna Farley Intertek

From: Tom Brinicombe <Tom.Brinicombe@elpower.com>
Sent: 22 February 2018 12:25
To: Anna Farley Intertek
Subject: Fwd: MoD and Freshwater west
Attachments: MOD Safety Zones.pdf

Begin forwarded message:

From: Tom Brinicombe <Tom.Brinicombe@elpower.com>
Subject: MoD and Freshwater west
Date: 22 October 2013 07:25:59 BST
To: Peter Harte <Peter.Harte@elpower.com>
Cc: Ger Breen <ger.breen@arup.com>

Hi Peter,

As discussed here is a brief overview of our discussions with the MoD regarding Freshwater West to date.

We first discussed the project with Lisa Payne within the MoD estates team. These discussions were open and constructive and lead to a meeting at Freshwater West with Castlemartin staff - Major John Nicholl and Colonel (Retd) Richard Howard-Gash.

During the meeting it was stated that while we were in the safety zone of the firing range - this was a historic safety zone rather than a current practical safety zone. The munitions currently fired from the range would not strike the area. However, they would not reduce this historic safety zone because they currently had issues with third parties entering this area and they didn't want risk third parties entering a current practical safety zone and face serious harm.

We were taken back to the firing range and given the attached document for information.

We have had subsequent conversations with these parties where it is clear that they have no ability to charge us for crossing the zone however Colonel (Retd) Richard Howard-Gash has stated that we need to carry out a munitions survey to ensure that the appropriate H&S issues are considered.

We also looked at ensuring the cables were installed in a manner that protected them from future harm. The discussions were informal. Major Nicholl suggested that we should look at the munitions they were firing and design appropriately. In discussions with Bactec and FirstlineDefence both companies said that two surveys could be of use. The first UXO survey for construction and the second a review of current and future plans for the range.

I have run this past the MoD and they see this route as sensible...although they are unclear on how much information they can share...but are open to discussions.

All the best,

Tom

MINUTES OF MEETING

Project:	P1975 - Greenlink
Subject:	Project Update & Discussion of Offshore Scoping Response
Date and Time:	04 May 2017, 09:30
Duration:	1.0 hrs
Venue:	Castlemartin Firing Range
Present:	Tom Brinicombe (TB) - Element Power Project Manager Anna Farley (AF) - Intertek Marine Consultant Colonel (retd) Richard Howard-Gash (RHG) - Commander, DIO SD Training Wales & West (Castlemartin) Capt Andy Johnson (AJ) - Security and Access Officer, DIO SD Training Wales & West (Castlemartin) Lisa Payne (LP) - Rural Estates Advisor, Defence Infrastructure Organisation Mark Griffiths (MG) - Regional Ops Manager, Landmarc Support Services
Level of Issue:	DRAFT
File Reference:	P1975_ABMAY04_Rev0
Distribution:	Attendees

ITEM	MINUTES	ACTION
1.	**Introductions** • TB is Element Power's Project Manager for the Greenlink Project – a 500MW electricity interconnector connecting the power girds of the UK and Ireland. • AF is Intertek Project Manager contracted to Element Power to provide marine environmental consultancy including marine permits and consents for the project. • RHG is Commander at Castlemartin and has previously been briefed by TB on Greenlink project. • AJ provided Castle martin's response to Greenlink Offshore Scoping Report in letter dated 15 February 2017. • Objective of meeting was to discuss scoping repose and agree way forward on areas of concern.	
2.	**Greenlink Project Update** TB provided brief project update to appraise attendees of progress since last meeting in September 2016. Key points included: • Uncertainty surrounding Irish regulator and how they plan to regulate market pricing mechanism has caused project to slow down. • Greenlink marine surveys (originally planned for May 2017) have been delayed by one year. It is now intention to mobilise survey May – August 2018. • Greenlink Offshore Scoping Document was issued to 29 consultees in December 2017 to appraise stakeholders of project plans and gather opinion on scope and content of future environmental reports. Castlemartin provided response on 15 February 2017. MOD Safeguarding also provided response. • Greenlink onshore scoping document to be issued within next three weeks (i.e. by end May). • Original project (Greenwire) also consider an export cable for Irish wind farm projects. It is no longer an option to connect Greenwire at Pembroke. If the project goes ahead it would look to connect into Devon.	

ITEM	MINUTES	ACTION
3.	**Castlemartin response to Greenlink UK Offshore Marine Scoping Report received 15 February 2017** Access to Danger Area AF explained that the intention is to start the tender process for the marine surveys September / October 2017. Within the tender package Element Power can include specific obligations to ensure that contractors are aware of and comply with conditions set by Castlemartin. It was noted that the range closes during Easter and August and that the preference would be for survey vessels to operate within the Danger Area during this time. AF explained that we could not necessary guarantee the survey could use these windows and raised question of whether 2 weeks' notice period of activities was still feasible option (as previously discussed). RHG and SJ agreed that they were open to co-operation and as long as due notice was given and contractors maintained regular contact with the range it would be possible to operate within the Safety Danger Area (SDA) outside of the closure periods. Castlematin's preference would be that survey work focused on the Castlemartin area in one period (i.e. ran all 5 geophys lines in one consecutive period rather than ran one line then came back a week later to run second line). However, they could accommodate either scenario. RHG noted that the range operate two high speed boats that encourage vessels to move out of the SDA as quickly as possible during live firing. Maintenance and repair AF explained that cables are installed to require minimal maintenance and repair. Repair scenarios are more likely if cable is snagged or at cable joints. TB explained cable joints would all be land based. Any communication protocols agreed for marine survey and cable installation would also be applied to maintenance and repair requirements within Danger Area. Electromagnetic Field (EMF) AF & TB confirmed that EMF studies would be undertaken once cable configuration is known to determine potential for navigation effects on small vessels. Any effects are typically limited to recreational vessels using magnetic compasses. Castlemartin agreed they were happy with the response to date on this issue. **ACTION 1:** AF & TB to issue draft letter for Castlemartin comment that lays out SDA access terms, communication protocols and draft text to be included into survey tender documents. Draft text for survey tenders will outline contractor's obligations to contact Castlemartin 2 weeks ahead of works in SDA and to maintain daily communication during works within SDA. Letter will also include statement on EMF.	AF / TB
4.	**UXO** MG raised question of what Element Power are doing with respect to UXO. AF explained process will be: • Undertake desk-top study of UXO risk (sub-contracted to civilian UXO contractor such as Bactec). • Geophysical survey will be equipped with magnetometer and gravimetric, techniques used with side-scan sonar and multi-beam echosounder to identify potential UXO items on seabed.	

ITEM	MINUTES	ACTION
	• Intrusive survey works (e.g. grab samples, geotechnical samples) will be positioned to avoid potential UXO. If necessary drop down cameras can be used to investigate objects ahead of equipment placement on seabed. • During cable installation options for dealing with UXO include: o Micro-routeing cable around potential UXO o Moving UXO (using specialist equipment) o In-situ detonation using specialist contractor. RHG commented that EOD teams currently available at Castlemartin are land based. Castlemartin do have access to marine teams through Navy if necessary. In his experience, since 1986 no UXO has been washed up on range. RHG also commented that he can identify when the SDA was established to provide indication of how much UXO might be found in area. Artillery is not fired from range. Testing focuses on small arms ammunition and small tank ammunition. **ACTION 2:** How Greenlink intend to undertake UXO risk assessment to be covered in draft letter to Castlemartin.	AF / TB
5.	**Will Brexit have any impact on project?** Short answer is Element Power do not expect it to.	
6.	**Is there any relationship between Greenlink and the Wave Hub project?** TB has spoken to Wave Hub Project Manager (Joe Kidd) in the past. Previously Wave Hub was also looking at bringing an export cable into Freshwater West. They are currently considering different landfall options as their offshore site has had to be moved. Discussions are ongoing but there is potential to collaborate on areas such as marine survey to save mobilisation costs and minimise disruption to stakeholders.	
7.	**Office location** TB asked whether RHG could recommend a location where TB could host a project drop-in office for one day per month from September 2017 onwards for duration of project. RHG commented that Castlemartin have an unoccupied bungalow just outside of boundary fence that would need a little work but might be a suitable location. Has 2-3 bedrooms so could be used to accommodate project staff as necessary as well. **ACTION 3:** TB and RHG to view bungalow after next Rural Steering Group Meeting (September 2017).	TB
8.	**Warrant Tower visit** RHG provided tour of Castlemartin observation tower. Identified different communication methods available e.g. marine VHF, radio, telephone. Tower has AIS monitoring system to track ships in vicinity of SDA. Also use radar to track non-AIS equipped ships. AF raised question whether there was potential that offshore vessels could disrupt communication e.g. by obstruction line-of-sight communications. This is not a concern due to positioning of radar and communications dishes. Within SDA each weapons system being tested has ‘envelope’ within which ordnance and debris will fall. When firing envelopes are plotted on map of SDA to show vessel movements in relation to live firing. Can quickly communicate with both vessels and range to ensure safe practices.	

Greenlink
c/o Element Power Ireland Limited
Unit C, Building 4200
Cork Airport Business Park
Cork
Ireland

T +353 (0)21 2427786
F + 353 (0)21 2380187
E info@elpower.com

www.greenlinkinterconnector.eu

Colonel (Retd). R. Howard-Gash,
Comd DIO SD Training, Wales and West Midlands,
HQ DIO SD Trg Wales and West Midlands,
Sennybridge Camp,
Brecon,
Powys,
Wales
LD38PN

Our ref: P1975F_ABMAY07
Tom Brinicombe
07814 169380

10 July 2017

Dear Colonel (Retd). Richard Howard-Gash,

Greenlink Interconnector Consultation (Letter dated 23 February 2017)

Thank you for your comments dated 23 February 2017 with regards the Greenlink Offshore Scoping Consultation.

We appreciate Captain Johnson taking the time to review the documentation we provided. We also welcomed the opportunity to discuss these comments with yourself and Captain Johnson at our meeting on 04 May 2017. As discussed at our meeting, our preliminary response to your comments is provided below:

Access to Sea Danger Area

We respect that Castlemartin is an active live firing range and that live ammunition is fired daily into the Sea Danger Area (SDA). When designing the cable route Greenlink have sought to minimise the length of route within the area and keep towards the boundary. Greenlink note that the range closes during specific periods of the year (Easter and August) and that ideally survey and installation (construction) work is carried out during this period. However, as was explained at the meeting Greenlink would not be able to guarantee work could be carried out during these periods. Greenlink are therefore looking to agree in writing an access and communication protocol which will provide our programme with greater flexibility whilst ensuring we do not adversely affect your operations.

As discussed at the meeting we are proposing the following:

1. Greenlink will notify Castlemartin Firing Range, a minimum of two weeks prior to commencement, of any works (survey, installation / construction, repair or maintenance) to be carried out in the SDA. This notice will be provided in writing.
2. Prior to works commencing within the SDA, Greenlink and their appointed contractor will arrange a meeting with Castlemartin Firing Range to provide a briefing of the works to be undertaken in the SDA; confirm timescales; confirm lines of communication; and understand what live firing activity will be undertaken during the period.
3. During activity within the SDA, Greenlink's appointed contractor will provide a daily briefing to Castlemartin Control that will cover: name of vessel(s) involved and exact location of works for the day.

Greenlink
c/o Element Power Ireland Limited
Unit C, Building 4200
Cork Airport Business Park
Cork
Ireland

T +353 (0)21 2427786
F + 353 (0)21 2380187
E info@elpower.com

www.greenlinkinterconnector.eu

4. Greenlink will include within the Marine Survey and Installation Contract tender documents the following requirements:
   "The appointed CONTRACTOR will be required to attend a meeting at Castlemartin Camp, (Pembroke, Wales, SA71 5HE) within two weeks of mobilisation to provide a briefing of works to be undertaken in the Castlemartin Sea Danger Area. Briefing should include description of works to be undertaken, timescales, works plan, and lines of communication. If the intention is to divide the work scope into phases (e.g. phase 1 - geophysical and environmental, and phase 2 – geotechnical) the CONTRACTOR must budget for attendance at two meetings."

   "Whilst operating with the Castlemartin SDA, or in close proximity, the appointed CONTRACTOR will be required to provide, as a minimum, daily briefings to Castlemartin Control (via VHF radio or telephone) on intended activity for next 24-hour period and position within the SDA."

   "The survey corridor passes through the Castlemartin Sea Danger Area (SDA) for approximately 17km. The appointed CONTRACTOR is required to design the survey [or installation works] *to minimise disruption to Castlemartin Firing Range. The CLIENT envisage that the survey may be split into two phases (e.g. phase 1 - geophysical and environmental, and phase 2 – geotechnical). All activities related to a particular phase within the SDA should be completed before work progresses to a new section of the survey corridor."*

If you are in agreement with the above proposal and contract text, we would be grateful if you confirm in writing your acceptance.

UXO Risk Mitigation

The potential for UXO within the SDA was discussed at the meeting. Greenlink note your comments that the majority of UXO is likely to be small arms ammunition and small ammunition from tank testing; artillery has not been tested at Castlemartin. To inform Greenlink's appointed contractors (survey & cable installation) a specialist UXO desk-based study will be commissioned from a suitably qualified company e.g. 1st Line Defence or Dynasafe BACTEC. This will recommend mitigation measures that should be followed by the project to reduce risk to personnel and equipment.

The geophysical survey will consist of five survey lines, spaced approximately 100m apart (to provide the necessary 500m wide coverage). A magnetometer will be used on each survey line to identify ferrous objects. The results of the magnetometer and side-scan sonar will be analysed to determine if the contacts identified potentially represent UXO. Seabed sampling positions will be reviewed to ensure that equipment is not positioned within close proximity of potential UXO.

Prior to cable installation the appointed contractor may be required to undertake a further UXO survey less than 6 months prior to installation.

Greenlink
c/o Element Power Ireland Limited
Unit C, Building 4200
Cork Airport Business Park
Cork
Ireland

T +353 (0)21 2427786
F + 353 (0)21 2380187
E info@elpower.com

www.greenlinkinterconnector.eu

If any significant UXO are identified, typically the following decision making protocol is followed:

1. Avoid by micro-routeing the marine cables.
2. If the UXO cannot be avoided by the minimum acceptable clearance distance of 10m, consider whether it is safe for a specialist sub-contractor to move it.
3. If it cannot be moved, detonate on site.

EMF Interference

The Offshore Scoping Report identified that the electromagnetic field (EMF) generated by the operational marine cables will have a small localised effect which could potentially cause compass deviation in magnetic compasses. The level of deviation at the sea surface will vary according to cable configuration, alignment with the Earth's natural magnetic field and water depth. As discussed at the meeting, inertial navigation systems and global positioning systems have negligible sensitivity to EMF. Although few vessels depend solely on magnetic compasses, they may still be used as auxiliary navigation systems and by recreational craft. Greenlink is aware of the potential risks to navigation and as part of the Environmental Report will provide a full assessment of the effect. If necessary, a specialist report will be commissioned to predict EMF and associated compass deviation to inform cable configuration decisions.

Greenlink appreciates your ongoing commitment to working with us to agree a practical access solution for the Castlemartin SDA. We trust that the above reflects your understanding of our discussions on 04 May 2017 and that you will be able to confirm in writing your agreement to our proposal.

We look forward to receiving your response and meeting again in September at the next Rural Steering Group session.

Yours sincerely,

Tom Brinicombe
Project Manager

APPENDIX D

Sandeel Bay Meeting Minutes

Minutes

ARUP

Project title	Greenlink	Job number	246369-00
Meeting name and number	NPWS Meeting	File reference	9-04
Location	NPWS, Custom House, Galway	Time and date	2.30pm 9 December 2015
Purpose of meeting	Discuss potential landfall options and environmental studies for the Greenlink Interconnector (DAU Ref: G Pre00357/2015)		
Present	NPWS - David Lyons Element Power - Tom Brinicombe Intertek - Anna Farley (Offshore consultant) Arup - Sheila O'Sullivan (Onshore consultant)		
Apologies	Connie Kelleher & Karl Brady (National Monuments Service - DAHG)		
Circulation	Those present		

Action

1. Introductions

David Lyons will be the NPWS point of contact for the project. David will deal with the offshore scope of work. Somebody else from NPWS will be appointed for the onshore scope of work when required at a later date in the project.

Tom Brinicombe represents the client of the project – Element Power.

Intertek are the offshore consultant for the project.

Arup are the onshore consultant for the project.

2. Project Overview

The Greenlink project is proposing to develop a 500MW interconnector between Ireland and the UK.

The project will link the power markets in Great Britain and Ireland.

Prepared by	Sheila O'Sullivan
Date of circulation	6 January 2015
Date of next meeting	N/A

Action

The current proposed connections are Pembroke in Wales and Great Island in Ireland.

Greenlink has obtained EU CEF (Connecting Europe Facility) funding to the end of next year.

Greenlink is also expected to be confirmed as an EU PCI (Project of Common Interest) early in 2016.

3. Draft Landfall Options & Environmental Constraints

A preliminary desk-top assessment & preliminary site visits have been completed to identify potential draft landfall options for the interconnector.

The shortest route corridor is preferable both from an economic point of view and an environmental point of view as it minimises potential impacts – therefore the preliminary assessment has focused on the southeast of Ireland.

The location of the landfall also requires a compromise between onshore and offshore constraints.

The southeast coast of Ireland is protected by numerous offshore environmental designations, including SAC's and SPA's and therefore create an environmental constraint to the landfall location.

While assessment work is an iterative process, the following three landfalls have been identified as preferable based on draft preliminary assessments:

- Booley Bay
- Boyce's Bay
- Baginbun Beach

Booley Bay landfall is located within the River Barrow and River Nore SAC.

Boyce's Bay landfall is location within the Hook Head pNHA.

Baginbun Beach is located within the Hook Head SAC.

Habitat maps and conservations area files are available on the NPWS website.

Booley Bay is located in close proximately to a very important subtidal reef within the River Barrow and River Nore SAC (Duncannon). DL noted the exact boundary of the reef in relation to the landfall and any potential impact should be assessed. Mitigation AF

Action

to be considered would include reinstating the top layer of the trench.

DL noted the pNHA's do not have protected status.

Summer installation would be preferable to avoid disturbance to the kittiwake colony in the Hook Head pNHA. Geese feed regularly on the shores in winter.

DL noted that the route and landfall locations within designated sites are acceptable once it can be demonstrated that there would be no negative impacts to the designated sites.

The Hook Head SAC is a rocky habitat and potential installation methodology would have to be assessed. DL noted it is preferable to use trenching or horizontal directional drilling under the designated sites rather than mattressing and/or rock protection, due to potential impact to the designated site and habitats with rock protection.

The offshore geophysical and geotechnical surveys will confirm the potential cable route installation methodology. Following confirmation of potential installation methodologies an assessment on potential impacts to the designated sites will be completed to evaluate suitability.

The installation is a relatively quick process and therefore potential impacts and mitigation for birds etc. are anticipated to be suitable for the environmental assessment.

Migratory fish species are designated features of the River Barrow and River Nore SAC. DL felt that the geophysical survey and installation would not prove to be a barrier to passage and no specific mitigation would be required.

DL noted that the estuary comprises of a sandy sediment top layer which should be suitable for installation. Within the estuary disturbance of the upper sandy sediment layers is common and therefore the quick installation is anticipated to create no significant impact with high recoverability of the seabed.

The SPA is a Ramsar site – DL to confirm. DL

4. Offshore Survey, Foreshore Licence & Environmental Constraints

A geophysical survey and geotechnical survey are proposed for the offshore route.

	Action
Pre-application has been prepared for the foreshore licence with will be submitted in the near future. DL confirm the DECLG Foreshore department will review this documentation.	
DL noted that the geophysical and geotechnical survey application should be completed together as for ease of NPWS assessment and approval.	
The actual application will be issued to the NPWS (DL) via the DECLG Foreshore department. DL noted all available information should be included within the application.	
It will take approximately 8 weeks to approve the licence once all information is submitted.	
A screening for appropriate assessment and a Marine Mammal Assessment will be required for the foreshore licence for the offshore survey.	AF
As it is a generic survey preliminary information is ok as it is understandable that the actual route is not confirmed and will be modified as results are gathered.	
It was agreed that a 1km wide corridor will be submitted to ensure all areas are covered within the application; however, it is anticipated that the survey will only require an approximate 500m wide corridor.	
It is anticipated that Multi-Beam Echo Sounder, Sidescan Sonar, Sub bottom profilers, magnetometers will be used for the survey.	
DL noted that a marine mammal observer will be required onboard for startups and works to be completed in accordance with the 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters'. DL highlighted the main concern for marine mammals would be the effect from sub bottom profilers in an embayment. DL outlined the area he considered to be an 'embayment' in the vicinity of the landfall locations.	
The River Barrow and River Nore SAC are protected for lamprey and salmon. DL noted this will not be an issue for the survey as noise levels created will not be significant and works also will be within a small area therefore not creating an obstacle. This will be similar for the cable installation.	
Intertek will issue actual GIS ArcView information to the NPWS, however, this will not be submitted to the Foreshore Department as not required for their systems.	

Action

5. Proposed Surveys & Studies

A separate screening for appropriate assessment (and potential Natura Impact Statement) and Environmental Report will be prepared for the actual cable installation. It is anticipated that a full EIA will not be prepared. A screening for EIA will be completed.

The offshore surveys proposed are as follows: Archaeological assessment, Marine Mammal Risk assessment, Marine Surveys (as detailed in Section 4 above), Intertidal Survey, and UXO survey.

Standard onshore (terrestrial) surveys will be completed. These will be discussed with onshore NPWS representative at a later date.

The standard onshore environmental studies anticipated are as follows: Flora & Fauna, Archaeological / Cultural Heritage, Geotechnical, Traffic, Noise, Air Quality, Flood, and Landscape & Visual.

The standard onshore ecological surveys anticipated are as follows:

- Winter Birds (landfalls)
- Breeding Birds
- Bats
- Badgers
- Otters
- Other Mammals
- Hedgerows & trees

6. Any other business

DL noted that more information may be available for the offshore marine routes from the Infomar website (geophysical data particularly should detail the sand-waves etc.)

There are no offshore marine protected sites (beyond the foreshore).

DL noted offshore Wexford is a busy fishing area with lots of trawling offshore.

Cable protection will be very important (particularly as High Voltage cable) to ensure no impacts to the cable but also to the fishing industry.

APPENDIX E

Booley Bay Meeting Minutes

MINUTES OF MEETING

Project: P1975 - Greenlink

Subject: Introduction to project and discussion of landfall options

Date and Time: 9th March 2016, 10.30am

Duration: 1.5 hrs

Venue: Port of Waterford, Marine Point, Bellview Port, Waterford

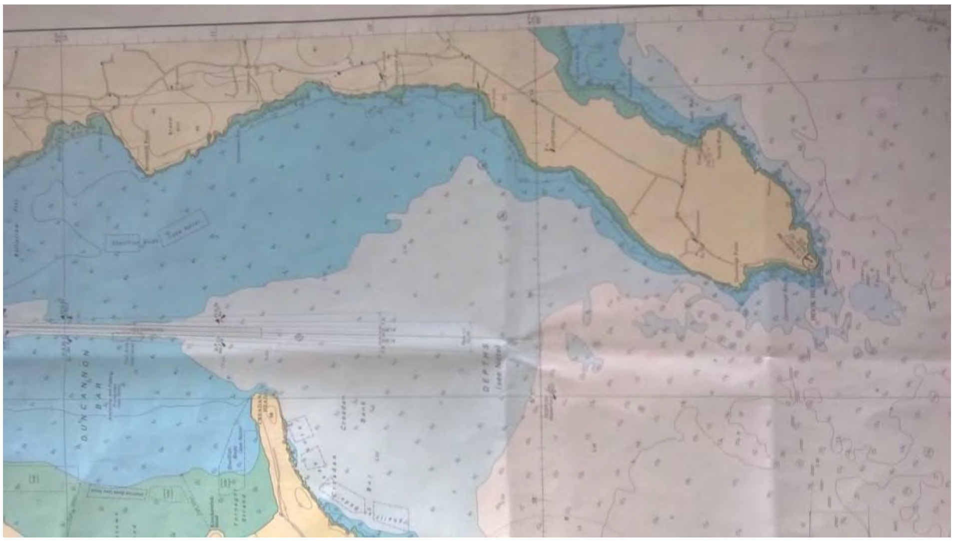
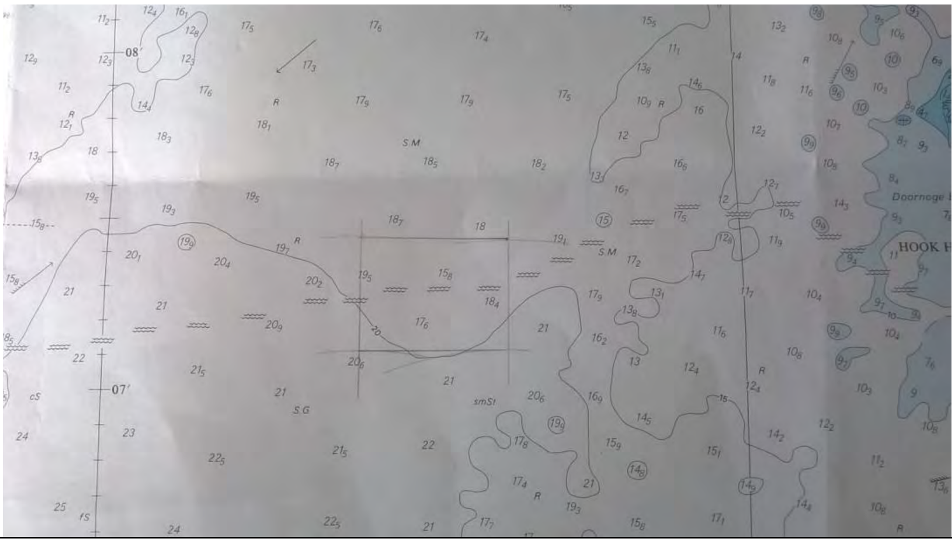
Present: Tom Brinicombe - Element Power Project Manager
Peter Harte - Element Power Ireland Director
Anna Farley - Intertek Marine Consultant
Frank Ronan - Chief Executive Port of Waterford Company
Captain John Foley - Assistant Harbour Master

Level of Issue: DRAFT

File Reference: P1975_AAMAR06_Rev0

Distribution: Element Power, Intertek, Arup

ITEM	MINUTES	ACTION
1.	**Introduction to Greenlink** PH & TB provided overview of Element Power and the Greenlink project. Embedded presentation was used as a talking point. Presentation to Port of Waterford_09031(AF briefly described cable installation requirements, potential anchor spread, positioning of lay vessels and survey techniques proposed. Presentation includes a map showing the proposed offshore routes.	
2.	**Port of Waterford Introduction** FR explained Port of Waterford is a commercial operation; although the main stakeholder is the state. http://www.portofwaterford.com/ Their authority extends to a line between Hook Head and Sheeps Head and 3nm out. They are looking at ways to invest in the Port and explore new areas of revenue. One area of interest is biomass / biofuel power station. They are open to discussing and facilitating projects that are in line with their interests or would not adversely affect future commercial opportunities. FR & JH are not aware of any trends (seasonal or otherwise) in shipping activity using the port. Ships can use the port at all states of the tide. Larger vessels require high tide but will adjust speed so approach is made at the correct time rather than anchoring. Designated anchor area is provided on west side of estuary near Dunmore East. Mainly used by cruise ships. Harbour Master can provide a 2 week look ahead of vessels expected. Website has daily visits listed.	

ITEM	MINUTES	ACTION
3.	**Dredging** The Port spend €1 million per annum on dredging two areas of the estuary: Cheek Point (area where 2 rivers meet); and centre of the channel at Duncannon (widest, slowest part of the estuary). Both areas get dredged 3 times per year to maintain access. A 100m wide corridor is dredged at Duncannon. Noted on Admiralty chart 2046.  Anthony Bates Partnership (Colm Sheehan) is dredging consultants. http://www.anthonybates.co.uk/ Dredged spoil is deposited at estuary mouth in boxed zone indicated below. Dredging licence is available on their website (http://www.environ.ie/planning/foreshore/applications/port-waterford-company). Foreshore Licence reference: FS005701 	

ITEM	MINUTES	ACTION
	 Discussed that in future they may consider or be required to dredge a deeper channel out of the estuary. They would not want to “sterilise the seabed” by having a cable installed in this area. Channel could be 100m wide like at Duncannon or 500m wide. Size would depend on need and modelling.	
4.	**Landfalls** Due to the level of dredging at Duncannon, the Booley Bay landfall would be inadvisable; both the cable and the dredging would be put at risk if this landfall was progressed. The Port would be willing to consider Boyce’s Bay if it did not sterilise the seabed for future dredging activity i.e. the route avoided the main channel and hugged closer to the coast. **ACTION:** Booley Bay to be removed from consideration in future assessments. **ACTION:** Element Power / Intertek to consider technical feasibility of Boyce’s Bay based on Ports response.	ITRK / ARUP ITRK / Element Power
5.	**Licences / Permits** <u>Marine Survey</u> – No specific permits required from Port for marine survey in their authority area. Requested that they be kept informed of all vessel movements and timings of survey. If necessary contractor may be asked to stand down for short period if impeding shipping activity. AF suggested that we could include conditions in the survey contract regarding open dialogue with the port. **ACTION:** AF to ensure that Survey contracts have appropriate conditions requiring open communication with Port. <u>Cable Installation</u> The Port does not have an application form but would expect that a works licence would be required for installation. As nothing is developed at the moment they would have to discuss it with their lawyers. They would not expect this to be onerous but it was mentioned that a process of negotiation would be necessary. Could take time. A fee would also be charged but they were keen to point out that this would be benchmarked against other ports and ‘the going rate’ charged.	 ITRK

ITEM	MINUTES	ACTION
6.	**CEF Funding** Port has applied for CEF funding for hydrographic surveys of estuary.	
7.	**Facilities** SSE used port facilities when constructing Great Island Power Station. Heavy items were barged across estuary with barges beaching for offloading. Heavy lift crane used to unload. 40-60 tonne loads can be moved by Port dock lifting facilities. However third parties have been bought in to deal with larger loads. 750 tonnes have been accommodated at dock facilities.	
8.	**General Information** Bord Iascaign Mhara (www.bim.ie) and Department of Agriculture have licensed a number of aquaculture sites within the estuary. These are not necessarily in place yet. Good lobster and crab territory offshore. Oysters caught on west coast of estuary. Dolphins seen in estuary.	