SCOTTISH FUTURES TRUST

INTERNATIONAL FIBRE OPTIC CABLE LANDING

DESK TOP STUDY

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02	7.3.3	81	Additional information on the fishing vessel anchorage offshore of Port William Harbour.	AR
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	9.3.1	109	Additional content added in the Scottish permit summary.	AR
	10.1	120	Updated RPL revisions.	MW
	13.2	154	An existing duct that is 150mm in diameter is available on the east of Bottle Hole Bridge added to site visit report	AR
	13.8	160	Model Option and Licence Agreements included as additional appendices.	AR
	13.9	162		
	13.10	162	Updated RPL revisions.	MW

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 12

1.1 Recommendations 12
1.2 Route Overview 13
1.3 Executive Summary Table 14

2.0 INTRODUCTION 18

2.1 Project Overview 18
2.2 Objective 18
2.3 Deliverables and Timelines 19

3.0 DATACENTRE CONNECTION 19

3.1 Introduction 19
3.2 Identified Datacentres 19
3.3 Terrestrial Connection 19
3.4 System Design Effects 20

4.0 INITIAL LANDING POINT SELECTION 20

4.1 Introduction 20
4.2 Transatlantic Connection 20
4.3 Republic of Ireland 21
4.4 Isle of Man 21
4.5 Scotland 22
4.5.1 Dunnet Bay, Caithness 22
4.5.2 Ullapool, Ross and Cromarty 23
4.5.3 Muasdale, Kintyre 23
4.5.4 Irvine, North Ayrshire 24
4.5.5 Girvan, South Ayrshire 24
4.5.6 Portpatrick, Dumfries and Galloway 24
4.5.7 Port William, Dumfries and Galloway 24

5.0 GEOPHYSICAL INFLUENCES 24

5.1 Introduction 24
5.2 Geology and Geomorphology of the Region 25
5.3 Shallow Geology and Seabed Sediments 28
5.3.1 Seabed Sediment Distribution 28
5.4 Bathymetric and Geological Risks to Cable Security that Impact on the Route 29
5.4.1 Sediment Transport 30
5.4.2 Rock Outcropping 31
5.4.3 Earthquakes 32
5.4.4 Mass Wasting, Sediment Slumping and Turbidity Currents 33
5.4.5 Submarine Canyons 34
5.4.6 Tsunamis 34
5.4.7 Pockmarks and Depressions 37
5.4.8 Gas Cemented Hardground 37
5.4.9 Gas Hydrates 38
5.5 Summary for Geological Routeing and Installation Report 39

6.0 METOCEAN INFLUENCES 41

6.1.1 Irish Sea and North Channel Oceanography 41
6.1.2 Irish Sea and North Channel Meteorology 44
6.1.3 Irvine 45
6.1.4 Girvan 48

6.1.5 Muasdale ... 49
6.1.6 Portpatrick ... 51
6.1.7 Port William ... 52
6.1.8 Peel ... 54
6.1.9 Port Grenaugh ... 56
6.1.10 Loughshinny and Portmarnock ... 58
6.1.11 Dunnet Bay ... 59
6.1.12 Ullapool ... 61
6.1.13 Metocean Summary ... 62

7.0 HUMAN HAZARDS ... 64

7.1 Introduction ... 64
7.2 Fishing ... 64
7.2.1 Fishing Methods ... 64
7.2.2 Evidence of Bottom Fishing ... 71
7.2.3 Distribution of Fishing Effort and Fishing Fleets ... 72
7.2.4 Summary for Fishing Impact ... 78
7.3 Shipping and Anchorages ... 78
7.3.1 Introduction to Shipping and AIS Technology ... 78
7.3.2 Risk from Anchors ... 79
7.3.3 Anchorages ... 81
7.3.4 Shipping ... 81
7.4 Wrecks and Obstructions ... 83
7.5 Dredging and Dumping Zones ... 84
7.5.1 Beaufort's Dyke ... 85
7.6 Renewable Energy ... 85
7.7 Hydrocarbon Exploitation ... 87
7.7.1 Oil and Gas Developments ... 87
7.7.2 Lease Blocks ... 87
7.7.3 Drilling Activity ... 87
7.7.4 Pipelines ... 88
7.8 Submarine Cables ... 89
7.8.1 Telecommunication Cables ... 89
7.8.2 Power Cables ... 92
7.9 Military Activities ... 92
7.9.1 Unexploded Ordnance ... 93
7.10 Summary of Anthropogenic Impact ... 94

8.0 PROTECTED AREAS ... 96

8.1 Introduction ... 96
8.2 Transatlantic Connection ... 96
8.3 Scotland to Ireland Cable System ... 97
8.4 Scotland to Isle of Man Cable System ... 98
8.5 Dunnet Bay Landing Point ... 100
8.6 Ullapool Landing Point ... 101
8.7 Muasdale Landing Point ... 102
8.8 Irvine Landing Point ... 102
8.9 Girvan Landing Point ... 102
8.10 Portpatrick Landing Point ... 102
8.11 Port William Landing Point ... 102
8.12 Isle of Man ... 103
8.13 Ireland Landing Point ... 104
8.14 Summary for Marine Protected Areas ... 105

9.0 PERMITTING ... 108

9.1 Introduction ... 108
9.2 Landings and Maritime Boundaries ... 108
9.3 Project Significant Influencing Factors ... 109
9.3.1 Scotland ... 109
9.3.2 Ireland ... 110
9.3.3 Isle of Man ... 110
9.4 Limitations ... 110
9.5 Scotland ... 111
9.5.1 Marine Scotland – Marine and Coastal Access Act 2009 ... 111
9.5.2 Crown Estate Scotland ... 113
9.5.3 Operational Permits ... 114
9.6 Ireland ... 114
9.6.1 Foreshore Unit ... 114
9.6.2 Operational Permits ... 116
9.7 Isle of Man ... 116
9.7.1 Marine Infrastructure Management Act ... 116
9.8 Permit Matrix Overview ... 118

10.0 CABLE ROUTE ENGINEERING ... 120

10.1 Introduction ... 120
10.2 Cable Fault Analysis ... 120
10.3 Cable Specification ... 123
10.4 Branching Units ... 124
10.4.1 Branching Unit Cable Allowances ... 125
10.5 Repeaters ... 126
10.6 Cable Protection Recommendations ... 126
10.6.1 General Recommendations ... 126
10.6.2 Cable Burial ... 127
10.6.3 Cable Armouring ... 127
10.6.4 Pipeline Crossings ... 128
10.6.5 Telecoms Cables Crossings ... 129
10.6.6 Power Cable Crossings ... 130
10.7 Cable Route Commentary ... 130
10.7.1 Transatlantic Connection ... 130
10.7.2 Scotland – Ireland ... 132
10.7.3 Scotland – Isle of Man ... 133
10.8 Summary for Cable Route Engineering ... 134

11.0 OPERATIONAL REVIEW ... 135

11.1 Cable Route Survey ... 135
11.1.1 Introduction ... 135
11.1.2 Equipment ... 135
11.1.3 Navigation ... 135
11.1.4 Bathymetry ... 136
11.1.5 Seabed and Sub-Bottom Characteristics ... 136
11.1.6 Magnetometer ... 136
11.1.7 Tow Fish Positioning ... 136
11.1.8 ROV Crossing Survey ... 137
11.1.9 Seabed Sampling ... 137
11.1.10 Cone Penetration Tests (CPTs) ... 137
11.1.11 Deep Water Survey ... 137
11.1.12 Charting and Reporting ... 137
11.1.13 Special Considerations for Survey ... 139

11.2 Installation Recommendations ... 139
11.2.1 Slack ... 140
11.3 Maintenance Recommendations ... 140
11.3.1 Repair Operations ... 143
11.3.2 ACMA ... 144
11.4 Marine Operations Summary ... 145

12.0 CONCLUSIONS AND RECOMMENDATIONS ... 146

12.1 Conclusions ... 146
12.2 Recommendations ... 146

13.0 APPENDICES ... 148

13.1 Bibliography ... 148
13.2 Site Visit Report ... 154
13.3 CES Heads of Terms ... 155
13.4 Marine Scotland Meeting Minutes ... 156
13.5 Crown Estate Decommissioning Guidelines ... 157
13.6 Foreshore License Consultees List ... 158
13.7 IoM Application for Authorisation ... 159
13.8 Master Licence Telecommunications Cables ... 160
13.9 Master Option Telecommunication Cables ... 161
13.10 RPLs and SLDs ... 162
13.11 Charts ... 163

TABLE OF FIGURES

Figure 1: System Overview 13
Figure 2: Clockwise from Top Left: Douglas, Port Groundle, Port Grenough, Port Erin, Peel (Global Marine) 21
Figure 3: Dunnet Bay (Google Earth, 2018) 23
Figure 4: Geological Timescale 26
Figure 5: Major Structural Features of the Hebrides (BGS, 1993) 27
Figure 6: Major Structural Features of the Irish Sea (BGS, 1995) 27
Figure 7: Quaternary Thickness in the Irish Sea (BGS, 1995) 28
Figure 8: Western Scotland & Irish Sea Sediments (BGS, 2018) 29
Figure 9: Interaction of a Cable Plough with Megaripples 31
Figure 10: Earthquake Locations (United States Geological Survey, 2018) 32
Figure 11: Mass-movement Processes 33
Figure 12: Submarine Canyons on the Donegal Fan (GEBCO, 2014) 34
Figure 13: Extreme Waves Map of Ireland (O'Brien, et al., 2013) 36
Figure 14: Sonar Image of Seafloor Pockmark and Satellite Pockmarks 37
Figure 15: Known Distribution of Gas Hydrates (USGS Gas Hydrates Project, 2013) 38
Figure 16: Area Overview 41
Figure 17: Peak spring velocity (m/sec) (Lewis, et al., 2015) 43
Figure 18: Mean significant wave height in the Irish Sea (Health and Safety Executive, 2001) 43
Figure 19: 3 hourly wind rose in the Firth of Clyde from 1983 – 2016 (North and South Ayrshire Council, 2018) 44
Figure 20: Correlation between wind direction from the south (left) from the southwest (middle) and from the northwest (right) and significant wave height in the Firth of Clyde during a force 8 storm (North and South Ayrshire Council, 2018) 46
Figure 21: Coastal erosion, Irvine (Sneddon, 2003) 47
Figure 22; Spring tide velocities (left) and direction of current flow around the Isle of Man (right). (Aquatera, 2006) (Brown, 1951). 55
Figure 23: Peel Harbour in 2014, 1 hour before high tide (Guardianwitness, 2014) 56
Figure 24: Climate summary, Dublin (Irish Meteorological Service Online, 2016) 58
Figure 25: Fishing Methods 1 (Fuller, et al., 2008) 64
Figure 26: Fishing Methods 2 (Fuller, et al., 2008) 65
Figure 27: Fishing Methods 3 (Fuller, et al., 2008) 65
Figure 28: Cable Fault Caused by Fishing Gear (Global Marine) 67
Figure 29: Typical Bottom Trawl Gear & Configuration 67
Figure 30: Bottom Trawler Catching Cable (ICPC, 2009) 68
Figure 31: Scallop Dredging Gear 69
Figure 32: Scallop Dredging Vessel in Peel, IoM (Global Marine) 70
Figure 33: Potting Vessel in Peel, IoM (Global Marine) 70
Figure 34: Trawl Scars from SSS Data 71
Figure 35: Trawl Fishing West of Scotland 2016 (MMO, 2016) 72
Figure 36: Fishing Density North of Ireland 2017 (Global Fishing Watch, 2018) 73
Figure 37: Fishing Density in the Firth of Clyde 2017 (Global Fishing Watch, 2018) 74
Figure 38: Dredge Fishing West of Stranraer 2016 (MMO, 2016) 74
Figure 39: Major Irish Fishing Grounds of the Irish Sea (Marine Institute, 2014) 75
Figure 40: Trawl Fishing in the Western Irish Sea 2016 (MMO, 2016) 75
Figure 41: Irish Fishing Effort Close to Portmarnock (Irish Marine Atlas, 2018) 76
Figure 42: Dredge Fishing North of the IoM 2016 (MMO, 2016) 77

Figure 43: Trawl Fishing North of the IoM 2016 (MMO, 2016) 77
Figure 44: AIS coverage North West Europe (Vespe, et al., 2015) 79
Figure 45: Anchor Penetration (m) vs Vessel Size (GT) in Firm Ground (Shapiro, et al., 1999) 80
Figure 46: Irish Sea Marine Traffic (MarineTraffic, 2015) 82
Figure 47: Dublin Marine Traffic (MarineTraffic, 2015) 82
Figure 48: Northern Scotland Marine Traffic (MarineTraffic, 2015) 83
Figure 49: Beaufort's Dyke Munitions Dumping Area 1918 - 1976 85
Figure 50: Planned and proposed OWF developments in the Irish Sea and North Channel 86
Figure 51: Hydrocarbon blocks and wells 88
Figure 52: Military Practice Areas, Scotland (Scottish Government, 2014) 93
Figure 53: Beaufort's Dyke and UXO migration 94
Figure 54: Protected Area Overview 96
Figure 55: Protected area overview of the Scotland to Ireland cable route 98
Figure 56: Protected area overview of the Scotland to Isle of Man cable route 99
Figure 57: Dunnet Bay protected area overview 100
Figure 58: Ullapool protected area overview 101
Figure 59: Port William protected area overview 103
Figure 60: Protected area overview in the Isle of Man 104
Figure 61: Protected area overview, Ireland 105
Figure 62: Area of Interest for Faults 121
Figure 63: Causes of Cable Faults 122
Figure 64: Fishing Faults related to Water Depth 123
Figure 65: HMN BU 1650 Branching Unit 125
Figure 66: Optimal BU Deployment 125
Figure 67: HMN RPT 1660 R2 Repeater 126
Figure 68: Deployment of a Flexible Concrete Mattress (GMG) 129
Figure 69: Eastern Rock Ridge (GEBCO, 2014) 131
Figure 70: Submarine Cables of the World 141
Figure 71: Ships Anchor caught up in cable 141
Figure 72: Cable fault with Cargo Lashing chain on cable 142
Figure 73: Cable fault caused by fishing gear entanglement 143
Figure 74: A cableship laying a final bight 144
Figure 75: Cable Maintenance Zones 145

TABLE OF TABLES

Table 1: Beach Manhole and BU Locations 18
Table 2: Deliverables 19
Table 3: IoM Shared Landings 21
Table 4: Nomenclature for Bedforms (Gass & Team, 1984) 30
Table 5: Summary of Geological Impacts 40
Table 6: Climate summary, Troon (Weather2, 2018) (Holiday-Weather, 2018) 45
Table 7: Force 7 storm occurrences (days) in the Firth of Clyde (Transport Scotland, 2018) 46
Table 8: Tidal range, Irvine (Admiralty Total Tide, 2018) 46
Table 9: Climate summary, Girvan (YR, 2018) 48
Table 10: Tidal range, Girvan (Admiralty Total Tide, 2018) 49
Table 11: Climate summary, Muasdale (Weather2, 2018) 50
Table 12: Tidal range, Muasdale (Admiralty Total Tide, 2018) 51
Table 13: Climate summary, Portpatrick (Weather2, 2018) 51
Table 14: Tidal range, Portpatrick (Admiralty Total Tide, 2018) 52
Table 15: Climate summary, Port William (Weather2, 2018) 53
Table 16: Tidal range, Port William (Admiralty Total Tide, 2018) 53
Table 17: Climate summary, Peel (Weather2, 2018) 54
Table 18: Tidal range, Peel (Admiralty Total Tide, 2018) 55
Table 19: Climate Summary, Ronaldsway Airport (Kennington & Hisscott, 2013) 57
Table 20: Tidal range, Port Grenaugh (Admiralty Total Tide, 2018) 57
Table 21: Tidal range, Loughshinny (Admiralty Total Tide, 2018) 59
Table 22: Climate Summary, Dunnet Bay (Weather2, 2018) 60
Table 23: Tidal range, Dunnet Bay (Admiralty Total Tide, 2018) 61
Table 24: Climate summary, Ullapool (Weather2, 2018) 61
Table 25: Tidal range, Ullapool (Admiralty Total Tide, 2018) 62
Table 26: Summary of Metocean Impacts 63
Table 27: Fishing Gear Severity Ranking (Fuller, et al., 2008) 66
Table 28: Summary of Risks to Cable from Fishing 78
Table 29: Anchor Fluke Tip Penetration (Shapiro, et al., 1999) 80
Table 30: Wrecks and Obstructions 84
Table 31: Active pipeline crossings 89
Table 32: Submarine Cable Crossings 91
Table 33: Power Cable Crossings 92
Table 34: Summary of Anthropogenic Impacts 95
Table 35: Summary of key protected species along the CC2 route (Birdlife International, 2016) (Evans & Baines, 2010) (Natural England, 2011). 107
Table 36: Summary for Marine Protected Areas 107
Table 37: Maritime Boundary Summary 108
Table 38: Report Cable Types 124
Table 39: Chart Layout Requirements 139
Table 40: Special Considerations for Survey 139
Table 41: Marine Operations Summary 145

ABBREVIATIONS

AIS	Automatic Identification System
AP	Articulated Pipe
BMH	Beach Manhole
BT	British Telecom
BU	Branching Unit
CES	Crown Estate Scotland
CLS	Cable Landing Station
CPT	Cone Penetration Test
CZ	Contiguous Zone
DA	Double Armour
DTS	Desk Top Study
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPS	European Protected Species
FO	Fibre Optic
GCH	Gas Cemented Hardground
GIS	Geographical Information Systems
GPS	Global Positioning System
HDD	Horizontal Direction Drilling
ICPC	International Cable Protection Committee
IMO	International Maritime Organisation
IoM	Isle of Man
LP	Landing Point
LW	Lightweight
LWP	Lightweight Protected
MMO	Marine Mammal Observer
MMO	Marine Management Organisation
MNR	Marine Nature Reserve
MOD	Ministry of Defence

MPA	Marine Protected Area
MS	Marine Scotland
NM	Nautical Mile
OOS	Out of Service
PLSE	Pre-Laid Shore End
ROV	Remotely Operated Vehicle
RPL	Route Position List
SA	Single Armour
SAC	Special Area of Conservation
SAL	Single Armour Light
SCI	Site of Community Importance
SFT	Scottish Futures Trust
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TSS	Traffic Separation Scheme
TW	Territorial Waters
UXO	Unexploded Ordnance

1.0 EXECUTIVE SUMMARY

Global Marine have been commissioned by Scottish Futures Trust to undertake a Desk Top Study (DTS) for proposed subsea fibre optic links between the north and west coasts of Scotland and:

- A transatlantic cable in the Rockall Trough
- Dublin, Ireland
- The Isle of Man

Preliminary landing points have been selected based on a requirement for onward connection to sites studied as potential datacentre locations and further specified based on site visits to the locations undertaken in October 2018. These are detailed in the Site Visit Report provided as Appendix 13.2 to this study.

This report presents the potential risks to the cable along the entire route and provides a summary of the perceived issues in each section. The system links are located in an area with a high intensity of marine users. Trawl fishing is the primary hazard to the cable once installed, followed by scallop dredging and anchoring by other vessels offshore. Areas of outcropping rock exist close to the landing points and may reduce burial of the cable if not avoided following the marine survey. Mitigation of potential faults is the primary aim of the route engineering carried out in this study; ensuring cable security is optimised and robustly engineered.

GMG have developed RPLs and SLDs that comprise the compound knowledge gained from customer supplied data and our own research. The routes have been designed to improve cable security and prevent loss of service. If the customer chooses to implement these routes then the optimum cable route will be achieved, with maximum mitigation against the perceived risks.

1.1 Recommendations

The key recommendations of this report are:

- Bury all cable in water depths shallower than 1,000m to a target burial depth of 1m below the seabed except in the Beaufort’s Dyke munitions dumping ground through which the cable should be surface laid.
- Negotiate crossing agreements for telecoms cable, pipeline and power cable crossings. Apply additional cable protection as required, such as mattresses and/or a polyurethane protection system such as Uraduct®.
- Review the cable route and armour levels during and following the marine survey to optimise security, with particular attention to the expected achievable depth of burial of the cable in locations with subcropping rock or hard clays.
- Ensure any areas of sandwaves and pockmarks along the route are captured during the marine survey and compensated for by route engineering, deeper burial or increased armouring.
- Undertake a marine offshore liaison program with fishing groups before, during and after installation to reduce the chances of damage to the cable.
- Perform marine survey and main cable lay during the annual good weather window from April to September.
- The PLSE at Portmarnock should be installed prior to the main lay.

- Make sure that the installed cable is marked on navigation charts.
- Begin application for permits and negotiate crossing agreements with cable and pipeline owners with plenty of time to spare.

The websites and charts used in this DTS are suitable for planning purposes but more detailed data intended for navigation purposes should be acquired before beginning operations. The issues and recommendations unique to each section of this report are reproduced in the table on Page 14.

1.2 Route Overview

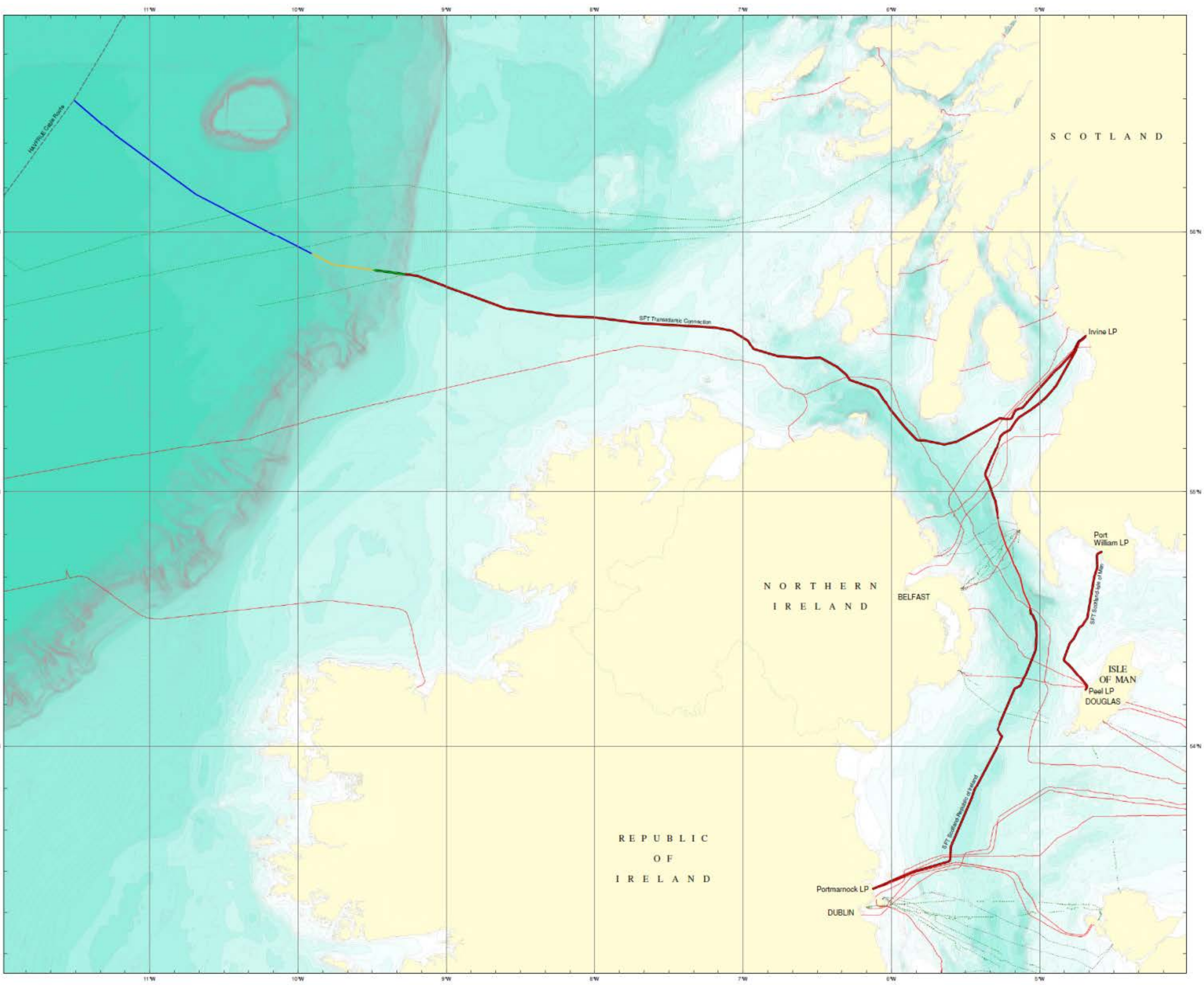

Figure 1: System Overview

1.3 Executive Summary Table

REPORT SECTION	RISK DETAILS			
GEOPHYSICAL INFLUENCES	FEATURES & PROCESSES	IMPACT	MITIGATION	RISK LEVEL
	Seabed Sediment Distribution	Affect burial capability of the cable. Sediments are expected to be sands and gravels on the continental shelf and in the eastern Irish Sea and muddy in the western Irish Sea, Rockall Trough and deeper areas of the Firth of Clyde. There is a risk from Glacial Till.	Conduct a burial assessment survey in areas where burial is designated to verify that recommendations are achievable.	Low/ Medium
	Sediment Transport Features	Bedforms may pose a risk to burial equipment or expose buried cables after installation. Few bedforms are thought to exist close to the cable routes.	Conduct a survey in areas where burial is designated to identify and avoid or compensate for the presence of bedforms.	Low
	Rock Outcrop	May damage cable plough if undetected during survey, or cause cable abrasion, suspension and/or exposure. Occur offshore of most landings and between Ireland and Islay.	Outcrops should be identified and avoided during the cable route survey where possible. Avoid steep slopes in deep water. Up armour and surface lay where avoidance is impossible.	Medium/ High
	Earthquakes	Ground shaking may damage onshore installations. May trigger tsunamis and mass movement. The region is very low risk for earthquakes.	Avoid routeing across steep slopes in the Rockall Trough.	Very Low
	Mass Wasting	Currents and sediment movement involved may break the cable. May bury the cable beyond recovery. Highest risk near to seamounts and other steep slopes. Low risk of initiating events such as earthquakes.	Avoid routeing parallel to slope contours to minimise cable exposure.	Low
	Submarine Canyons	May channel mass wasting events. Likely rock outcrops on canyon walls. Occur on the slopes of the Rockall Trough.	Avoid canyons identified during the cable route survey if possible. Avoid routeing across a canyon or along the canyon floor.	Low
	Tsunamis	May inundate and/or destroy onshore installations. May also trigger mass wasting events. Very rare in the region.	Design cable landing station and BMH to resist inundation as for floods. Avoid routeing the cable across slopes.	Very Low

	Pockmarks	May damage cable plough or ROV if undetected during survey, or cause cable suspension and/or exposure.	Locate during survey and avoid where possible, proceed with caution where avoidance is impossible.	Low
	Gas Cemented Hardground	May damage cable plough if undetected during survey, or cause cable abrasion, suspension and/or exposure. Known to occur in the Irish Sea.	Locate during survey and avoid where possible, proceed with caution where avoidance is impossible.	Low
	Gas Hydrates	May prevent burial or cause mass movement. Not known to occur in the region.	Look for indications of hydrates during marine survey and avoid if possible.	Very Low
METOCEAN INFLUENCES	FEATURES & PROCESSES	IMPACT	MITIGATION	RISK LEVEL
	Currents	Bottom currents may create bedforms that hamper installation in waters less than 100m deep. Currents may alter vessel positioning, cable touch down positioning or hamper ROV operations.	Conduct a survey in areas where burial is designated to identify and avoid or compensate for the presence of bedforms.	Low
	Winds, Waves & Swell	May degrade survey data due to excessive pitch and roll of survey vessel. May prevent cable ship from launching a plough or ROV. May create transient seabed currents, exposing or abrading the cable.	Restrict installation and survey operations to the spring and summer months to reduce the risk of delay. It should be noted that offshore conditions can vary dramatically.	Low/ Medium
	Storm conditions	As above.	Restrict operations to the spring and summer season. Review target burial depths if storm derived bedforms are found by the survey.	Low

	Tidal Currents	Currents may affect cable touch down position or hamper ROV operations.	Low as tidal streams are believed to be relatively minimal at the majority of the LPs however to ultimately reduce the shore end installation risk, the neap tidal window should be optimised.	Low
HUMAN HAZARDS	HAZARD	IMPACT	MITIGATION	RISK LEVEL
	Fishing	Trawl fishing has been identified as the biggest risk to the cable. Otter boards and beams may snag cables. Scallop dredging is also a significant risk.	The cable should be buried and appropriately armoured.	High
	Shipping	The Irish Sea and other areas studied are high traffic areas. There will be a significant risk from anchor dragging.	The cable should be buried. The routes have been designed to minimise the traffic lanes crossed where possible.	Medium
	Anchorages	The only anchorage near to the cable route is a small vessel anchorage at Port William. Anchors can snag on the cable and damage or sever it.	The cable should be buried. AP should be applied if burial cannot be achieved.	Low
	Wrecks	All known wrecks are avoided. Wrecks pose an abrasion risk to the cable and a risk of damage to burial equipment.	If uncharted wrecks are found during the survey, separation of 1 x WD or a minimum of 500m should be sought between the wreck and the route.	Low
	Dredging and Dumping	There is dredging activity at all ports in the region, but none close to the proposed cable routes. For Beaufort's Dyke dumping ground see Military and UXO below.	After installation, the cable must be clearly marked on admiralty charts.	Very Low
	Renewable Energy	All three of the cable route options and associated LP options do not conflict with any existing or proposed offshore wind farm areas.		
	Hydrocarbon Exploitation	The hydrocarbon industry and its associated infrastructure is relatively limited in the Irish Sea, North Channel and Northwest Scotland. All three of the proposed cable routes avoid all existing wells by at least 1km. There are various pipeline crossings along the proposed cable routes.	No significant mitigation is required. After installation, the cable must be clearly marked on admiralty charts. If any pipelines or additional hydrocarbon infrastructure is proposed, crossing agreements and early consultation with the cable owner will be required.	Low
	Submarine Cables	There are numerous in-service and out-of-service (OOS) cable crossings. Crossing agreements should be reached with the respective owners prior to installation of the proposed cable systems	Additional cable protection measures have been recommended for crossings.	Low

	Military Activities & UXO	The cable routes cross several firing and exercise areas which pose minimal risk. The Scotland – Ireland route crosses the Beaufort's Dyke Dumping Ground.	Scrutinise survey results for potential UXO and adjust the route and burial plans as necessary. Surface lay the cable through the Beaufort's Dyke Dumping Ground.	Medium
PROTECTED AREAS	MPA KEY FACTOR	IMPACT	MITIGATION	RISK LEVEL
	Protected Areas	Protected areas can cause significant delay to a project by extending permitting timelines and may introduce additional requirements, such as such as an Environmental Impact Assessment (EIA) for the cable. Where possible, the proposed cable routes have avoided protected areas however some have unavoidably been crossed.	Where possible, the proposed cable routes have avoided protected areas however some have unavoidably been crossed. Any mitigation conditions issued as conditions of the marine licencing should be followed to ensure that any impact is reduced as much as possible.	Low
	Protected Species	The cable will be low impact with some transient noise and disturbance during survey and installation, both of which are common in this region. The low surface area and benign nature of a subsea cable system will have little impact on the local benthic community.		
OPERATIONAL REVIEW	OPERATIONAL PHASE	HAZARD	MITIGATION	RISK LEVEL
	Survey	The survey specification is too generic and does not address the specific requirements of the project.	Reference Section 11.1.13 when designing the survey scope.	Low
		Poor weather prolongs the survey and affects survey quality.	Plan the survey between the beginning of April and the end of September to take advantage of better weather periods.	Low
	Installation	Poor weather prolongs the installation and affects the quality of the installation and therefore security of the cable.	Plan operations between the beginning of April and the end of September to take advantage of better weather periods	Low
		PLSEs are delayed, holding up the main installation.	Install PLSEs before main lay operations.	Medium
	Maintenance	Soon after the system comes into service a fault occurs and the system does not have a maintenance solution, causing an extended outage.	Provide for maintenance of the SFT cable system by joining a cable maintenance zone agreement such as ACMA or negotiating a private agreement with a cableship operator.	Low

2.0 INTRODUCTION

2.1 Project Overview

Global Marine have been commissioned by Scottish Futures Trust to undertake a Desk Top Study (DTS) for proposed subsea fibre optic links between the north and west coasts of Scotland and:

- A transatlantic cable in the Rockall Trough
- Dublin, Ireland
- The Isle of Man

Mitigation of potential faults is the primary aim of the route engineering carried out; ensuring that cable security is optimised and robustly engineered. This process also includes a consideration of potential installation methods and applicable risk mitigation measures to produce a series of recommendations.

Table 1 shows the coordinates of the landing points at Irvine and Port William which were identified as the optimum landing points in Scotland by this study.

LOCATION	COORDINATES	
	LATITUDE	LONGITUDE
Irvine BMH	55°36.176’N	004°41.6172’W
Port William BMH	54°46.0336’N	004°35.1973’W

Table 1: Beach Manhole and BU Locations

2.2 Objective

The aim of this DTS is to engineer the optimum cable route to link the landing points detailed in Table 1 with their designated international connection points. To achieve this, the impact of environmental and anthropogenic factors on the cable routeing, engineering, installation and maintenance are studied in Sections 5.0 to 9.0 as follows:

- Geology
- Metocean: Sea Ice, Oceanography and Meteorology
- Fishing & Other Anthropogenic Hazards (shipping, other cable routes, oil exploration etc.)
- Protected Areas
- Permitting

Each section identifies the issues and the impact on the SFT cable’s integrity and perceived risks, providing a summary of the key drivers at each stage. The knowledge gained from this information will feed into Section 10.0 addressing routeing and engineering considerations. This section describes the routes and LPs that comprise the final RPLs, the cable specification to be used, any faults on similar systems and risk mitigation measures. Section 11.0 covers recommendations for survey, installation and maintenance.

A final conclusion draws together the data from each section and provides an overview of the rationale for the recommendations made. All additional data such as the detailed site visit information, charts, websites visited, references and contact details are included in Appendices.

2.3 Deliverables and Timelines

DELIVERABLE	DUE DATE
Complete Site Visits	22/10/2018
Draft Issue DTS, RPLs and charts	01/11/2018
Final Issue DTS, RPLs and charts	15/11/2018

Table 2: Deliverables

3.0 DATACENTRE CONNECTION

3.1 Introduction

The intention of the new cable system which SFT are supporting the development of is to increase Scotland's international data connectivity. The primary aim is to develop Scotland's datacentre hosting capacity, as well as increase capacity for other users in digital industries.

3.2 Identified Datacentres

The Scottish Futures Trust has previously commissioned CBRE to identify the top sites with potential for new datacentre construction in Scotland (Scottish Futures Trust, 2018). The top five sites identified by this study were:

- Eurocentral (Mossend, North Lanarkshire)
- North Canal Bank Street (Glasgow)
- Gartcosh Business Interchange (Glasgow)
- i3, Irvine Enterprise Area (Irvine, North Ayrshire)
- Oracle Facility, Blackness Road (Linlithgow, West Lothian)

Two additional sites with high potential were also identified in Rosyth, Fife and three existing datacentres are located in eastern areas of Scotland.

3.3 Terrestrial Connection

Over short distances of up to a few kilometres the Cable Landing Station (CLS) can be connected to a datacentre by a dedicated fibre optic link. At longer distances than this a connection via a third party network would likely be required in order for the system to be economically viable. This option would increase the ongoing costs of the system and reduce its financial attractiveness.

In most of Scotland, as for the rest of the UK, the only significant existing network of fibre optic cables is owned and operated by Openreach, part of BT plc. Openreach would need to be approached about onward connection from the cable landing point. As part of the study Commsworld were approached as a potential other supplier of onward connectivity. On discussion, it was found that they would also be relying on BT's existing network, although utilising dedicated wavelengths. A cable owner may want to investigate this option either to operate themselves or through a third party such as Commsworld.

3.4 System Design Effects

This study was commissioned to identify potential landing points (LPs) for international fibre optic cables on the western and northern coasts of Scotland. For this reason the potential datacentre sites in Mossend, Glasgow and Irvine were given most weight when determining potential LPs. Datacentres on the eastern side of Scotland are sufficiently distant that the choice of LP in the west makes much less difference to the terrestrial connection distance.

This fact leads to a preference for landings located in North or South Ayrshire. Irvine was identified at an early stage as a preferred landing due both to the fact that the town hosts a potential datacentre itself and because it is located relatively close to Glasgow, facilitating short onward connection distances. A landing in Glasgow itself was not assessed to be practical given the difficulties of routeing a cable up the Firth of Clyde and the dangers to a cable from high vessel traffic and anchoring activity following installation.

For potential LPs away from the datacentres identified by SFT, proximity to an existing BT exchange was used as a guide to the ease of onward connectivity (SamKnows, 2018).

4.0 INITIAL LANDING POINT SELECTION

4.1 Introduction

The initial stage of route planning is to identify potential landings for the cables to narrow down the area of the seabed under consideration and allow the DTS to focus only on the factors which are salient.

This report concentrates on identifying potential landings in Scotland. Therefore a longlist of potential Scottish LPs has been created. For the other ends of the cable system only a single potential LP has been identified for each system option. This is the most likely LP location based on Global Marine's experience but may be subject to change based on future studies and commercial considerations.

The landings in Scotland were further investigated during the site visit, details of which are included in the report in Appendix 13.2.

4.2 Transatlantic Connection

The first option for system design is to connect to a transatlantic cable passing through Scottish waters. This would be done via a branching unit (BU) in the transatlantic cable that allowed a branch to be laid to Scotland from the main trunk.

The transatlantic cable that has been used as a base case for this system option is the Havfrue system from New Jersey in the USA to Denmark and Norway. The main trunk cable passes north of Scotland. A BU on this cable has been suggested at:

56°29.7267'N, 011°30.6514'W

This has been used to determine the non-Scottish end of the cable in this study.

4.3 Republic of Ireland

Guidance from SFT indicated that the landing in Ireland should be near to or within the Dublin metropolitan area. With this in mind Portmarnock has been selected as the nominal LP. This location is already the landing point of the Sirius South and Emerald Bridge One cables to Blackpool and Holyhead, respectively. By landing just to the north of these cables the new cable to Scotland avoids tricky shallow water crossings and establishes onward connectivity. The beach is sandy and benign for a cable landing.

4.4 Isle of Man

A key consideration with the landing on the Isle of Man (IoM) is onward connectivity to other locations. Another is the amount of terrestrial works required. For these reasons the existing or planned fibre optic cable landings on the Isle of Man, of which there are five, have been assumed to be the most likely landing points and have been reviewed (Table 3).

Three are on the south-eastern coast of the island at Douglas, Port Groundle and Port Grenough. The fourth is at Peel on the northwest coast. The final LP is a planned landing of the Celtix Connect 2 cable at Port Erin on the southwestern end of the island. The landing points have previously been visited by Global Marine (Figure 2).

Figure 2: Clockwise from Top Left: Douglas, Port Groundle, Port Grenough, Port Erin, Peel (Global Marine)

LANDING	OTHER CABLES
Douglas	IOM Interconnector
Port Groundle	BT-MT
Port Grenough	LANIS Seg A, Celtix Connect 2 (*Planned*)
Port Erin	Celtix Connect 2 (*Planned*)
Peel	LANIS Seg B, IOM-NI

Table 3: IoM Shared Landings

Of these landings, there is space to land a new cable at Port Groundle, Port Grenough, Port Erin and Peel. Peel has been selected as the nominal LP for a direct link from mainland Scotland for a number of reasons:

- Peel's position on the north-western coast significantly reduces the required length of the submarine fibre optic cable to Scotland.
- The beach and bay are sandy, allowing good cable burial.
- The LP is shared with two other cables (LANIS and IOM-NI to Northern Ireland) rather than the single cable at all the other landing points, which creates extra redundancy for onward traffic.
- A cable route to the north of the island reduces the length of cable within scallop fishing and trawling grounds both of which are a significant hazard to submarine cables.
- The northern coast of the island has significantly less rock outcrop than the south, reducing the risk to the cable from poor burial and chafing.

A branching unit has also been inserted on the Scotland – Ireland link west of the Isle of Man. The position of the BU has been designed to allow the optimum connection to any of the IoM landings. The preferred landing is likely to be at Port Erin as this is the closest to the BU position and the landing of the planned Celtix Connect 2 cable here would facilitate onward connectivity to both Ireland and England.

4.5 Scotland

4.5.1 Dunnet Bay, Caithness

Dunnet Bay was selected as a potential LP for a branch from a transatlantic system as the most northerly viable LP on the Scottish mainland. It is the current landing of four cables – the Northern Lights fibre optic cable and Pentland Firth 1 & 2 power cables to Orkney and the Farice fibre optic cable to the Faroe Islands and Iceland.

The bay itself is wide and sandy (Figure 3). Landing a cable would be relatively straightforward, although crossings of the other cables would be inevitable offshore.

Terrestrially the landing is not close to any of the datacentres identified by SFT, which are concentrated in the south of Scotland particularly around Glasgow (Scottish Futures Trust, 2018). Connection to these centres would require either a large and expensive buildout of fibre or piggybacking on Openreach's terrestrial network, reducing the commercial attractiveness of the system (Section 3.0).

Figure 3: Dunnet Bay (Google Earth, 2018)

4.5.2 Ullapool, Ross and Cromarty

The design of the Havfrue transatlantic cable system originally had a branching unit located east of Rosemary Bank Seamount, 160km offshore of Stornoway. Ullapool is the closest significant mainland settlement to this point. It could therefore be expected to have the shortest cable route and thus minimum cost to connect to Havfrue. As part of this study it was suggested to Bulk and TE SubCom that the BU could be positioned further south to the position in Section 4.2 which would open up additional landings.

Similar to Dunnet Bay, Ullapool is less practical from a terrestrial perspective. It is almost as far from the Central Belt datacentre sites as Dunnet Bay. Connection to these centres would require either a large and expensive buildout of fibre or piggybacking on Openreach's terrestrial network, reducing the commercial attractiveness of the system.

4.5.3 Muasdale, Kintyre

A landing on the Kintyre peninsula was investigated as a way of designing a cable route that linked to the Central Belt datacentres, particularly around Glasgow and Irvine, from a transatlantic cable with a minimum new route length and without passing through the high-traffic and potentially rocky area south of Kintyre. Muasdale was chosen as the potential LP as it is the existing landing of one of BT's Highlands & Islands cable segments, with a link to Islay. From here there is a relatively direct link via the Highlands & Islands network via Arran to Portencross, 17km north of Irvine.

The disadvantage of this landing is similar to Dunnet Bay and Ullapool in the reliance upon Openreach/BT's existing fibre infrastructure. This downside is expected to outweigh the putative advantages of avoiding the marine area south of Kintyre and a shorter length of installed cable. This is especially the case because despite the potentially hazardous area, the seas around Kintyre and the Firth of Clyde have experienced very few cable faults to date.

4.5.4 Irvine, North Ayrshire

Irvine has been chosen as the preferred landing for both a transatlantic link and a cable to the Republic of Ireland. It is close to both the Irvine and Glasgow datacentres identified by SFT (Scottish Futures Trust, 2018). It also has good onward links to Northern Ireland via the LANIS and Sirius North cables which land nearby.

4.5.5 Girvan, South Ayrshire

Girvan was selected as a potential alternative to Irvine. It is the current landing point of the Scot-NI 2 cable owned by BT. Onwards terrestrial connection to datacentres would still rely upon Openreach/BT's existing fibre infrastructure. This makes the landing less optimal than Irvine.

4.5.6 Portpatrick, Dumfries and Galloway

Portpatrick was chosen for further investigation as it is the existing landing of BT's Scot-NI 1 fibre optic cable to Northern Ireland and would have a relatively short marine route to Ireland and the Isle of Man. The Beaufort's Dyke munitions dumping ground is located offshore but this is not expected to be a major hazard for a fibre optic cable (Section 7.5.1).

Once again onwards terrestrial connection to datacentres from Portpatrick would rely upon Openreach/BT's existing fibre infrastructure.

4.5.7 Port William, Dumfries and Galloway

A landing point at Port William would offer the shortest distance for a direct link to the Isle of Man of all potential landing points identified during this study. It is located on the eastern shore of Luce Bay which is very sheltered. Port William is the most southerly town of reasonable size on this coast. Further east towards Dumfries the coast becomes rockier and less suitable for landing a cable. The waters in the Solway Firth and Wigtown Bay are too shallow for straightforward cable installation.

Onwards terrestrial connection to likely datacentre sites from Port William would again rely upon Openreach/BT's existing fibre infrastructure.

5.0 GEOPHYSICAL INFLUENCES

5.1 Introduction

Understanding the marine geology and geomorphology is a fundamental aspect of cable system design. A review of the region provides a preliminary assessment of the likely hazards and burial conditions that will be encountered. This enables optimal routeing of the cable, avoiding regions where cable security could be compromised by factors such as sediment slumping and turbidity flows or where burial could be difficult.

A detailed survey of the route then enables further modifications based on an exact view of the shallow geology and cable burial conditions along the individual segments. Sediment type, thickness, distribution and strength can only be confirmed in detail during the geophysical and geotechnical route survey.

Section describes the regional geology and geomorphology. Specific factors affecting the cable route design, engineering and landing point selection are discussed in Section 10.7, with direct reference to the cable sections affected by factors including:

- Seismic activity and related hazards such as tsunami and turbidity flows.
- Mass wasting causing sediment movement and slumping.
- Sediment transport due to storms and strong currents.
- Subcropping and outcropping rock on the seabed.

5.2 Geology and Geomorphology of the Region

The geology of the area of interest with relation to the new cable system is split into two main regions. These are the Hebridean region of the west coast of Scotland in the north and the Irish Sea region to the south. Between the two is the North Channel that separates Scotland from Northern Ireland.

The Hebrides area is rugged with highly variable topography and bathymetry. The crustal structure underlying the region is complex, having largely attained its present form during the Caledonian orogeny (mountain-building episode) as the Iapetus Ocean closed during the Ordovician to Early Devonian period (see Figure 4 for a geological timescale). There are a very large number of significant geological faults throughout the region resulting from this history (Figure 5). Rifting associated with the opening of the North Atlantic created many large basins in the Permo-Triassic and throughout the Mesozoic. By the late Cretaceous much of the area was already below sea level (BGS, 1993). The area was uplifted in the Palaeocene and early Eocene by processes related to the opening of the Atlantic and the Alpine orogeny in southern Europe. Volcanism was common at this time. The region was relatively quiescent through the rest of the Cenozoic era, with changes in elevation and sea level largely due to glaciation.

Sediments from the Quaternary Period can exceed 300m in basins eroded by glacial action on the shelf, particularly north and south of Tiree. Further offshore, thicknesses can exceed 800m on the flanks of the Rockall Trough. Basins are often separated by outcropping rock ridges.

The Irish Sea is a continental shelf sea lying between the islands of Great Britain and Ireland. It is semi-enclosed, with connections to the Atlantic Ocean through the North Channel to the north and St Georges Channel to the south. The underlying crust also mostly reached its present form during the Caledonian orogeny. During the Devonian the area was exposed on land and accumulated deposits of Old Red Sandstone, which outcrop today on Anglesey and the Isle of Man. Basin subsidence and deposition of sedimentary rocks continued through the Carboniferous, Permian and Triassic. A map of major basins and other structural features is shown in Figure 6. The opening of the Atlantic Ocean in the early Cenozoic Era triggered widespread igneous activity and volcanism. From the Oligocene onwards the sea has been dominated by erosion and the uplift of an arch running from the Rhins of Galloway through the Isle of Man and Anglesey (Figure 6). Deposition has mostly occurred in the two basins in the western and eastern Irish Sea on either side of this arch.

Quaternary sedimentary infill reaches up to 300m thickness in the Irish Sea although they do not completely cover the area and older rocks and sediments are also exposed (Figure 7). These sediments record several phases of deposition and erosion, largely corresponding to the repeated glaciations of the period. Pleistocene age glacial tills composed of very stiff clays with intermixed rock and boulders (diamicton) are common and often infill eroded glacial valleys and kettle holes. Holocene sediments are largely sandy and composed of coastal, intertidal and marine members recording the development of the modern Irish Sea. At their top, these sediments grade into the modern seafloor.

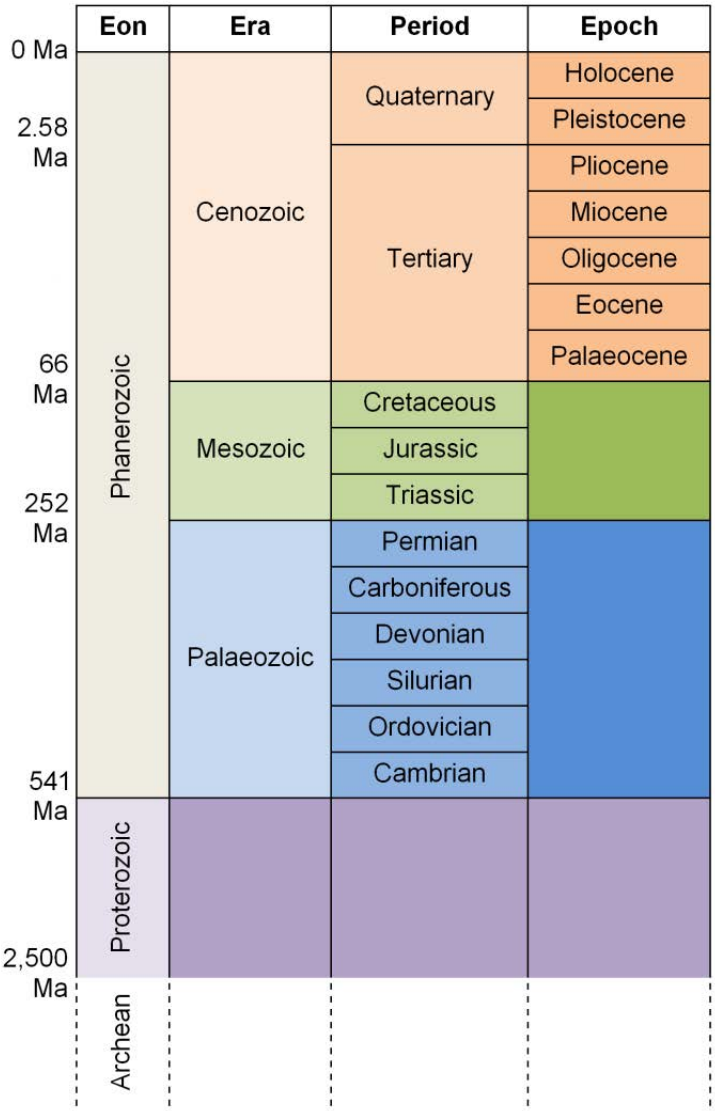

Figure 4: Geological Timescale

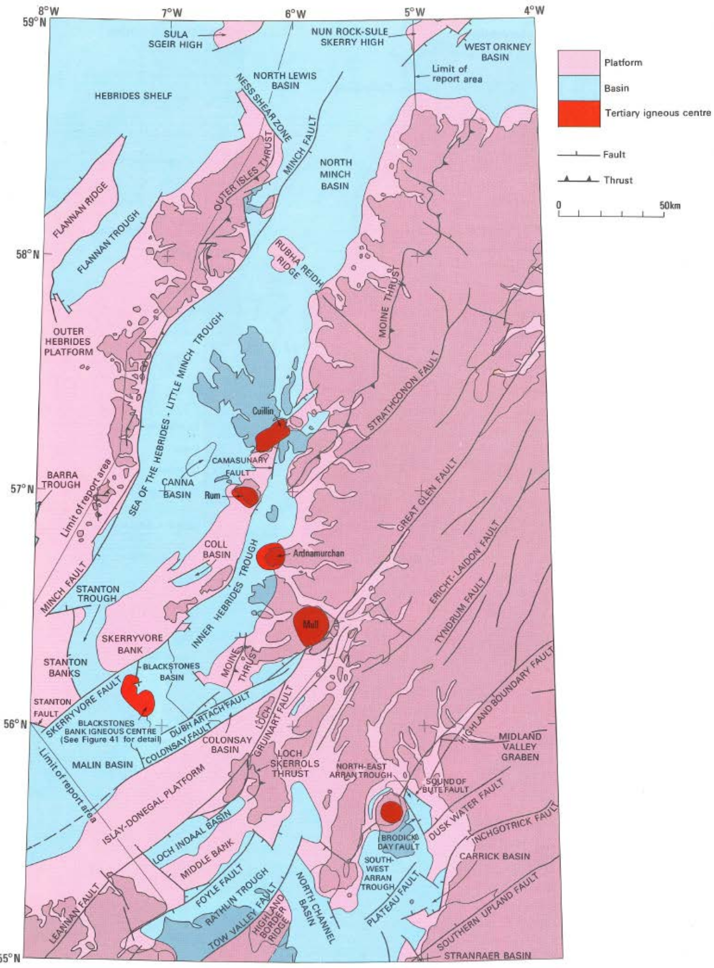

Figure 5: Major Structural Features of the Hebrides (BGS, 1993)

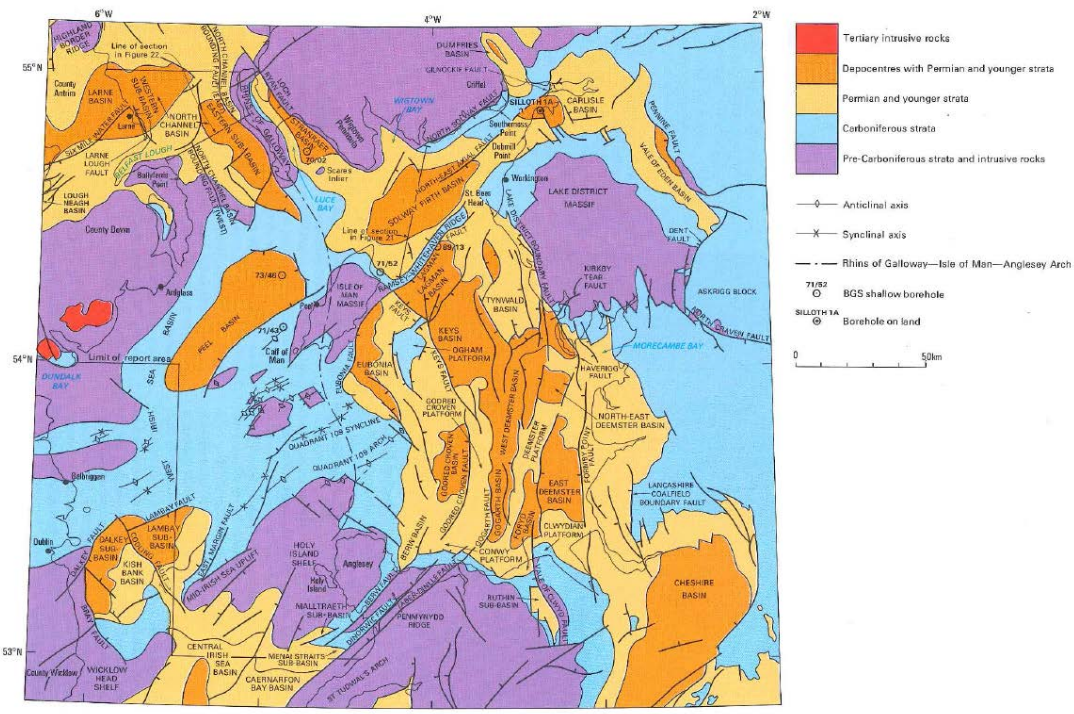

Figure 6: Major Structural Features of the Irish Sea (BGS, 1995)

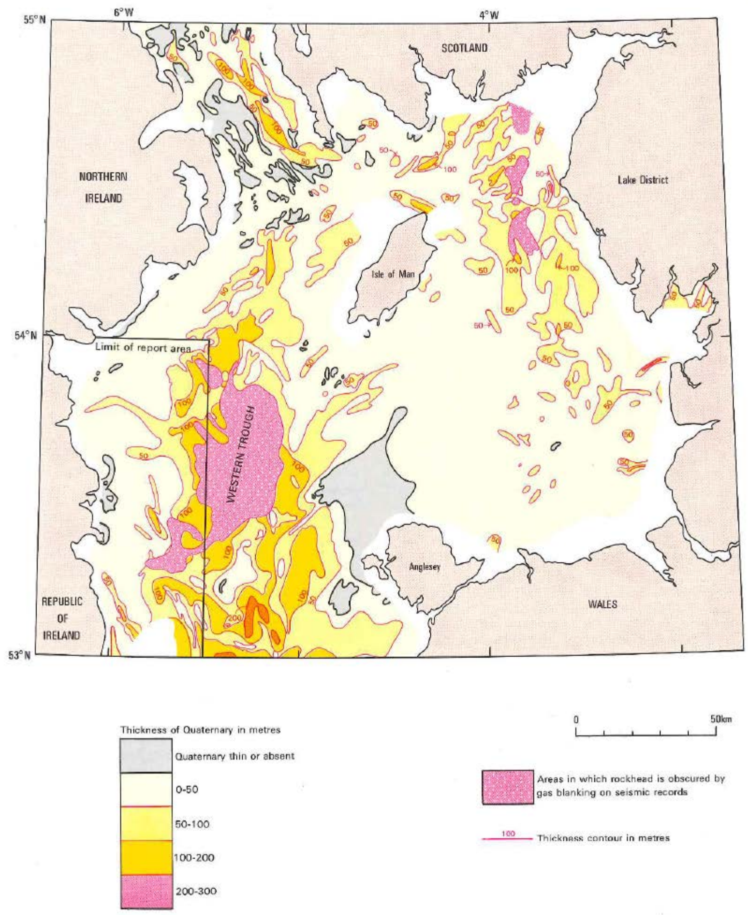

Figure 7: Quaternary Thickness in the Irish Sea (BGS, 1995)

5.3 Shallow Geology and Seabed Sediments

5.3.1 Seabed Sediment Distribution

An important aspect of cable route design, engineering and future security is the shallow geological conditions along the route including the soil properties, relative strength and thickness which all influence the depth to which the cable can be buried and the effectiveness of burial as a protection mechanism.

The pattern of seabed sedimentation and bottom morphology in the area is influenced by a complex interplay of regional seismic activity, glacial advances and retreats, oceanic and tidal currents, waves, storms, sea level changes, and gravity-driven processes.

The best source of information discovered showing sediments in the area is the 1:250,000 series of maps compiled by the BGS (Figure 8). Within the Firth of Clyde and the western Irish Sea the sediments are largely sandy and muddy. This suggests that good burial can be achieved and the abrasion risk to the cable is minimal in these areas. The Scotland – IoM link lies entirely on more gravelly seabed, as does the central part of the Scotland – Ireland cable in the North Channel and the western part of the Transatlantic Connection route. Where the Transatlantic Connection cable exits the area of the BGS data to the west EMODnet seabed data has been consulted instead and confirms that similar seabed persists to the continental shelf break, becoming muddy in the deeper waters of the Rockall Trough. Gravelly sediments are more challenging for burial than sands and muds both because of the larger sediment grain size and because in this region they often represent a lag deposit over hard glacial till. This may lead to reduced burial in some areas and should be investigated as part of the marine survey (Section 11.1).

Because the Rockall Trough is located close to land and mass wasting events may have carried relatively coarse sediments and rock fragments into the trough, there remains a slight risk of abrasion for an unprotected cable in this location.

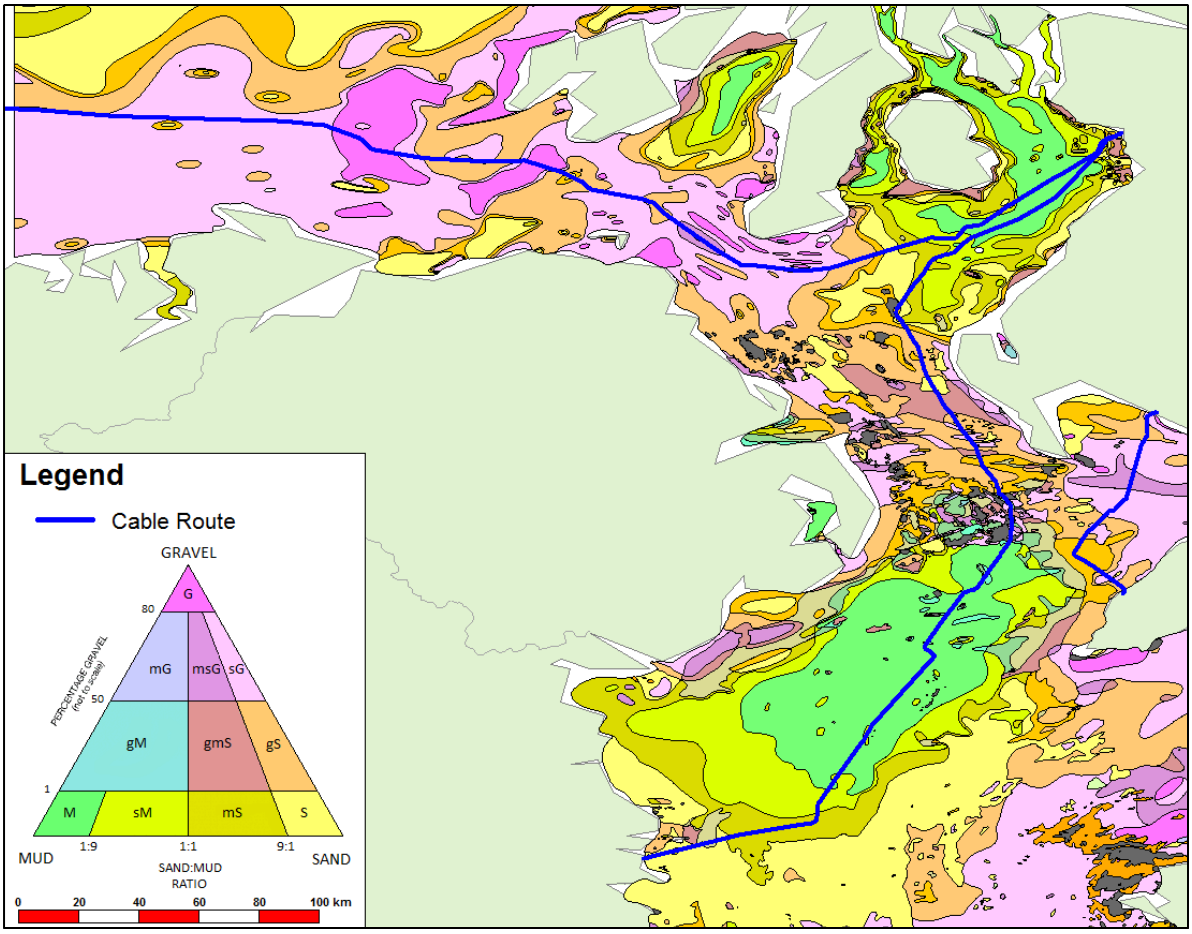

Figure 8: Western Scotland & Irish Sea Sediments (BGS, 2018)

One of the primary purposes of the pre-installation route survey is to provide detailed data on the sediment types and their distribution for the entire route. Using Side Scan Sonar (SSS), sub-bottom seismic profiling techniques and geotechnical sampling the survey should determine and map the various sediment types, their strengths and their thickness (vertical extent below seabed). Using these data an assessment of cable burial potential can be made.

5.4 Bathymetric and Geological Risks to Cable Security that Impact on the Route

There are numerous features, events and processes that could give rise to hazards affecting the security of both the submarine cable and also any associated landing site installations, such as terminal stations. The following sections give a brief description of geohazards affecting the cable route segments.

5.4.1 Sediment Transport

Sediment transport features, or bedforms, such as sandwaves are created by the movement of sediments in the local current. Bedforms can have a different effect on the cable route and installation depending on their size and nature, a summary of which is given in Table 4. Very large bedforms such as sandbanks are usually relatively stable and rarely have steep faces, allowing the cable to simply be installed over them. Others, such as ripples, are too small to affect the cable route or installation. Medium-scale bedforms represent a greater threat than either of these.

NAME	RELIEF	WAVELENGTH	LENGTH
Ripples	Typically less than 100mm	Function of grain size and bottom orbital velocity.	May be continuous or form a complex network.
Megaripples	0.4m to 1.5m	0.6m to 30m	Tens to hundreds of metres.
Sandwaves	1.5m to 25m	Typically 30m to 500m but 1km or more is possible.	Hundreds of metres to tens of kilometres.
Sandbanks	5m to 50m	Single distinct feature or a series.	Many tens of kilometres.

Table 4: Nomenclature for Bedforms (Gass & Team, 1984)

Because of the localised steep gradients in areas that host bedforms, the stability of a plough or ROV may be at risk. The bedforms can also reduce the burial depth that can be achieved using a cable plough, as shown in the diagram below. Cables may even be pulled entirely out of the seabed as the cable plough crosses the ridge of the bedform (Allan, 2000). If areas with dense fields of bedforms are discovered during the cable route survey they should be avoided or the burial solution adapted to compensate. Options for burial are discussed further in Section 10.6.2.

As some bedforms actively move, usually within fairly defined fields, even if full burial is achieved the cable can later become exposed and suspended between them. This will happen if the amplitude of the bedforms is greater than the depth of burial of the cable. Whether a particular bedform is active is usually indicated by an asymmetrical cross-section in survey data.

In order to mitigate the effect of bedforms on the system, it is recommended that all areas with significant bedforms are identified and recorded during the marine survey, along with their slopes and heights. The cable should then ideally be installed in the bottom of a trough parallel to the crests of the waves. In this manner, the cable will not be unearthed by the movement of the bedforms during its lifetime. If this routeing is impossible due to other considerations then the sandwave field should be crossed at right angles to the wave crests, minimising the risk to the burial equipment from side slopes and maximising burial.

Bedforms usually only form in shallow water and are due to the effect of storms, tides and other events that generate significant currents. An analysis of the bathymetry along the SFT routes alongside satellite imagery near to the landing points indicates that no large-scale bedforms exist nearby. If significant fields of smaller bedforms are discovered during the marine survey then appropriate measures should be taken to mitigate the risk as outlined in this section.

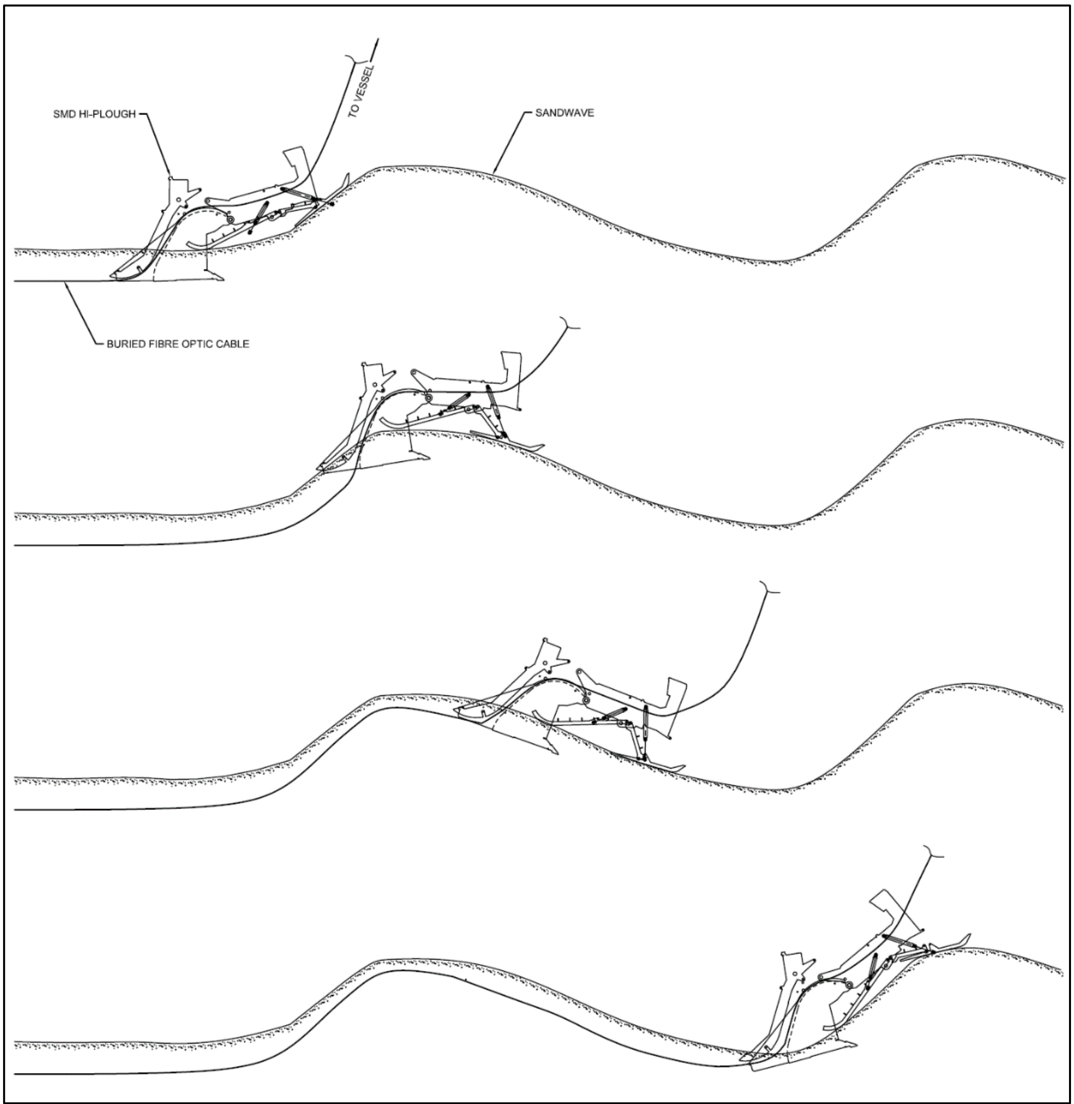

Figure 9: Interaction of a Cable Plough with Megaripples

5.4.2 Rock Outcropping

Rock outcrops are a potential risk to the cable's security due to:

- Abrasion.
- Suspension.
- Exposure.

Suspensions and exposure on the seabed also increase the risk of damage from fishing gear and anchor damage, as well as chafing on the rock itself. Rock outcrops are most likely to occur inshore on approaches to landing sites and on relatively steep gradients.

Cemented sediments, where the sediment grains have become stuck together by geological or biological processes, can form areas of hardground which pose a similar threat. Cemented sediments are additionally occasionally difficult to identify during the marine survey as they retain their internal layers and only direct investigation by geotechnical techniques such as cores or CPTs may reveal the cementation.

Rock outcrops are known to occur close to the cable landings in Irvine, Port William and Portmarnock. There may also be limited outcrops in the nearshore area at Peel. The highest risk offshore occurs along the route of the Transatlantic Connection cable, particularly where the cable crosses two significant rock ridges that extend southwest from Islay towards Ireland.

Only survey data will reveal the precise extent of the risk and allow the route to be adjusted to reduce and eliminate the risk.

5.4.3 Earthquakes

Earthquakes are the principal mechanism for triggering mass movements of sediment, notably on steep submarine slopes, and the forces involved in these events are a threat to cables crossing these areas. Earthquakes can also cause faulting and displacement of adjacent crust, posing a threat to both the submarine cable and land installations. Tsunami can also result from seismic activity, further increasing the risk to shore installations.

The USGS online earthquake database records 50 earthquakes with a magnitude greater than 2.5 (the minimum to be felt by humans) in and around the Irish Sea and western coast of Scotland since 1970. The area searched was defined by a box from 53°N to 60°N and 3°W to 12°W. The most powerful earthquake to occur was a magnitude 4.3 event on 10/08/1974. As this is below the usual threshold to cause damage to structures the direct risk to the new cable from seismic activity is assessed to be negligible.

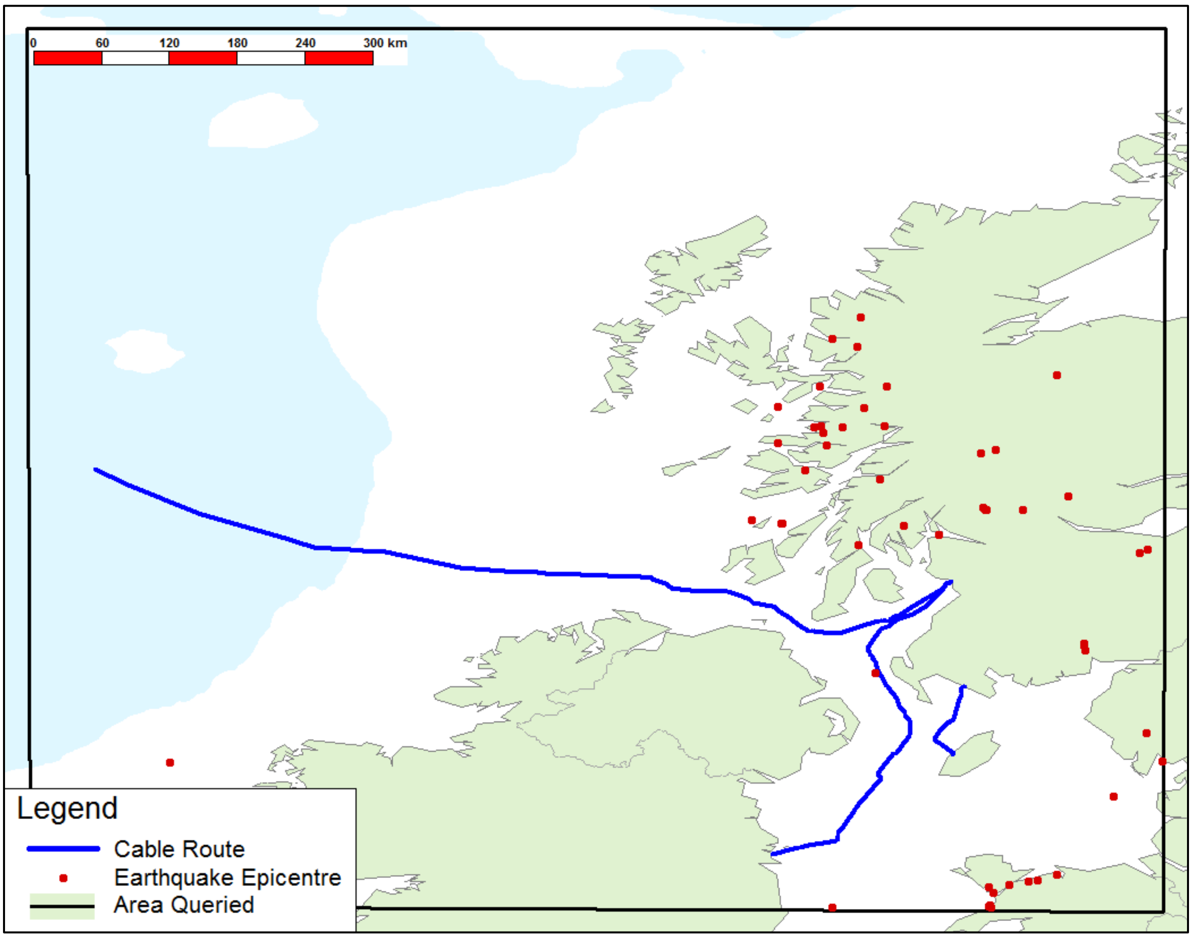

Figure 10: Earthquake Locations (United States Geological Survey, 2018)

5.4.4 Mass Wasting, Sediment Slumping and Turbidity Currents

Cable segments from Scotland to deep water in the Rockall Trough cross steep slopes and could be at risk from mass wasting processes where large volumes of sediment are transported downslope into the deeper sea areas.

Mass-movement redeposition of sediment on a slope occurs when the forces resisting movement are overcome by the force of the combined shearing stresses applied causing slope failure. The type of mass-movement that occurs following slope failure involves a spectrum of mechanical behaviour ranging from rigid block motion to viscous flow. This includes rockfall, creep, slides, slumps and sediment gravity flows such as debris flows, grain flows, liquidised/fluidised flows and turbidity currents.

Slope failure probably occurs as a result of one, or a combination, of the following factors:

- Tectonics / earthquakes.
- Overloading.
- Erosion on the slope with exposure at the seafloor of over-consolidated sediments.
- In situ changes in the internal pore pressures related to gas generation etc.

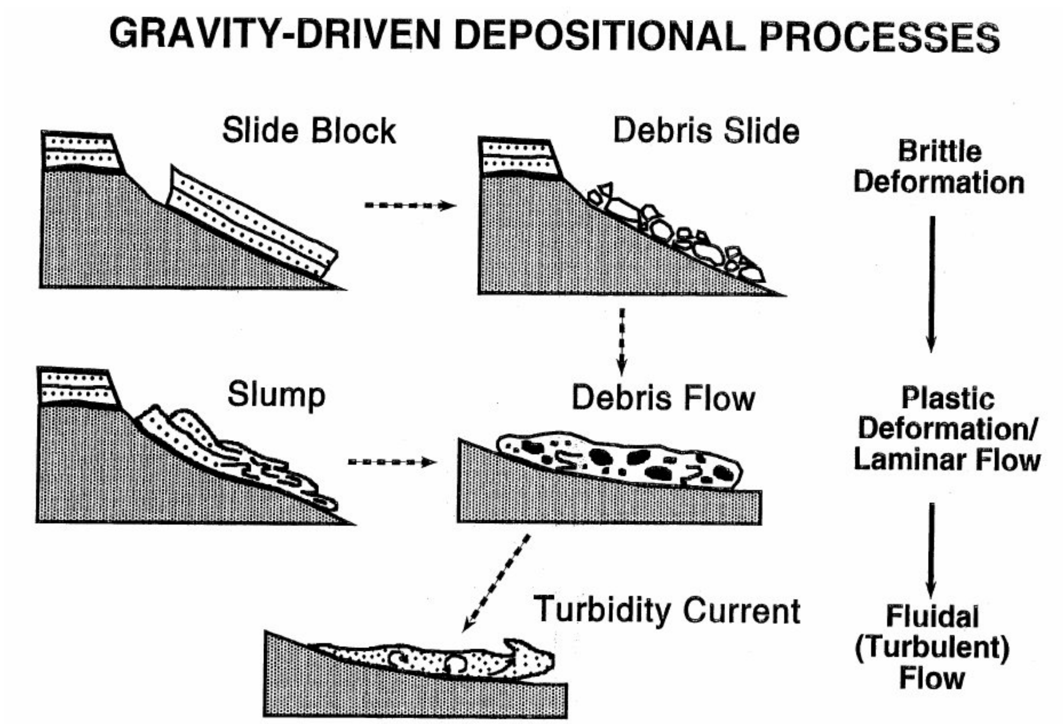

Figure 11: Mass-movement Processes

To minimise this risk the cable has been routed to avoid slopes where possible and economic. Where this has not been possible it has been engineered to approach the slopes at close to a perpendicular angle. By routeing straight up and down the slope the cable minimises the cross section exposed to sediment movement and presents its long axis to any sediment movement that does take place, maximising the tensile strength of the cable and minimises the risk of a fault.

5.4.5 Submarine Canyons

Canyons are rare on the continental shelf and will not affect links from Scotland to the Isle of Man or Ireland. Canyons do occur on the flanks of the Rockall Trough. The largest examples are west of the island of Ireland and have been avoided by the cable route but smaller canyons are expected to be crossed by the transatlantic system link.

Submarine canyons are features that are subject to sediment transport, incision and slope instability. Mass wasting can occur within them and the canyons can act as funnels for other mass wasting events further upslope. Laboratory studies and direct observations of the processes occurring on the ocean floors have shown that turbidity currents are extremely effective agents for both the erosion and transport of sedimentary materials. In fact, turbidite deposited sediments have been found on the ocean floors far from their origin on the continental slopes. As far as the erosional effect of these currents is concerned, it can be noted that, just as rivers erode valleys on the continents, turbidity currents cut submarine canyons similar to those in Figure 12 through the continental margins and slopes.

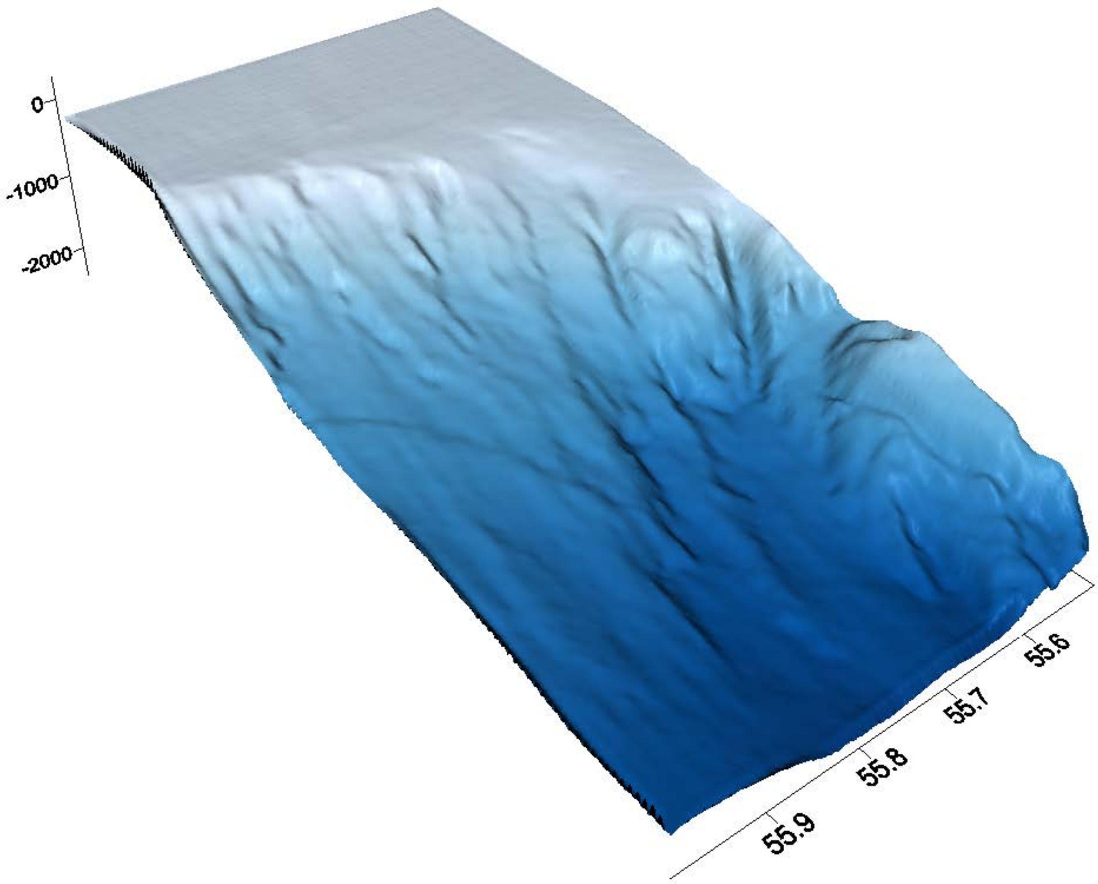

Figure 12: Submarine Canyons on the Donegal Fan (GEBCO, 2014)

5.4.6 Tsunamis

Tsunami is a Japanese word meaning harbour wave. It is a water wave or a series of waves generated by an impulsive vertical displacement of the surface of the ocean. Other terms for tsunami include: seismic sea wave, *flutwellen*, *vloedgolven*, *raz de mare*, *vagues sismique*, *maremoto* and tidal wave.

Most tsunamis are caused by a rapid vertical movement along a break in the Earth's crust (i.e., their origin is tectonic). A tsunami is generated when a large mass of earth on the bottom of the ocean drops or rises, generating an earthquake and displacing the column of water directly above it. This type of displacement commonly occurs in large subduction zones, where the collision of two tectonic plates causes the oceanic plate to dip beneath the continental plate to form deep ocean trenches.

Volcanoes can generate significant tsunamis as a result of the initial blast and subsequent collapse, usually of the caldera. Roughly one quarter of the deaths occurring during volcanic eruptions where a tsunami was generated, were the results of the tsunami rather than the volcano. This may be greater, such as in the 1883 eruption of Krakatau in Indonesia in which tsunamis killed the majority of the 36,000 victims.

Other possible, but less common or efficient methods of tsunami generation include:

› Strong oscillations of the bottom of the ocean, or transmission of energy to a column of water from a seismic impulse (e.g. a deep-focus earthquake that has no surface rupture).
› Transmission of energy from a horizontal seismic impulse to the water column through a vertical or inclined wall such as a bathymetric ridge.
› Strong turbidity currents.
› Both underwater and above-water explosions.
› Sub-aerial and submarine landslides.
› Meteorite impact.

Several mechanisms are commonly involved in the generation of a tsunami, for example vertical movement of the crust by a seismic impulse or an earthquake, and a submarine landslide.

Even over short distances along a coast, the heights of a tsunami wave will vary considerably. An important part of the risk assessment is to gain a clearer understanding of the effects of past tsunamis.

Studies of the available data suggest that the size of a tsunami is proportional to:

› The size and shape of the rupture zone.
› The rate of displacement and sense of motion of the ocean floor in the source (epicentral) area.
› The amount of displacement of the rupture zone and the depth of water in the source area.

Once the energy from an undersea disturbance has been transmitted to the column of water, the wave can propagate outward from the source at a speed of more than 1,000km per hour depending on the depth of the water.

Because the height of the long-period waves in the open ocean is commonly 1m or less and their wavelength is hundreds of kilometres, they pass unnoticed by observers in ships in the region. As bottom friction reduces the velocity of the waves, the height of each wave increases, causing the waves to pile up on shore, especially in the region of the earthquake source, producing a local tsunami. Some dramatic examples of such local tsunami include those generated by landslides or by volcanic eruptions, which have caused run-up heights of 30 to 50 metres in some coastal areas.

Run-up is the maximum height of the water observed above a reference sea level. If the energy produced by the generating disturbance is sufficiently large, such as that released by a major deformation of the crust in a trench area, the resulting tsunami wave may cross the open ocean and emerge as a destructive wave many thousands of kilometres from its source.

If the tsunami encounters a coastal scarp, the height of its waves increases. Because the long-period wave can bend around obstacles, the tsunami can enter bays and gulfs having the most intricate shapes. Experience has shown that wave heights increase in bays that narrow from the entrance to the head, but decrease in bays that have narrow entrances. Shores of islands protected by coral reefs commonly receive less energy than unprotected coastlines lying in the direct path of an approaching tsunami. Islands in a group may shadow one another reducing the tsunami effect. Small islands may experience reduced run-up as the tsunami waves may refract around them.

A tsunami wave may break on the beach, appear as flooding, or form a bore (a violent rush of water with an abrupt front) as it moves up a river or stream. When the trough of the wave first arrives, the water level drops rapidly. Where this occurs, the harbour or offshore area may be drained of its water, exposing sea life and the ocean bottom. This phenomenon may be the only warning to residents that a large tsunami is approaching.

Although there may be an interval of minutes, or perhaps an hour, between the arrivals of waves, the second, third, or later waves can be more destructive than the first, especially if residents return to their homes, believing the worst to be over.

Tsunamis are typically of no concern to the laid marine portion of a submarine cable system with the exception that tsunamis can, like earthquakes, act as a trigger mechanism for sediment slope failure. The avoidance of routeing the cable parallel to contours along slopes should therefore be considered wherever possible to avoid susceptibility to sediment flows.

A second consideration with regard to a tsunami is run-up. When the wave comes ashore, water inundates a low lying shore causing extensive flooding. The siting of terminal infrastructure should therefore consider locations on high ground or away from the coast.

Although very rare, tsunamis are thought to affect the area. O'Brien et al. (2013) catalogued extreme wave events on the island of Ireland (Figure 13). Most of these are thought to be extreme storm waves but several tsunamis, including the 1755 and 1761 Lisbon tsunamis (T3 in Figure 13), are recorded in the historical record. The NGDC Natural Hazards Database records an observation of the 1761 tsunami as far north as Belfast. A 1.5m run-up on the River Liffey in Dublin in 1767 may have been caused by a tsunami. Other authors report evidence for large tsunamis including transported boulders and sand sheets on Anglesey (Haslett, 2007).

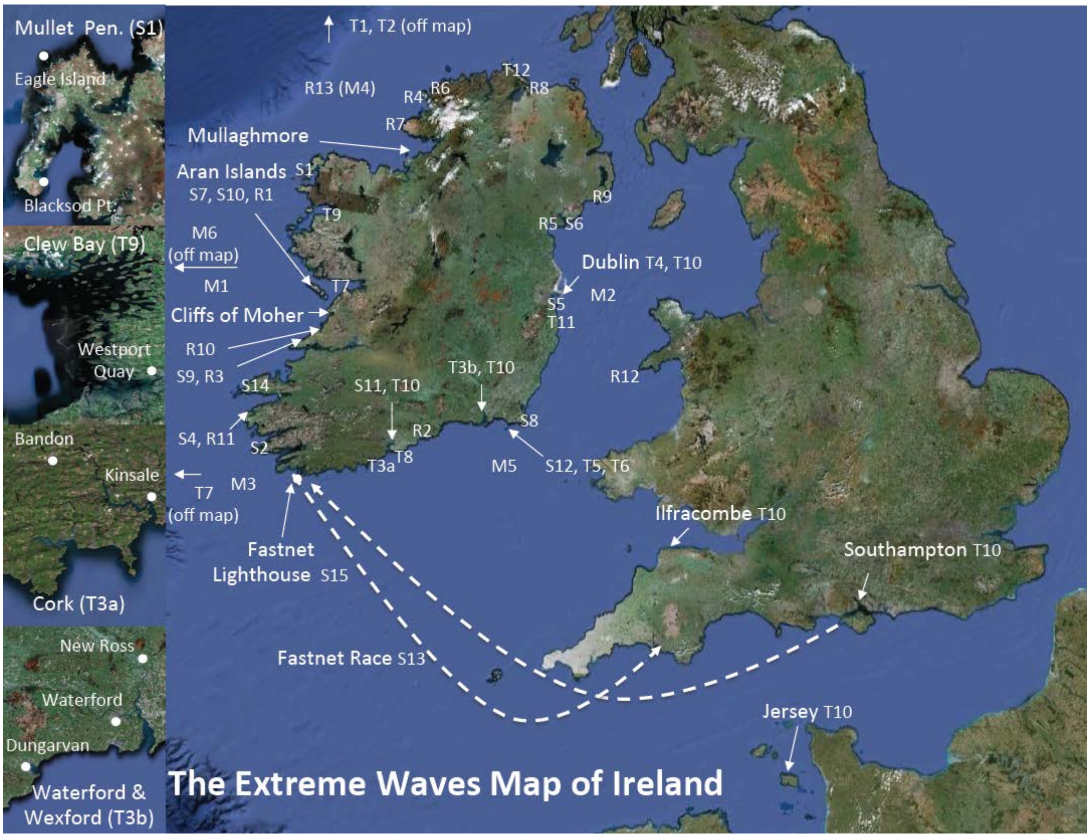

Figure 13: Extreme Waves Map of Ireland (O'Brien, et al., 2013)

Overall, the very low recurrence times for large tsunamis in the area means that the cable is very unlikely to be affected within its operational lifetime.

5.4.7 Pockmarks and Depressions

Pockmarks and depressions in the seabed may be found in areas with muddy sediments. They occur where the gas seeps to the surface of the seabed, possibly as a result of ground movement, and escapes. The seabed collapses and forms a pit, similar to that in Figure 14. The size of these features varies from shallow depressions to pits with diameters of hundreds of metres and up to tens of metres deep.

Pockmarks and their associated slope gradients are a potential hazard to cable burial tools such as a cable plough or tracked ROV. As well as the local steep slopes, pockmarks can also contain lithified sediments due to the effect of communities of microorganisms living off of the gas seep that created the pockmark.

Pockmarks can be detected by sonar and should be identified and the route modified to avoid them post survey, if present. If routeing around the pockmarks is impossible then cable burial should be undertaken with additional caution.

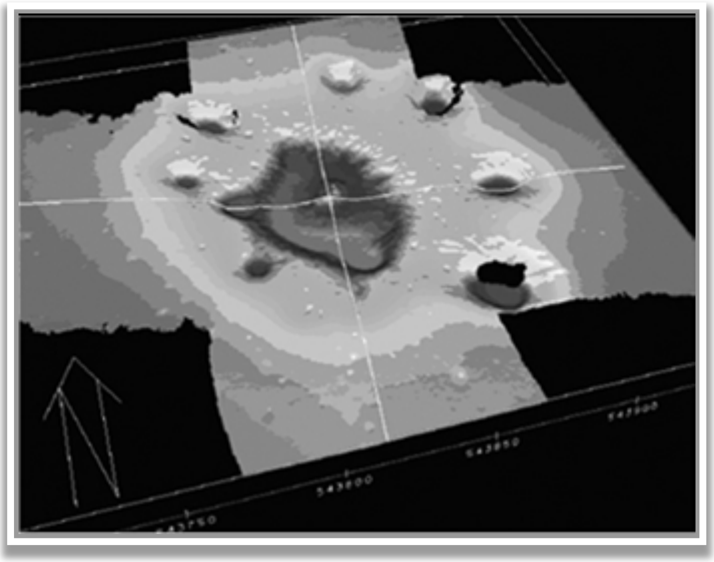

Figure 14: Sonar Image of Seafloor Pockmark and Satellite Pockmarks

Pockmarks are often associated with areas of oil and natural gas extraction such as the Irish Sea. The results of the marine survey should be scrutinised for pockmarks in areas of muddy sediment and where found they should be routed around if possible. If rerouteing is impractical then the cable burial and armouring options should be reviewed.

5.4.8 Gas Cemented Hardground

Existing telecommunications cable systems have encountered Gas Cemented Hardground (GCH) in active hydrocarbon basins. During the installation works ROV trenching tools experienced widespread resistance to excavation in areas of otherwise relatively soft silts and sands. This had a significant impact on the speed of burial operations and the depth of burial achieved.

Much of the GCH was not associated with pockmarks, unlike previous discoveries, and was found in a number of locations as a weakly cemented blanket layer. A number of different stages of GCH development were identified, each type having a differing impact on the trenching operations.

GCH is difficult to detect during survey and is typically only 0.2-0.4m below the seabed surface. Its characteristics vary from large areas of weakly cemented sediments covering over several hundred metres which did not prevent burial to much thicker 'slabs' of cemented sediment. Unfortunately no samples of the thicker cemented material were recovered so the hardness of this material is unknown.

GCH is relatively rare but several patches are known to exist in the Irish Sea. Use of CPTs and cores during the survey as described in Section 11.1 will increase the chance of detecting other patches of GCH prior to installation and it can then be avoided or planned for accordingly. GCH has been associated with gas hydrates (Section 5.4.9) at depth and may therefore be more likely in locations where a bottom-simulating reflector is seen in sub-bottom profiler data.

5.4.9 Gas Hydrates

Gas hydrates form in low-temperature, high-pressure conditions and can be found in many places around the world (Figure 15). They consist of molecules of a gas, usually methane, that become trapped in a lattice of water molecules forming a material appearing similar to ice. This methane is usually derived from the decomposition of living organisms and so most hydrates occur where there is a source of organic matter. Loose sediments such as sands are believed to host most hydrate deposits due to the available pore space between grains compared to finer sediments such as muds. Deposits may be homogenous, or may have the form of veins or nodules (Long, et al., 2009).

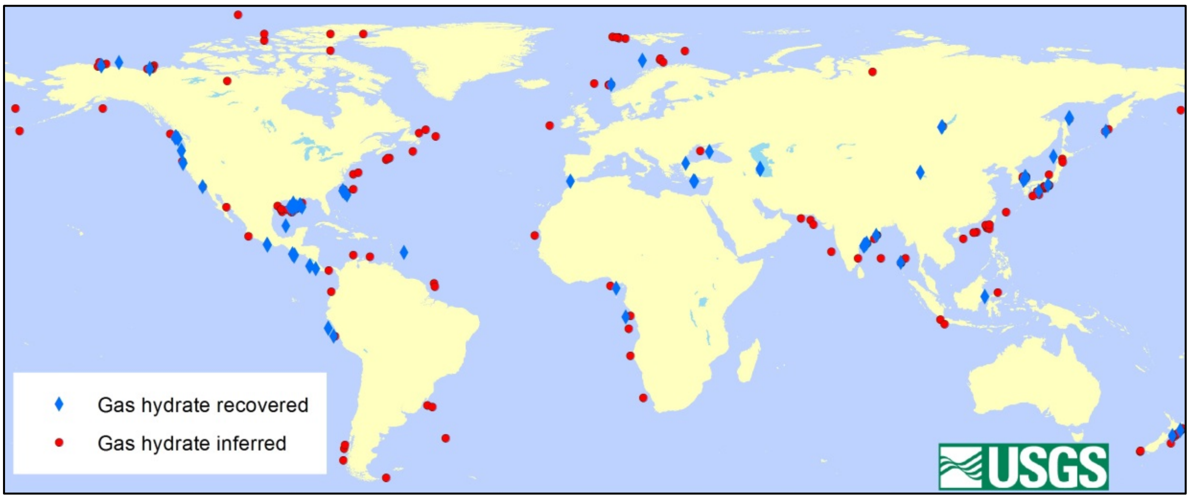

Figure 15: Known Distribution of Gas Hydrates (USGS Gas Hydrates Project, 2013)

The risk to a cable from gas hydrates is two-fold. Firstly the relatively resistant hydrates are difficult to bury into. They may therefore reduce the amount of burial achievable with a plough and even entirely prevent jet burial by ROV depending on the extent, form and density of the hydrate deposits. Secondly the hydrates may decompose back to water and gas which has been known to trigger subsea landslides which may damage the cable (see Section 5.4.4). A final minor risk from hydrates is that they can burn and if accidentally recovered to deck via core or burial equipment may pose a fire hazard.

Traditionally, gas hydrates have been identified in survey data by a bottom-simulating reflector (BSR) which forms along the underside of the hydrate stability zone where free gas is trapped by the hydrate. A BSR strongly reflects sonar pulses and mimics the shape of the seabed as this defines the temperature at which the hydrates can form. This method is not wholly reliable as a BSR can arise from other sources, and hydrates will not create a BSR if no free gas is present. Other detection methods include direct sampling via cores and the identification of bright spots on the seabed using side-scan sonar. The hydrates may dissociate when cores are recovered to the surface and may leave behind a very soft "soupy" layer (Long, et al., 2009).

5.5 Summary for Geological Routeing and Installation Report

The geology and geomorphology of the region is well understood and diverse, with the cable landing in the Firth of Clyde and Luce Bay, crossing the Irish Sea and western Scottish shelf, and connecting to a branching unit in the deep water of the Rockall Trough. The main geophysical considerations when routeing the cable are the risk level from geohazards along the route, the potential for cable burial and the resultant effects on cable security.

In general the region is a stable one with only minor exposure to major geohazards such as earthquakes and tsunamis. Other constraints such as slope and fishing must be considered when plotting the cable route. The glacial history of the region in particular has created a unique seabed morphology that must be taken into account when designing the optimum cable route, with particular regard to the risk of rock outcrop and glacial till and the effect of the seabed on fishing resources.

The geological factors discussed in this section are summarised in the table below and have been taken into account in the cable routeing and engineering section. Once a full survey has been carried out the exact information can be used to modify the route, optimising cable burial and security.

GEOLOGICAL FEATURE	IMPACT	MITIGATION	RISK LEVEL
Seabed Sediment Distribution	Affect burial capability of the cable. Sediments are expected to be sands and gravels on the continental shelf and in the eastern Irish Sea and muddy in the western Irish Sea, Rockall Trough and deeper areas of the Firth of Clyde. There is a risk from Glacial Till.	Conduct a burial assessment survey in areas where burial is designated to verify that recommendations are achievable.	Low/ Medium
Sediment Transport Features	Bedforms may pose a risk to burial equipment or expose buried cables after installation. Few bedforms are thought to exist close to the cable routes.	Conduct a survey in areas where burial is designated to identify and avoid or compensate for the presence of bedforms.	Low
Rock Outcrop	May damage cable plough if undetected during survey, or cause cable abrasion, suspension and/or exposure. Occur offshore of most landings and between Ireland and Islay.	Outcrops should be identified and avoided during the cable route survey where possible. Avoid steep slopes in deep water. Up armour and surface lay where avoidance is impossible.	Medium/ High
Earthquakes	Ground shaking may damage onshore installations. May trigger tsunamis and mass movement. The region is very low risk for earthquakes.	Avoid routeing across steep slopes in the Rockall Trough.	Very Low
Mass Wasting	Currents and sediment movement involved may break the cable. May bury the cable beyond recovery. Highest risk near to seamounts and other steep slopes. Low risk of initiating events such as earthquakes.	Avoid routeing parallel to slope contours to minimise cable exposure.	Low
Submarine Canyons	May channel mass wasting events. Likely rock outcrops on canyon walls. Occur on the slopes of the Rockall Trough.	Avoid canyons identified during the cable route survey if possible. Avoid routeing across a canyon or along the canyon floor.	Low

Tsunamis	May inundate and/or destroy onshore installations. May also trigger mass wasting events. Very rare in the region.	Design cable landing station and BMH to resist inundation as for floods. Avoid routeing the cable across slopes.	Very Low
Pockmarks	May damage cable plough or ROV if undetected during survey, or cause cable suspension and/or exposure.	Locate during survey and avoid where possible, proceed with caution where avoidance is impossible.	Low
Gas Cemented Hardground	May damage cable plough if undetected during survey, or cause cable abrasion, suspension and/or exposure. Known to occur in the Irish Sea.	Locate during survey and avoid where possible, proceed with caution where avoidance is impossible.	Low
Gas Hydrates	May prevent burial or cause mass movement. Not known to occur in the region.	Look for indications of hydrates during marine survey and avoid if possible.	Very Low

Table 5: Summary of Geological Impacts

6.0 METOCEAN INFLUENCES

Environmental considerations can play a part in cable routeing and design, but often only at the level of avoiding relatively small regions of extreme currents in straits which can cause abrasive faults. The physical environment generally has more influence on the survey, cable installation and maintenance operations rather than the lifetime security of the cable system itself.

The St Georges Channel and the North Channel define the boundaries of the Irish Sea. The Irish Sea is relatively shallow due to its location on the European continental shelf with a maximum water depth of 110 meters. The Irish landmass naturally shelters the Irish Sea from the Atlantic Ocean regime however inflows through the St Georges and the North Channels are responsible for some similarities with the Atlantic Ocean, primarily tidal currents and ranges. The Kintyre Peninsula naturally shelters the preferred LP at Irvine however if strong south westerly winds were to flow up the Firth of Clyde then Irvine would be exposed to the weather and sea conditions. The meteorology in the Irish Sea can also be similar to that of the Atlantic. For example, low pressure depressions sourced from the Atlantic tend to track through the Irish Sea and British Isles. The waters of the northwest coast of Scotland are more exposed than that of the Irish Sea however the Dunnet Bay and Ullapool LPs are also sheltered from any metocean influences that elevate the risk to the cable and its associated offshore operations.

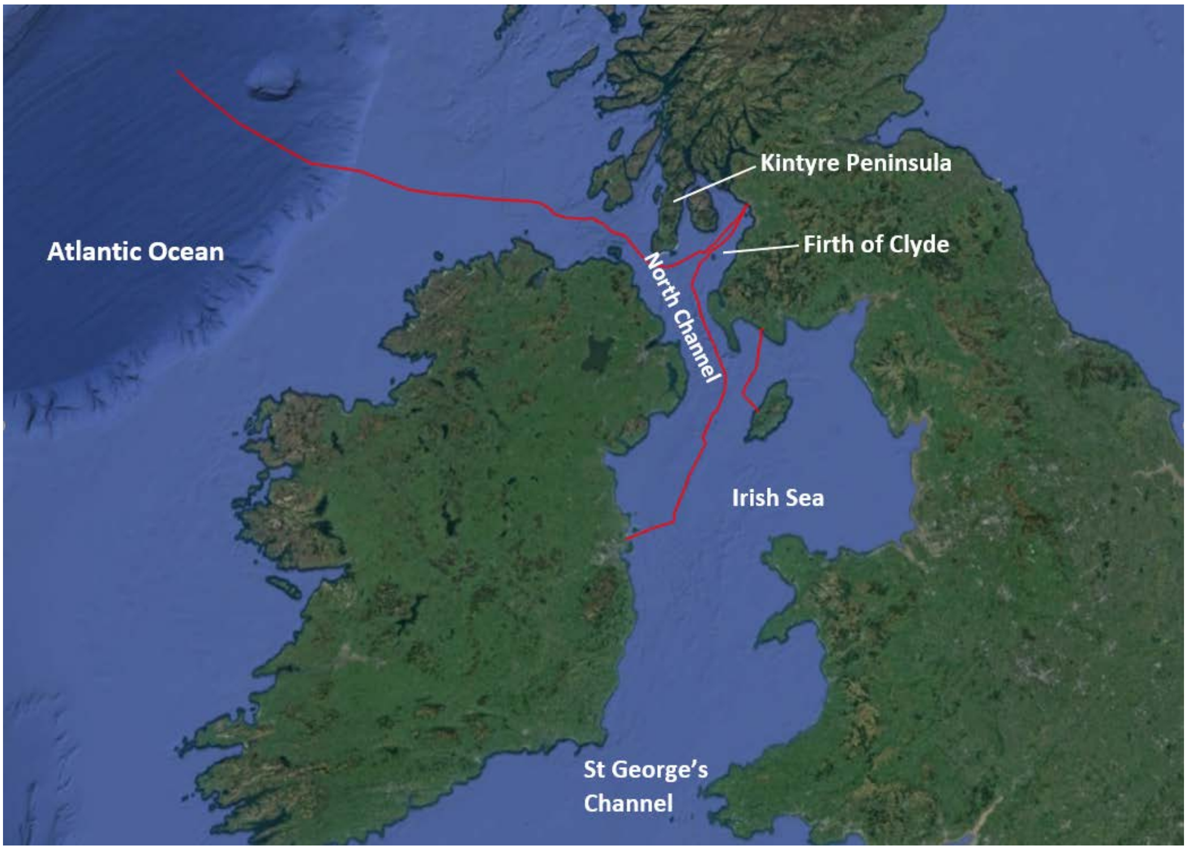

Figure 16: Area Overview

6.1.1 Irish Sea and North Channel Oceanography

The residual surface and bottom currents in the Irish Sea are complex and can flow in different directions throughout the water column. Localised wind conditions have a strong influence on current direction and velocity, causing the Irish Sea to have high annual variability. Tidal currents are stronger and will have a far greater influence on the cable and its associated landing points. The Irish Sea experiences a semi-diurnal flood and ebb tide which is essentially an extension of the Atlantic

Ocean tidal regime. During the flood tide, currents will wrap around the Irish landmass and enter the Irish Sea through the North Channel from the north and through St Georges Channel from the south before converging within the central area of the Irish Sea near the Isle of Man. The current flow reverses in direction during the ebb tide. Tidal currents are concentrated where the landmasses constrict current flow or where there are headlands present (see Figure 17). The preferred Scottish LP in Irvine does not host any areas of significant current flow however the alternative Portpatrick LP is open to the North Channel where the tidal currents can flow up to 3m/sec during springs. The Girvan LP is also exposed to significant current flow during springs and must be highlighted as a potential risk if selected as one of the preferred LP options.

Localised wind conditions can potentially amplify or retard current flow therefore the direction of the prevailing winds will be an important factor to consider for the landing and installation of the cable and is summarised in Section 6.1.2

Surface wave conditions are primarily characterised by wind duration, fetch and strength. As the Irish Sea is naturally sheltered from Atlantic swell with two relatively narrow ‘windows’, along the axes of St George’s and North Channels, the majority of waves are locally generated which are steep and of short period (Howarth, 2005). The dominant wave direction is from the southwest and west which is directly linked with the prevailing wind direction detailed in Section 6.1.2. The significant wave height defined as the highest third of waves in the Irish Sea varies all year round; ranging from its highest value of 1.37m in January and lowest of 0.62m in May (Health and Safety Executive, 2001).

Two of the most important characteristics of seawater are temperature and salinity which together control its density. Any density gradient creates a vertical movement of water which may potentially alter the buoyancy of the cable in the water column. To follow best industry practice, it will be important to note any anomalies in the water column’s temperature, salinity or density. This will help plan the cable installation to proceed with maximum efficiency and increase the accuracy of the cable lay operation, particularly in deeper water.

The surface temperature and salinity in the Irish Sea varies with the season and is controlled by the balance of evaporation and precipitation. As the Irish Sea and northwest Scotland is on the continental shelf, its average depth is low and the temperature throughout the water column is generally unified and well mixed which will have a negligible effect on the cable’s buoyancy. The highest salinities in the Irish Sea are recorded in the south in St Georges Channel and decrease northwards. The net northerly flow of Atlantic water which gradually reduces in salinity is due to the increased freshwater input from land. There is a continuous density front present between the cooler North Channel waters and the shallow less saline waters of the Clyde however the buoyancy effects and vertical movement in the water column is expected to be minimal; this is primarily due to the relatively shallow water depths in this region.

The average temperature in the Irish Sea ranges from 14.9°C in the summer to 8.4°C in the winter (Global Sea Temperature , 2016).

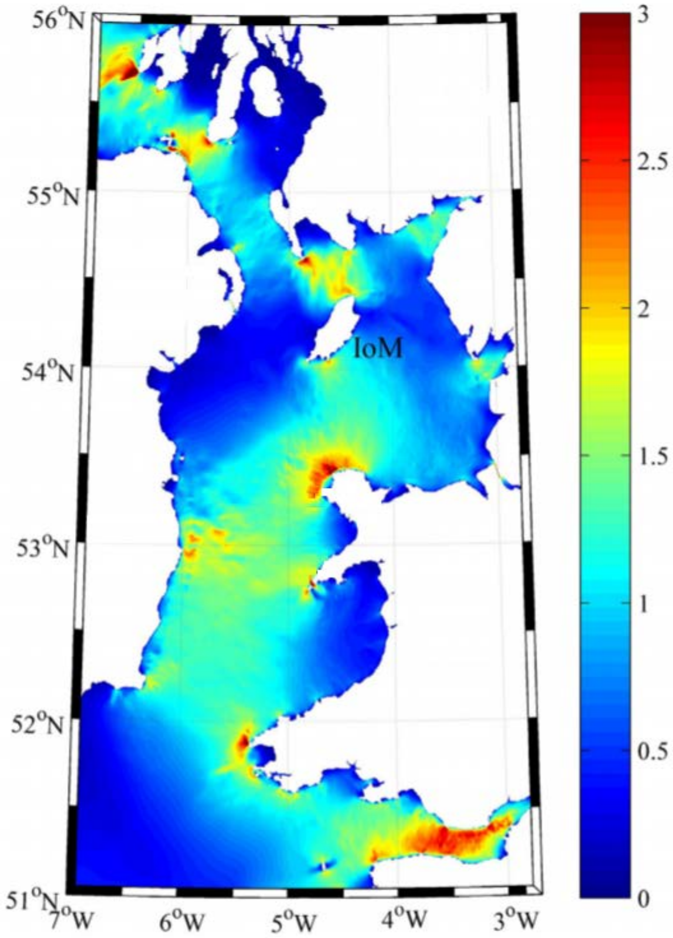

Figure 17: Peak spring velocity (m/sec) (Lewis, et al., 2015)

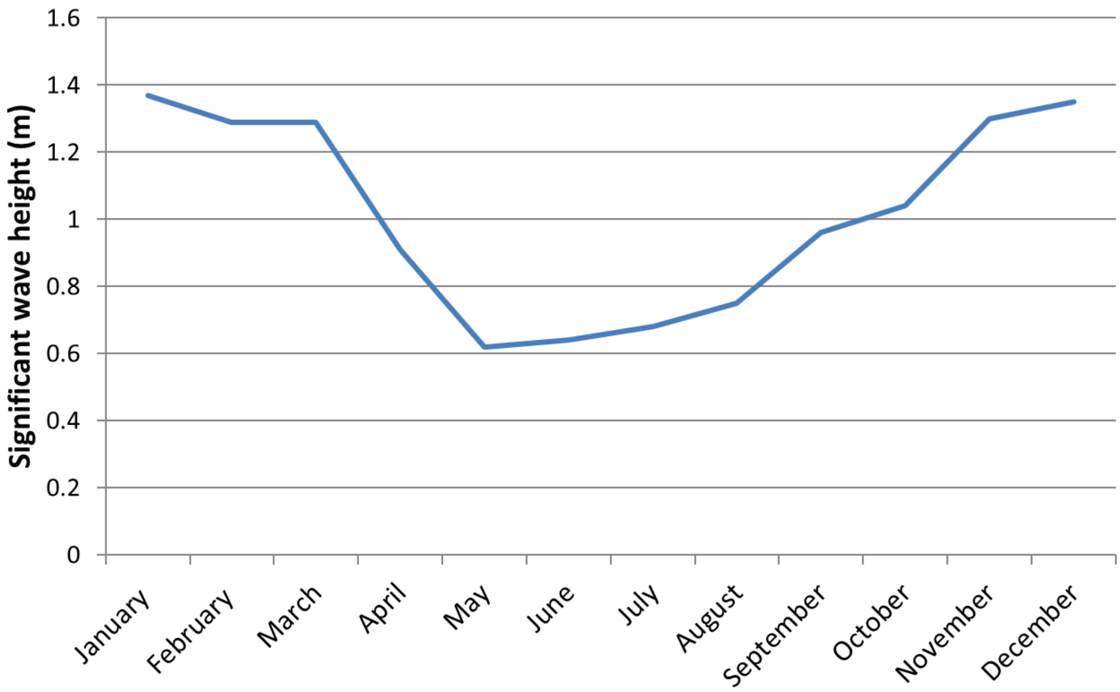

Figure 18: Mean significant wave height in the Irish Sea (Health and Safety Executive, 2001)

6.1.2 Irish Sea and North Channel Meteorology

The Irish Sea and its northern approaches host a temperate climate strongly influenced by conditions in the Atlantic and by the large scale westerly air circulation which frequently contains low pressure systems. The winds that prevail in the region range from the southwest to northwest which are associated with the meandering upper troposphere jetstream; they develop along the zones of strongest temperature gradients and generally transverse the area from southwest to northeast (shown in Figure 19). There is an increased frequency of north to northeast winds in spring and a decrease in easterly winds in the summer. Local wind conditions may be variable in both direction and speed over all seasons owing to frequent mobile depressions. When an anticyclone establishes over Europe, often during spring and autumn, an east to northeast wind may persist for several weeks (Admiralty, 2006).

Very strong breezes of force 6+ (11-14m/sec) occur 40 - 35% of the time during December in comparison to July when the frequency lowers to 6 - 9% (UKHO, 2017).

As the Irish Sea and the Firth of Clyde are essentially semi-enclosed bodies of water, the wind conditions (both speed and direction) play a key role on the sea state and therefore dictate the working season for offshore operations. Figure 19 below is a wind rose established over a 33 year period in the Firth of Clyde indicating the predominant wind direction and strength for all LPs associated with the proposed cable system.

The coastal and offshore visibility in the Irish Sea and the north and west coast of Scotland is generally very good, although marginally less so in the east of the Irish Sea and the Firth of Clyde where it is more sheltered. Fog at sea is infrequent from November to May and is most common in June (UKHO, 2017).

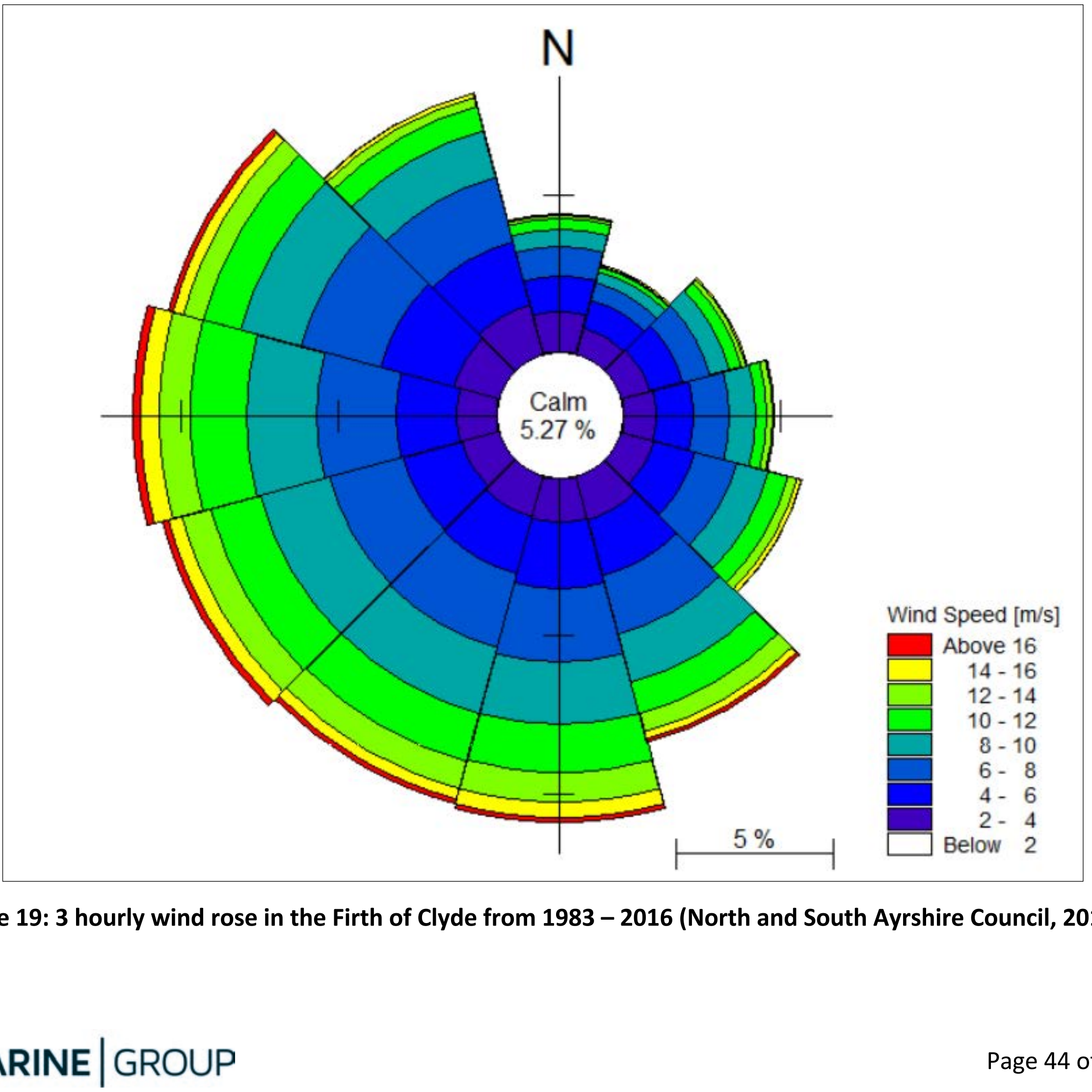

Figure 19: 3 hourly wind rose in the Firth of Clyde from 1983 – 2016 (North and South Ayrshire Council, 2018)

6.1.3 Irvine

The cable LP in Irvine is situated in the east or inner Firth of Clyde in North Ayrshire, Scotland. The inner Firth of Clyde is a relatively sheltered body of water that does not host any extreme meteorological or oceanographic conditions and is therefore a favourable landing point for a cable system. Table 6 below is the local climatological summary at the Troon LP.

Month	Mean Temperature (°C)		Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
	Daily Minimum	Daily Maximum				
Jan	5	7	115	14	84	1
Feb	4	7	72	14	82	2
Mar	5	8	88	12	80	3
Apr	7	11	61	10	76	5
May	10	14	67	9	74	6
Jun	12	16	70	8	78	6
Jul	14	17	83	7	80	5
Aug	14	17	101	7	82	4
Sep	12	15	129	9	83	4
Oct	9	12	132	10	84	2
Nov	7	9	127	11	84	1
Dec	5	7	119	11	84	1

Table 6: Climate summary, Troon (Weather2, 2018) (Holiday-Weather, 2018)

6.1.3.1 Seasonal Weather and Sea State

Wind direction and strength play a key role on the sea state of the Firth of Clyde. During the spring to summer season which is the recommended period of both survey and installation, surface winds average 7 – 10mph in comparison to 10 – 14mph during the winter months (Weather2, 2018). The maximum fetch in the Firth of Clyde for the prevailing south-westerly winds is under 100km which means that the significant wave height rarely exceeds 2.5m in the offshore zone and 1.25m in the inshore zone (Ross, et al., 2009) (Transport Scotland, 2018). A study conducted by JNCC in 1997 states that summer wave heights in the Firth of Clyde exceed 0.5m for only 10% of the time (JNCC, 1997). Nevertheless, the sea state of the Firth of Clyde responds to the direction of the wind and therefore Irvine can be exposed to an above average swell should the wind direction be sourced from the southwest to west. Figure 20 shows the waves essentially being pushed towards the northeast of the Firth during a force 8 storm; although installation in these conditions would not be conducted, Figure X indicates how the local sea state reacts to wave direction and strength.

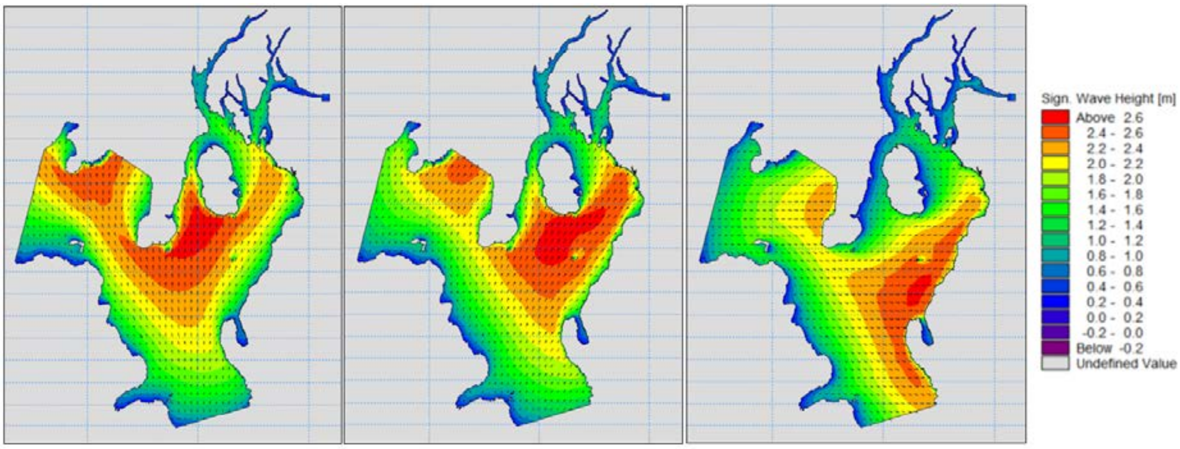

Figure 20: Correlation between wind direction from the south (left) from the southwest (middle) and from the northwest (right) and significant wave height in the Firth of Clyde during a force 8 storm (North and South Ayrshire Council, 2018).

Force 8 (Figure 20) and even force 7 storm conditions that would definitely bring delay to offshore operations are not common in the Firth of Clyde however storms or particularly bad weather must be taken into account in terms of quantifying risk and weather windows. Table 7 below outlines the average number of days per month when gale force 7 conditions occur, equating to an average of 14 days per year. The spring to summer season (April – September) is the recommended period of installation for the cable.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
3.3	2.9	1.6	0.5	0.3	0.2	0.1	0.3	0.5	1.3	1.4	1.6

Table 7: Force 7 storm occurrences (days) in the Firth of Clyde (Transport Scotland, 2018)

6.1.3.2 Currents and Tidal Range

During the flood tide, an extension of the North Channel current runs up the east of the Firth of Clyde and flows anticlockwise from southeast to northwest past Troon and Irvine before entering a variety of lochs further inland in Scotland. Current flow is reversed during the ebb tide and will therefore flow from northwest to south east. Although a prevailing tidal current is present just offshore of the landing point, tidal streams are barely noticeable and would not impact the positioning of the shore end installation vessel (UKHO, 2004). Depending on the state of the tide, the northwest or southwest flow may be accelerated or retarded dependant on wind direction and strength.

The tidal range along the coastline of Troon and Irvine is relatively benign and does not create any real threat to shore end operations however, it is recommended that the neap tidal window is still used to ease installation operations. As mentioned above, localised wind conditions can make a slight difference on tidal ranges, should the wind be prevailing from the northeast the range will be lower than usual and vice versa from the southwest. Table 8 below highlights the mean tidal range data for Troon during springs and neaps.

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Troon	3.1	0.3	2.5	0.9

Table 8: Tidal range, Irvine (Admiralty Total Tide, 2018)

6.1.3.3 Beach Erosion and Flooding

Coastal erosion is an important consideration when looking at possible landings for a cable system and any possibility of reducing the risk of the BMH flooding should be taken. A study conducted by D. Sneddon on behalf of the Glasgow University Archaeological Research Division (GUARD) highlights that the cable landing is in an area that is 'definitely eroding' (see Figure 21). This is because the beach is exposed to continuous wind and wave action. A number of approaches have been attempted with varying success, including the planting of marram grass, gabion baskets and aggregate dumping. In 2014 the Environmental Trust, Scotland had also recognised that the area was popular with tourists and recreation activity which increased general wear and erosion further. In response, beach erosion works were conducted by ASH landscape and design consultancy to upgrade pedestrian links over the sand dunes from the park to the beach. The completed scheme helps to protect this sensitive coastal environment while still allowing the community to access the coastline (ASH, 2014). Although the area is subject to erosion, the dunes do offer stability and would shelter the BMH which is located approximately 70m behind them. The cable would also be routed in between a gap in the dunes minimising any potential environmental impact to this sensitive ecosystem (see Section X).

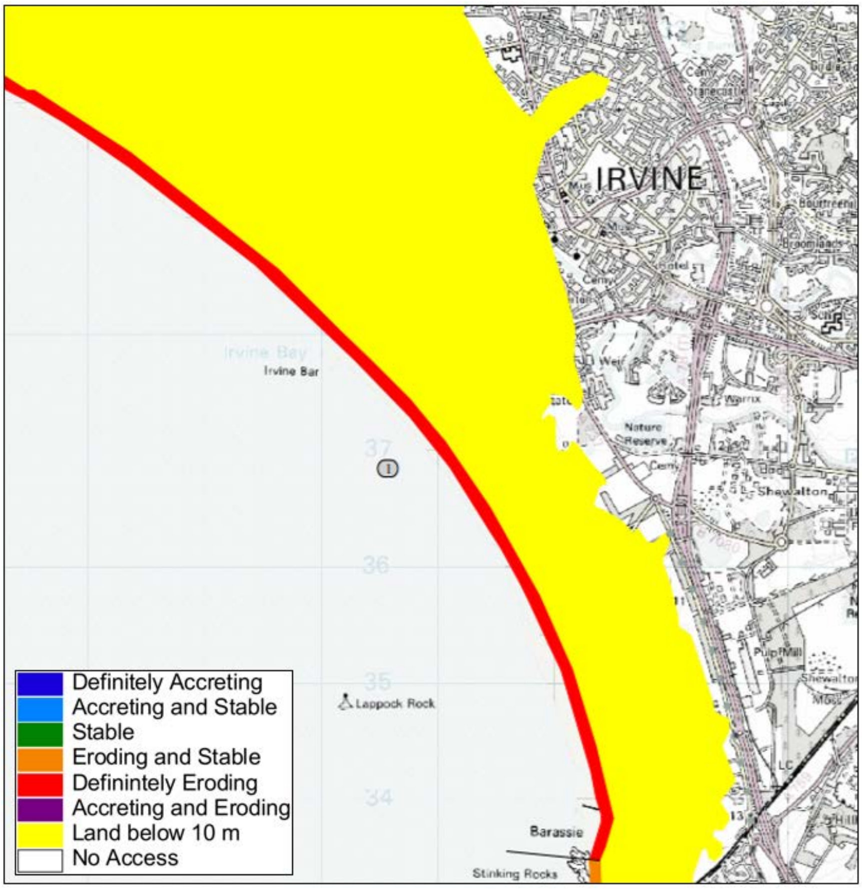

Figure 21: Coastal erosion, Irvine (Sneddon, 2003)

As shown in Figure 21 above, a large area of the coastline is less than 10m above sea level causing the Ayrshire District to categorise this area as a particularly vulnerable area in terms of flood risk. A report conducted by North Ayrshire Council in 2009 analysed the causes of flooding along Irvine and Troon which equated to 70% from local rivers, 20% coastal and 10% surface water (North Ayrshire Council, 2016). The flood risk is therefore greatest near the local rivers such as the River Irvine which is relatively close to the proposed LP. The BMH is elevated to approximately 3m above sea level to reduce this risk. As mentioned above, the region is classified as a particularly vulnerable area however there are very few floods that have been recorded near Irvine and Troon; the last coastal flooding event occurred at Titchfield Road near Troon harbour in January 2014. The last significant flooding event prior to this was in 1936 (North Ayrshire Council, 2016). As the LP has frontage to the

Firth of Clyde, coastal flooding remains a continuous threat however, the location provides suitable protection for the cable BMH.

During the write up of this study (19/09/2018) Storm Ali approached the western coastline of Scotland causing significant sand and sea spray into Irvine and Troon however coastal flooding did not occur.

6.1.4 Girvan

The cable LP in Girvan is situated in the southeast outer Firth of Clyde in South Ayrshire, Scotland. The outer Firth is a relatively sheltered body of water that does not host any extreme meteorological or oceanographic conditions and is therefore a favourable landing point for a cable. Due to its location, Girvan is more exposed than the Irvine LP and is sometimes subjected to some Atlantic swell conditions during north-westerly winds. Table 9 below is the local climatological summary at the Girvan LP.

Month	Mean Temperature (°C)		Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
	Daily Minimum	Daily Maximum				
Jan	5	7.5	115	14	84	1
Feb	5	7.5	72	14	82	2
Mar	6	8.7	88	12	80	3
Apr	7.4	10.6	61	10	76	5
May	10.1	13.7	67	9	74	6
Jun	12.3	15.6	70	8	78	6
Jul	14.1	17.1	83	7	80	5
Aug	14.2	17.2	101	7	82	4
Sep	12.6	15.5	129	9	83	4
Oct	10.2	12.9	132	10	84	2
Nov	7.3	9.9	127	11	84	1
Dec	5.8	8.3	119	11	84	1

Table 9: Climate summary, Girvan (YR, 2018)

6.1.4.1 Seasonal Weather and Sea State

Wind direction and strength play a key role on the sea state of the Firth of Clyde. During the spring to summer season which is the recommended period of both survey and installation, surface winds average 7–10mph in comparison to 10–14mph during the winter months (Weather2, 2018). The maximum fetch in the Firth of Clyde for the prevailing south-westerly winds is under 100km which means that the significant wave height rarely exceeds 2.5m in the offshore zone and 1.25m in the inshore zone (Ross, et al., 2009) (Transport Scotland, 2018). Nevertheless, the sea state of the Firth of Clyde responds to the direction of the wind and therefore Girvan can be exposed to Atlantic swell should the wind direction be sourced from the northwest. Figure 20 above shows the waves essentially being pushed towards the southern Firth of Clyde during a force 8 storm. Installation and survey operations could not be conducted in these conditions.

6.1.4.2 Currents and Tidal Range

During the flood tide, an extension of the North Channel current runs up the east of the Firth of Clyde and flows in an anticlockwise direction from the southwest to northeast past Girvan before entering a variety of lochs further inland in Scotland. Current flow is reversed during the ebb tide and will therefore flow from northeast to southwest during the ebb tide. During the spring flood tide, the maximum current velocity occurs equating to 1.5m/sec (UKHO, 2004). Cable landing operations in water velocities in excess of 1m/sec presents a risk to shore end operations therefore it is paramount that the neap tidal window is optimised if Girvan is selected as the preferred LP. Depending on the state of the tide, the northward or southward tidal flow may be increased or decreased depending on wind direction and strength.

As mentioned above, localised wind conditions can make a slight difference on tidal ranges, should the wind be prevailing from the northeast the range will be lower than usual as water is pushed away from Scotland towards the North Channel and vice versa with winds from the southwest. Table 10 below highlights the mean tidal range data for Girvan during springs and neaps.

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Girvan	3.0	0.4	2.5	1.1

Table 10: Tidal range, Girvan (Admiralty Total Tide, 2018)

6.1.4.3 Beach Erosion and Flooding

Coastal erosion must be considered when looking at possible landings for a potential cable system and any risk of the BMH flooding should be reduced where possible. The cable lands on the beach just to the south of Girvan harbour which is classed as an area of coastline that is accreting sediment (North and South Ayrshire Council, 2018). To the north of the harbour, the erosion rate is considerably higher.

The proposed cable landing point in Girvan (similar to that of Irvine) is listed as a potentially vulnerable area to flooding by the South Ayrshire Council. The LP has frontage to the Firth of Clyde therefore coastal flooding remains a continuous threat, however the majority of historical flooding events are river related (87%) rather than from coastal flooding (North Ayrshire Council, 2016). A report conducted by the North and South Ayrshire Council in January 2018 states that there is a very limited flood risk in the area with only one non-residential property presently estimated to be at risk of flooding during a 1 in 200 year coastal event (North and South Ayrshire Council, 2018).

6.1.5 Muasdale

The cable landing at Muasdale is on the northwest coastline of the Kintyre Peninsula in Argyll and Bute, Scotland. This entire stretch of coastline is open to the Atlantic which beats heavily on it even during calm weather, and especially when the tidal stream is setting southeast. Muasdale is one of the most exposed LPs considered during this study, however this LP is where an existing BT Highlands and Islands FO cable lands which to date has not had a recorded fault. Table 11 below is the local climatological summary at the Muasdale LP.

Month	Mean Temperature (°C)		Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
	Daily Minimum	Daily Maximum				

Jan	2	6	108	18	84	1
Feb	3	8	102	17	83	2
Mar	3	9	98	16	82	3
Apr	4	11	89	14	81	5
May	7	14	77	12	80	6
Jun	9	16	65	11	83	6
Jul	11	18	64	11	84	5
Aug	11	18	81	11	85	4
Sep	9	15	114	13	84	4
Oct	7	12	126	15	126	2
Nov	5	10	136	16	83	1
Dec	3	8	125	15	83	1

Table 11: Climate summary, Muasdale (Weather2, 2018)

6.1.5.1 Seasonal Weather and Sea State

The irregular and mountainous shape of the coastline causes a great variation in the wind climate across the Kintyre Peninsula; however the winds do still prevail from the west and southwest as shown in Figure 19. These westerly winds are associated with the meandering upper troposphere jetstream; they develop along the zones of strongest temperature gradients and generally traverse the area from southwest to northeast. In comparison to the other southerly LPs in Scotland, the Kintyre Peninsula is very exposed and has higher associated wind speeds; during the spring to summer season which is the recommended period of both survey and installation, surface winds average 11–14mph and increase to 18mph during the winter months (Weather2, 2018). Although the area is more exposed, the location has more influence on the survey, cable installation and maintenance operations rather than the lifetime security of the cable system itself, therefore Muasdale should still be considered as a potential LP for the cable. The irregular form of the coastline and presence of numerous islands and sea lochs results in great variability in the wave energy experienced offshore of the Kintyre Peninsula. Summer wave heights offshore of Muasdale exceed 1m for only 10% of the time (JNCC, 1997).

6.1.5.2 Tidal Currents and Range

Figure 17 above shows that the maximum current velocities are greater than 3m/sec off Rathlin in Northern Ireland and decrease in all directions away from this zone. The tidal currents reach their maximum of 2m/sec during spring tides offshore of the proposed Muasdale LP, requiring careful timing to avoid excessive currents during the shore end operation. The tidal range along the coastline of Muasdale is relatively low and does not create any real threat to shore end operations however, it is recommended that the neap tidal window is optimised to ease installation operations. Table 12 below highlights the mean tidal range data for Muasdale during springs and neaps.

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)

Muasdale	1.2	0.3	1.0	0.5

Table 12: Tidal range, Muasdale (Admiralty Total Tide, 2018)

6.1.5.3 Beach Erosion and Flooding

Coastal erosion must be considered when looking at possible landings for a potential cable system and any possibility of risk to the BMH from flooding should be reduced where possible. There is no available data to suggest that beach erosion occurs along the central western coastline of Muasdale. Using satellite imagery history on Google Earth, there has been no noticeable change to the coastline from 2005 to the present day. In terms of flood risk, the nearest particularly vulnerable area to flooding is on the southeast of the peninsula which will therefore not risk the BMH or other terrestrial infrastructure on the west of the peninsula.

6.1.6 Portpatrick

The cable landing at Portpatrick faces southwest and has frontage to the North Channel which is the northern passageway between the Atlantic Ocean and the Irish Sea. Tidal currents in the North Channel can reach 3m/sec in both directions (northwest or southeast) during spring tides and therefore must be avoided to ease installation operations and reduce risk to the cable system. Portpatrick is also the LP for the Scotland – Northern Ireland 1 FO cable system as it is one of the shortest marine routes between Scotland and the Irish landmass. Table 13 below is the local climatological summary at the Port Patrick LP.

Month	Mean Temperature (°C)		Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
	Daily Minimum	Daily Maximum				
Jan	3	8	84	14	85	1.8
Feb	2	8	68	14	83	2.8
Mar	3	10	75	13	82	3.5
Apr	4	11	67	11	80	5.9
May	6	15	51	10	78	7
Jun	9	17	61	10	81	6.1
Jul	11	18	59	10	83	6.9
Aug	11	18	70	9	84	5.5
Sep	9	17	66	10	84	4.2
Oct	7	13	125	12	84	3
Nov	5	10	103	13	85	2
Dec	2	8	100	13	85	1.5

Table 13: Climate summary, Portpatrick (Weather2, 2018)

6.1.6.1 Seasonal Weather and Sea State

The winds prevail from the southwest to northwest all year round as shown in Figure 19. These westerly winds are associated with the meandering upper troposphere jet stream. During the spring to summer season which is the recommended period of both survey and installation, surface winds average 9-11m/sec in comparison to >13m/sec during the winter months (Weather2, 2018). As mentioned in Section 6.1.6.2 below, the sea state offshore of Portpatrick is dominated by the southeast and northwest tidal flow therefore particular caution is required in winds from the northwest or southeast during the installation period as current flow may be amplified to a velocity that is higher than usual.

6.1.6.2 Tidal Range and Currents

The currents in the North Channel are complex due to the irregular shape of the Northern Irish and western Scottish coastlines. Such irregular landmasses with alternately open and constricted areas greatly alter the current flow and direction. The residual current direction in the North Channel is therefore northwest to southeast during the flood tide and vice versa during the ebb tide. The flood tide is known to be considerably higher in velocity than the ebb tide and can reach a peak spring velocity of 3m/sec (Bacan, et al., 2018). The flood tide has a slightly higher velocity due to the additional 'bottleneck' effect that the Isle of Man causes which further constricts the water between the Scotland and the Isle of Man.

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Portpatrick	3.9	0.5	3.1	1.2

Table 14: Tidal range, Portpatrick (Admiralty Total Tide, 2018)

6.1.6.3 Beach Erosion and Flooding

Coastal erosion must be considered when looking at possible landings for a potential cable system and any possibility of reducing the risk of the BMH flooding should be taken where possible. There is no available data to suggest that beach erosion occurs along the coastline or surrounding area of Port Patrick. Using satellite imagery history on Google Earth, there has been no noticeable change to the coastline from 2003 to the present day. Similar to the other LPs further north, Port Patrick has been classified by the Solway Local Plan District as a potentially vulnerable area to flooding however this is mainly associated with the potential overflow of Dinvin Burn which flows through Portpatrick (SEPA, 2016). This section of the coastline is also vulnerable to flooding from rising sea levels and climate change towards 2080 however this is not relevant to the lifetime security of the cable and its potential BMH.

6.1.7 Port William

The LP at Port William is located near a small built up resort on the east of Luce Bay in Dumfries and Galloway, Scotland. The bay is exposed to an almost continuous inflow of water due to southerly wind conditions which are frequent all year round. From a meteorological and oceanographic perspective, Port William is a good landing point for a FO cable system however when outside of Luce Bay, current flow can be significant in between the Scottish and the IoM landmasses. Table 15 below is the local climatological summary at Port William.

Month	Mean Temperature (°C)				

	Daily Minimum	Daily Maximum	Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
Jan	5	7	86	18	87	3
Feb	2	5	59	17	86	4
Mar	4	7	66	17	86	6
Apr	6	10	53	14	82	8
May	10	13	60	12	80	9
Jun	12	15	64	11	79	10
Jul	12	16	66	12	81	8
Aug	14	16	80	12	82	7
Sep	10	13	85	13	81	7
Oct	9	12	89	14	82	5
Nov	6	9	78	15	85	3
Dec	4	6	77	15	86	4

Table 15: Climate summary, Port William (Weather2, 2018)

6.1.7.1 Seasonal Weather and Sea State

The winds prevail from the southwest to northwest all year round as shown in Figure 19. These westerly winds are associated with the meandering upper troposphere jetstream. During the spring to summer season which is the recommended period of both survey and installation, surface winds average 12-14mph in comparison to >15mph during the winter months (Weather2, 2018). In comparison to the other LPs, Port William hosts a relatively windier climate due to its frontage to the prevailing south-westerly winds and the Irish Sea however even during storm conditions, Luce Bay is still relatively sheltered from any wave action.

6.1.7.2 Tidal Range and Currents

The direction of the currents in Luce Bay changes continually in a clockwise manner over the course of the tidal cycle. It is likely that, in addition to the general trend of water entering and leaving the bay over the cycle, currents will flow clockwise around the bay on the flood tide and anticlockwise on the ebb. The peak current flow is approximately 0.6m/sec and will therefore not influence the landing or present any sort of abrasion risk to the cable. It should be noted that when outside of Luce Bay, current flow is significant and spring conditions can create current velocities of >3m/sec that should be avoided.

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Port William	6.4	1.8	5.2	2.1

Table 16: Tidal range, Port William (Admiralty Total Tide, 2018)

6.1.7.3 Beach Erosion and Flooding

Coastal erosion must be considered when looking at possible landings for a potential cable system and any possibility of reducing the risk of the BMH flooding should be considered where possible. There is no available data to suggest that beach erosion occurs along the coastline or surrounding area of Port William. Using satellite imagery history on Google Earth, there has been no noticeable change to the coastline from 2003 to the present day.

Port William has a relatively high risk of minor coastal flooding. The last flooding event to occur in Port William was in 2018 during Storm Eleanor which coincided with a high tide to create a storm surge. Properties along the main road were partially flooded and affected by wave action however the area quickly recovered after the storm. A very similar event occurred in 2014 which suggests that high tides and storm related weather are likely to cause a flooding event near this LP. Following the site visit conducted in October 2018, the BMH will be located behind the beach to reduce risk. It should be noted that Port William generally has a higher flooding risk than some of the other LPs however it is unlikely that the lifetime security of the cable system would be significantly compromised.

6.1.8 Peel

The LP at Peel is located on the west of the Isle of Man and is the preferred landing point for the cable if it connects to the Isle of Man from mainland Scotland directly. The northward and southward tidal currents are relatively minimal offshore of Peel, it is only at the northern and southern headlands where tidal currents along the Isle of Man are concentrated. Peel is the most common LP for FO cables between Ireland and the Isle of Man. Table 17 below is the local climatological summary at Peel.

Month	Mean Temperature (°C)		Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
	Daily Minimum	Daily Maximum				
Jan	4	7	81	18	80	3
Feb	3	8	63	17	80	4
Mar	4	9	64	16	80	6
Apr	4	11	61	13	79	8
May	7	13	36	12	77	9
Jun	9	16	73	11	80	10
Jul	11	18	55	11	81	8
Aug	11	18	70	11	81	7
Sep	10	17	66	13	81	7
Oct	9	13	102	16	80	5
Nov	5	11	99	16	80	3
Dec	4	9	92	17	80	4

Table 17: Climate summary, Peel (Weather2, 2018)

6.1.8.1 Seasonal Weather and Sea State

The winds prevail from the southwest to northwest all year round (Figure 19). During the spring to summer season which is the recommended period of both survey and installation, surface winds average 11-13mph in comparison to >16mph during the winter months (Weather2, 2018). As the west coast of the Isle of Man is the windward shore to the prevailing winds, this coastline is fairly exposed from a meteorological perspective however; the marine conditions are favourable for a cable landing. Figure 18 shows the mean significant wave height in the Irish Sea which will range from its lowest value of 0.6m in May to its highest of 1.35m in January.

6.1.8.2 Tidal Range and Currents

The tidal currents and streams off the west of the Isle of Man are very weak and do not exceed 0.5m/sec during springs. It is only around the headlands such as the Point of Ayre located on the north of the island and Langness Point on the southeast of the island where current flow is amplified (see Figure 22). From an oceanographic perspective, Peel is the preferred LP over Port Grenaugh for the proposed cable system. The direction of current flow is north during the flood tide and south during the ebb tide.

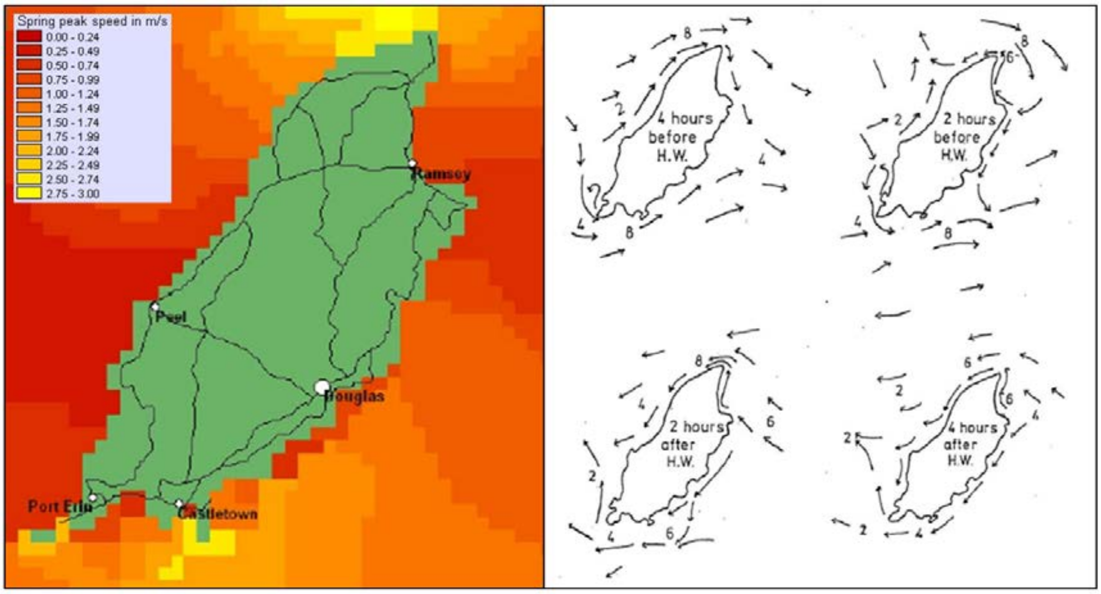

Figure 22; Spring tide velocities (left) and direction of current flow around the Isle of Man (right). (Aquatera, 2006) (Brown, 1951).

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Peel	5.2	0.4	4.3	1.5

Table 18: Tidal range, Peel (Admiralty Total Tide, 2018)

6.1.8.3 Beach Erosion and Flooding

The landing point at Peel is suitably protected from coastal erosion; it is the northwest of the island that experiences the highest erosion rate where soft cliffs are slowly crumbling away. The Isle of Man is exposed to a relatively high coastal flooding risk. In 2014, nearly all of the coastal towns (including Peel) flooded in response to abnormally high tides and storm surges and this will remain a continuous threat to all coastal areas of the Isle of Man (BBC News, 2015). According to a study conducted by the Manx Government in 2016, Peel has flooded 8 times in 90 years meaning that the annual probability of flooding is around 1 in 10 (Isle of Man Government, 2016). The majority of these floods are fluvial, sewerage and surface water related rather than coastal however the BMH should be positioned in an area of high ground near the LP.

Figure 23: Peel Harbour in 2014, 1 hour before high tide (Guardianwitness, 2014)

6.1.9 Port Grenaugh

The LP at Port Grenaugh is situated on the southeast coast of the Isle of Man and shares the same LP as the existing LANIS cable system. In comparison to the LP at Peel, Port Grenaugh experiences greater tidal currents which are concentrated to the north and southern coastlines of the Isle of Man however the nearshore waters of Port Grenaugh are relatively sheltered in comparison to its surroundings. Table 19 below is the local climatological summary at Ronaldsway Airport in the Isle of Man.

Month	Mean Temperature (°C)				

	Daily Minimum	Daily Maximum	Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
Jan	3.4	7.7	86.0	17.9	86	1.8
Feb	2.9	7.4	60.0	17.4	85	2.3
Mar	3.8	8.7	65.6	15.8	83	3.9
Apr	4.9	10.7	55.7	13.3	77	4.8
May	7.2	13.7	50.3	12.2	80	7.2
Jun	9.8	16.1	54.8	11.3	81	7.1
Jul	11.7	17.7	56.3	10.8	85	6.1
Aug	11.9	17.7	67.7	11.4	83	5.8
Sep	10.7	16.0	80.3	13.2	83	4.5
Oct	8.8	13.4	96.5	15.4	84	3.3
Nov	5.9	10.5	97.5	16.7	84	2.0
Dec	4.4	8.7	93.8	17.7	85	1.5

Table 19: Climate Summary, Ronaldsway Airport (Kennington & Hisscott, 2013)

6.1.9.1 Seasonal Weather and Sea State

The winds prevail from the southwest to northwest all year round (Figure 19). During the spring to summer season which is the recommended period of both survey and installation, surface winds average 11-13mph in comparison to >16mph during the winter months (Weather2, 2018). Due to the natural orientation of Port Grenaugh, local wave action is very low as the fetch is limited.

6.1.9.2 Tidal Range and Currents

Certain regions on the Isle of Man coastline are subject to strong tidal currents. This occurs particularly around headlands such as the Point of Ayre located on the north of the island and Langness Point on the southeast approximately 4km south of Port Grenaugh. During the peak of the spring tides, the stream can reach velocities of up to 5 knots (2.5m/sec) on the southeast of the Isle of Man (IoM Government, 2016). In terms of risk, Port Grenaugh is subjected to daily currents that are expected to be around 2m/sec in comparison to the 0.5m/sec at the preferred Peel LP on the IoM. The direction of the current during the flood tide is northward and southward during the ebb (see Figure 22).

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Port Grenaugh	6.9	0.8	5.4	2.4

Table 20: Tidal range, Port Grenaugh (Admiralty Total Tide, 2018)

6.1.9.3 Beach Erosion and Flooding

The landing point at Port Grenaugh is suitably protected from coastal erosion due to the relatively steep cliffs at either side of the bay that shelter the narrow and existing beach. The Isle of Man is exposed to a relatively high coastal flooding risk. In 2014, nearly all of the coastal towns including Douglas and Castletown situated on either side of Port Grenaugh flooded in response to abnormally high tides and storm surges and this will remain a continuous threat to all coastal areas of the Isle of Man (BBC News, 2015). Port Grenaugh itself runs a lower risk of flooding to other areas in the Isle of Man as the BMH would be in a fairly high location above mean sea level and any wave overtopping is very unlikely due to the narrow and steep protection that the cliffs provide.

6.1.10 Loughshinny and Portmarnock

Loughshinny and Portmarnock are the preferred LPs in Ireland and are situated just to the north of Dublin. The climate in this region is similar however the northward and southward flowing tidal currents are more varied at the Portmarnock LP due to the presence of Lambay Island and Baily headland in comparison to a more linear flow at Loughshinny. Areas where strong tidal currents exist can increase the potential risk of abrasion if they are combined with a hard, rugged seabed; maintenance procedures may also be inhibited in areas where currents are concentrated. Following the cable route survey, micro routeing may be required to avoid any areas where burial may not be possible or there is any elevated risk of abrasion. Table 24 below is the local climatological summary of Dublin.

Month	Mean Temperature (°C)		Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
	Daily Minimum	Daily Maximum				
Jan	2.5	7.6	69.5	14.0	86	1.8
Feb	2.5	7.5	50.4	13.5	84	2.5
Mar	3.1	9.5	53.5	13.3	82	3.6
Apr	4.4	11.4	51.1	11.1	79	5.2
May	6.8	14.2	54.8	10.0	76	6.1
Jun	9.6	17.2	55.8	9.3	76	6.0
Jul	11.4	18.9	50	10.0	78	5.4
Aug	11.1	18.6	71.1	10.2	81	5.1
Sep	9.6	16.6	66.4	10.2	82	4.3
Oct	7.6	13.7	70.1	11.3	85	3.1
Nov	4.2	9.8	64.3	12.4	86	2.4
Dec	3.4	8.4	75.8	13.6	86	1.7

Figure 24: Climate summary, Dublin (Irish Meteorological Service Online, 2016)

6.1.10.1 Seasonal Weather and Sea State

The winds prevail from the southwest to northwest all year round (Figure 19). During the spring to summer season which is the recommended period of both survey and installation, surface winds average 9-11mph in comparison to >14mph during the winter months (Irish Meteorological Service Online, 2016). The wind speed in Dublin is fairly low in comparison to the other LPs and does not exceed 14mph due to Ireland's land mass naturally sheltering the coast from the prevailing south westerlies. The wave action is fairly low along the eastern Irish coastline ranging from its highest value of 1.37m in January to its lowest of 0.62m in May (Health and Safety Executive, 2001).

6.1.10.2 Tidal Range and Currents

The tidal currents run northward during the flood tide and southwards during the ebb tide however the presence of Lambay Island and Ireland's Eye disrupts linear flow creating some turbulence and meandering eddies just offshore of Portmarnock. As these currents are squeezed through various channels in-between landmasses, the current velocity is higher reaching 1.2m/sec during springs (Visit My Harbour, 2013). In comparison, Loughshinny has a weaker spring tidal flow that rarely exceeds 1m/sec and the current flow is always in line with the coastline in comparison to the more turbulent flow further south. The daily tides also vary depending on wind conditions; a persistent southerly wind will prolong the flood tide and a persistent northerly wind will prolong the ebb tide.

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Loughshinny	4.4	3.2	3.6	1.3

Table 21: Tidal range, Loughshinny (Admiralty Total Tide, 2018)

6.1.10.3 Beach Erosion and Flooding

Ireland has a varied coastline, but there is a basic distinction between the westerly shores exposed to the full force of the Atlantic Ocean and the more sheltered east coast where the cable is intended to land. Active coastal erosion occurs in Killiney and Bray head for example however this is where soft boulders and clay materials exist rather than at the sheltered beach of Portmarnock.

Ireland is quite fortunate in that the effects of sea level rise and flooding are relatively low, according to a study conducted by Fingal County Council in 2016, Portmarnock has a probability of 1 in 100 of flooding in any given year (Fingal County Council, 2016).

6.1.11 Dunnet Bay

The LP at Dunnet Bay is situated on the north coastline of Scotland which is also the LP of the Farice and Northern Lights FO cable systems that connect mainland Scotland to Orkney, the Faroe Islands and Iceland. The climate in the northern extents of Scotland is volatile compared to the other LPs further south however the Bay itself is relatively sheltered. The tidal streams between the Scottish landmass and Orkney are significant, even during neaps and should be highlighted as an offshore risk to cable operations. Table 22 below is the local climatological summary at Dunnet Bay.

Month	Mean Temperature (°C)				

	Daily Minimum	Daily Maximum	Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
Jan	4	7	62	15	82	1.3
Feb	4	6	58	15	81	2.4
Mar	4	7	61	13	81	4.2
Apr	5	9	67	12	79	4.6
May	8	11	73	11	77	7.8
Jun	10	13	85	11	80	7.5
Jul	12	15	84	9	83	5.4
Aug	12	15	89	9	83	5.1
Sep	10	14	84	11	82	4.3
Oct	8	11	74	13	82	3.1
Nov	6	9	80	14	81	2.4
Dec	4	7	80	13	82	1.7

Table 22: Climate Summary, Dunnet Bay (Weather2, 2018)

6.1.11.1 Seasonal Weather and Sea State

The winds prevail from the southwest to northwest all year round (Figure 19). During the spring to summer season which is the recommended period of both survey and installation, surface winds average 9 -11mph in comparison to >15mph during the winter months (Weather2, 2018). During storms and very strong westerly gales, the sea state is amplified within the Bay however, the headlands either side of the bay (Dunnet Head and Scrabster Head) take the majority of the swell impact which creates wave refraction and dissipation within the bay prior to the beach. The local wave heights are therefore influenced by localised winds rather than oceanic swell. During the spring and summer season, operations within the bay itself have a low chance of delay.

6.1.11.2 Tidal Currents and Range

The currents within Dunnet Bay are minimal and will not influence shore end operations however offshore of Dunnet Bay is the Pentland Firth between Scotland and Orkney where the current flow is significant. During the spring flood tide, the mean current velocity is 3m/sec as water is forced from the Atlantic through the narrow channel of the Pentland into the North Sea in the east. During the ebb tide, current flow is reversed and sets west into the Atlantic. Even during neap tides, current flow is expected to reach a maximum velocity of 1.05m/sec. Should Dunnet Bay be selected as the preferred LP, the cable would be routed directly west which avoids the area where current flow is constricted between the landmasses. Installation operations need to be aware of this as there is a high chance of meandering eddies to be present, installation during the neap tidal window is highly recommended. This will also be beneficial during shore end operations as the tidal range would be lowest.

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Dunnet Bay	5.0	1.0	4.0	2.2

Table 23: Tidal range, Dunnet Bay (Admiralty Total Tide, 2018)

6.1.11.3 Beach Erosion and Flooding

Dunnet Bay is orientated towards the northern Atlantic Ocean and is therefore exposed to a relatively high level of coastal erosion, particularly during the winter. Dunnet Bay is backed by sand dunes where according to a study conducted by J. Hanson in 2007, frontal erosion is evident along almost its entire length (Hanson, 2007). This form of beach erosion is caused by the local wind conditions and not the oceanography which the Bay is sheltered from. The deep penetration of the embayment means that incoming waves are completely refracted along the northern and southern cliffs of Dunnet Bay. Sand fences and marram planting techniques have been applied to the dunes to helps stabilise the local wind blasting.

According the Highland and Argyll Local Plan District, Dunnet Bay is not situated in a potentially vulnerable area for flooding (SEPA, 2018).

6.1.12 Ullapool

The LP in Ullapool is at the only major town in northwest Scotland and has an oceanic climate that is relatively mild considering its northerly latitude. From a meteorological and oceanographic perspective, Ullapool is a good landing point for a FO cable system as the town has a deep penetration into the Scottish mainland, which offers good protection from the Atlantic Ocean and The Minch situated to the west. Table 24 below is the local climatological summary at Ullapool.

Month	Mean Temperature (°C)		Total Precipitation (mm)	Mean Wind Speed (mph)	Relative Humidity (%)	Mean Daily Sunshine (hours)
	Daily Minimum	Daily Maximum				
Jan	0	5	207	12	86	1.3
Feb	-1	6	163	12	84	2.4
Mar	0	7	143	12	82	4.2
Apr	2	10	102	10	79	4.6
May	4	13	87	9	75	7.8
Jun	7	15	83	10	78	7.5
Jul	9	17	68	8	81	5.4
Aug	9	17	87	8	83	5.1
Sep	7	15	101	9	83	4.3
Oct	4	11	172	10	84	3.1
Nov	1	7	176	10	86	2.4
Dec	-1	5	182	10	87	2.1

Table 24: Climate summary, Ullapool (Weather2, 2018)

6.1.12.1 Seasonal Weather and Sea State

The winds prevail from the southwest to northwest all year round (Figure 19). During the spring to summer season which is the recommended period of both survey and installation, surface winds average 8-10mph in comparison to 12mph during the winter months (Weather2, 2018). Ullapool is effectively sheltered from the majority of the Atlantic Ocean regime and the Minch which host particularly dangerous seas during northeast and southwest gales. During gale force conditions the waves can be very steep however within Loch Broom and the nearshore waters of Ullapool, wave action is minimal.

6.1.12.2 Tidal Range and Currents

The currents in the vicinity of the Summer Isles and Ullapool are fairly weak, irregular and uncertain in direction. During spring tide conditions, current flow does not exceed 0.25m/sec (UKHO, 2004).

Landing point	Mean high water spring (m)	Mean low water spring (m)	Mean high water neap (m)	Mean low water neap (m)
Ullapool	5.2	0.7	3.9	2.1

Table 25: Tidal range, Ullapool (Admiralty Total Tide, 2018)

6.1.12.3 Beach Erosion and Flooding

Ullapool and the surrounding coastline of Loch Broom is sheltered with its steep landscapes covered in vegetation all year round, this offers a good level of stability to the coastline and mitigates against coastal erosion.

According the Highland and Argyll Local Plant District, Ullapool is not a vulnerable area to flooding (SEPA, 2018).

6.1.13 Metocean Summary

The oceanography and meteorology have little impact on the three proposed cable routes or any of any of the associated LP's however the physical environment will dictate offshore operations and must not be overlooked. The table below summarises the main metocean factors and their effect on the cable system and its associated operations. The key driver is the localised weather conditions which are well known to show a high variability. It is recommended that the survey and installation of the proposed cable systems is conducted between April and September when the wind speeds and wave heights are at their lowest. Better working conditions offshore will reduce the likelihood of delay ultimately saving time and cost. It is recommended that local meteorological and oceanographic reports are acquired throughout operations and should be noted that offshore conditions in the Irish Sea and waters of Northwest Scotland can vary dramatically. Table 26 below provides a summary of the metocean impact in the North Sea to the proposed SFT Cable system.

FEATURES & PROCESSES	IMPACT	MITIGATION	RISK LEVEL
Currents	Bottom currents may create bedforms that hamper installation in waters less than 100m deep. Currents may alter vessel positioning, cable touch down positioning or hamper ROV operations.	Conduct a survey in areas where burial is designated to identify and avoid or compensate for the presence of bedforms.	Low
Winds, Waves & Swell	May degrade survey data due to excessive pitch and roll of survey vessel. May prevent cable ship from launching a plough or ROV. May create transient seabed currents, mobilising the seabed sediment and potentially exposing the cable	Restrict installation and survey operations to the spring and summer months to reduce the risk of delay. It should be noted that offshore conditions can vary dramatically.	Low/Medium
Storm conditions	As above.	Restrict operations to the spring and summer season. Review target burial depths if storm derived bedforms are found by the survey.	Low
Tidal Currents	Currents may affect cable touch down position or hamper ROV operations.	Low as tidal streams are believed to be relatively minimal at the majority of the LPs however to ultimately reduce the shore end installation risk, the neap tidal window should be optimised.	Low

Table 26: Summary of Metocean Impacts

7.0 HUMAN HAZARDS

7.1 Introduction

This section covers human related hazards that could be encountered along the route of the cable system. Consideration is given to the impact on cable installation and maintenance throughout its lifetime.

Globally, human activities are the major hazard to submarine cables. The most frequent cause of faulting on submarine cable systems is fishing activity. Of more than five thousand cable faults recorded by Global Marine worldwide, 39% were caused by fishing. Anchor-related faults are the second most common cause of faults, responsible for 14% worldwide.

7.2 Fishing

7.2.1 Fishing Methods

Commercial fishers use many different fishing gears and fishing methods, from lone divers picking shellfish from the ocean floor to huge trawlers that use massive nets to catch fish more than a kilometre deep. Each gear type is used for specific species or groups of species and different gears can have very different impacts on the marine environment and cable security, as shown in Figure 25, Figure 26 and Figure 27.

Some fishing methods have no impact on the seafloor as they target the upper to middle water column and thus pose no direct threat to cables. However they could still impede the survey, cable installation and maintenance operations. Other fishing methods such as bottom trawl and scallop dredging are directly seabed invasive, posing a high risk to submarine cables.

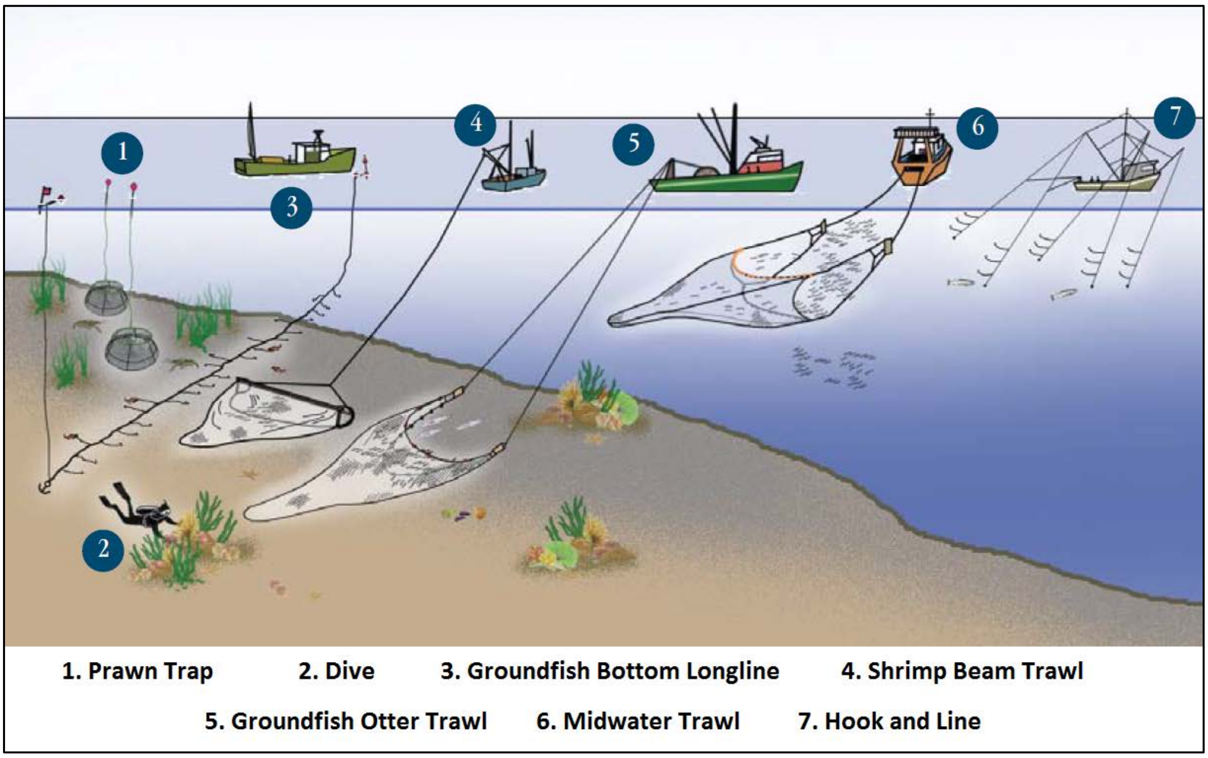

Figure 25: Fishing Methods 1 (Fuller, et al., 2008)

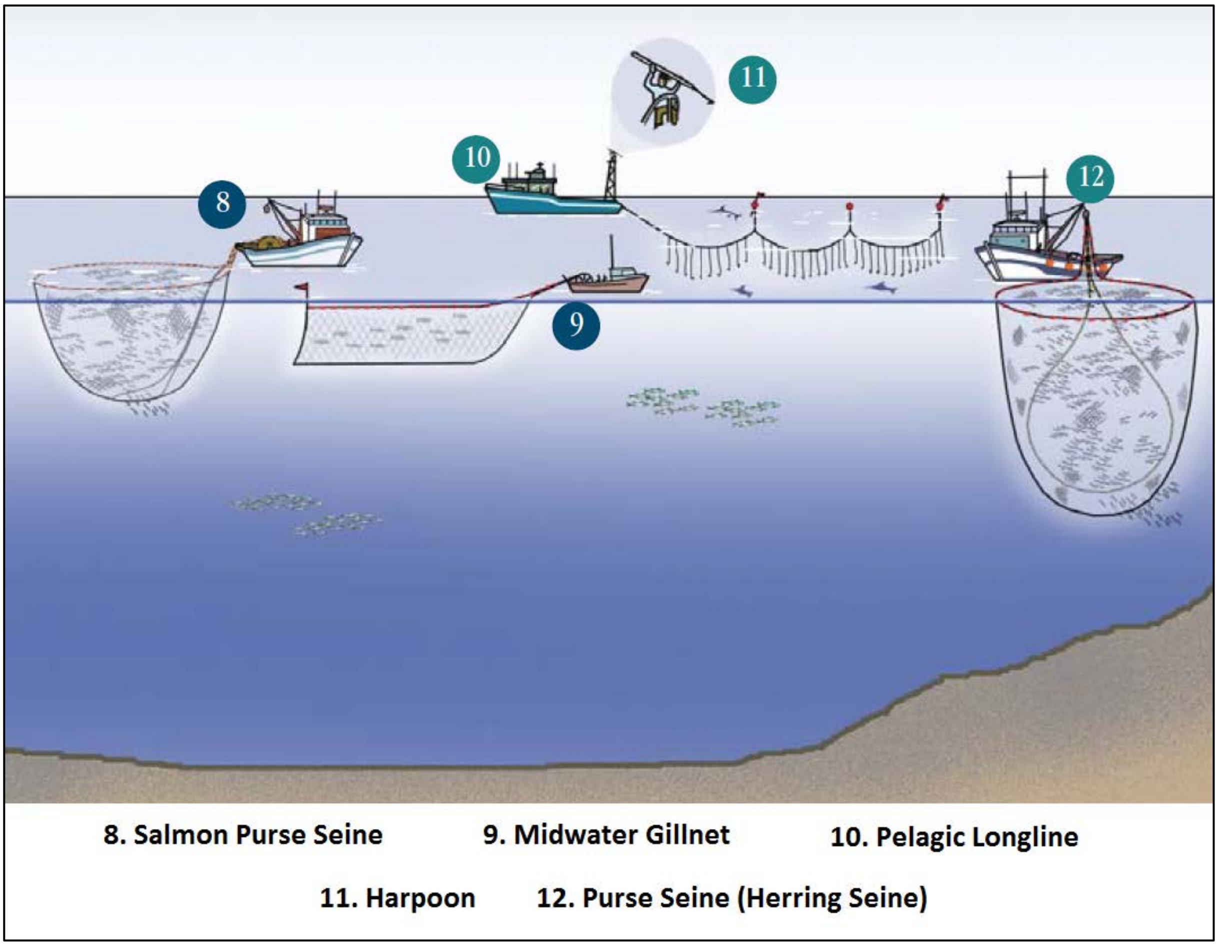

Figure 26: Fishing Methods 2 (Fuller, et al., 2008)

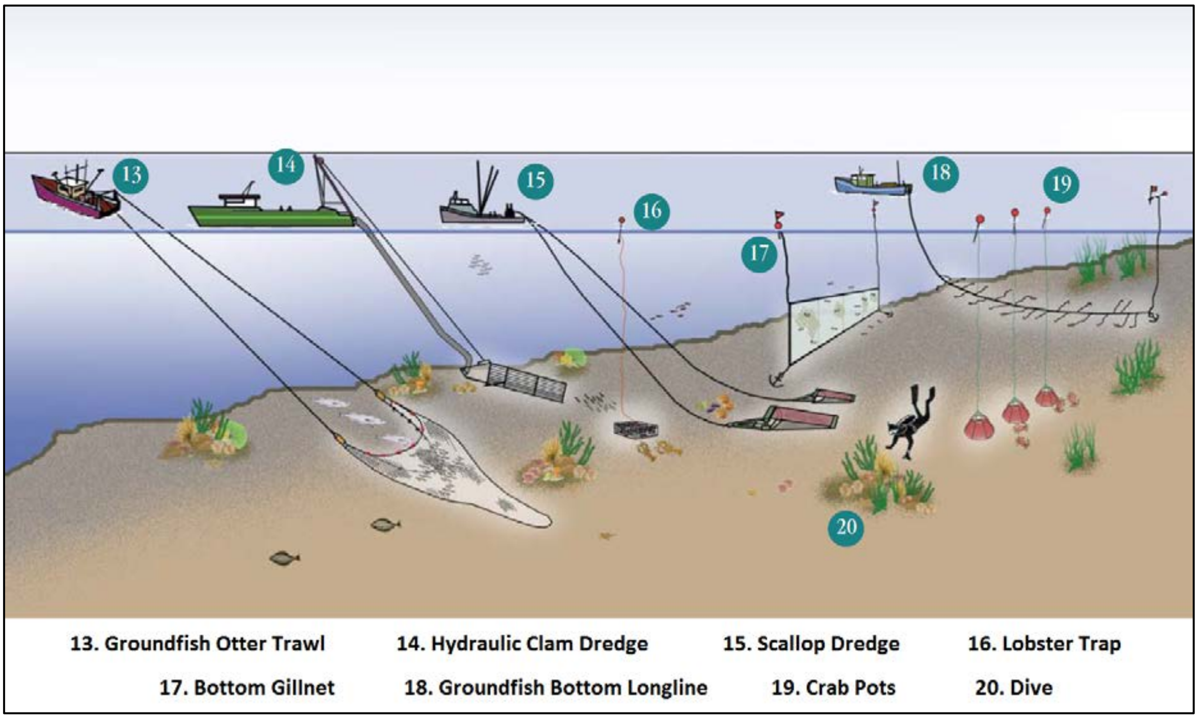

Figure 27: Fishing Methods 3 (Fuller, et al., 2008)

During the planning, installation, operational and maintenance phases of the cable system life cycle liaison with the fisheries authorities and commercial fishing operators is advisable. The Figure below ranks the fishing gears according to ecological impact on the seabed including the effect on fish habitat. Bottom trawl is ranked as the most severe and areas where trawlers operate should be avoided if possible.

There is a high correlation between ecological impact on the seafloor by fishing gear types and impact on submarine cables, especially if the cable is exposed on the seafloor or only shallow buried. It is therefore important to recognise the most threatening fishing methods and determine where they are practised in relation to the cable system. Table 28 summarises the types of fishing operating in western Scotland and the Irish Sea and the expected threat to the cable.

Ideally the cable route can be diverted away from areas with bottom invasive fishing. In many cases along the cable route this has not been possible and burial into the seabed is recommended as detailed in Section 10.6.2. Increased cable protection is also advisable. The decision to armour a cable and the degree of cable armouring (e.g. single, double) balances the threat versus the burial potential. Armouring does not guarantee cable security and cable faults can still occur as a result of damage by fishing gear if the cable is exposed (Figure 28).

The individual types of fishing and their potential impact on cables are discussed in the following subsections and Section 7.2.3 assesses the impact of fishing on the individual cable segments designed as part of this study.

GEAR TYPE	SEVERITY RANKING (0-100)
Harpoon	1
Dive	4
Hook and Line	22
Purse Seine	28
Midwater Gillnet	35
Pelagic Longline	41
Pot and Trap	44
Midwater Trawl	52
Bottom Longline	62
Dredge	74
Bottom Gillnet	79
Bottom Otter Trawl	98
Beam Trawl	98

Table 27: Fishing Gear Severity Ranking (Fuller, et al., 2008)

Figure 28: Cable Fault Caused by Fishing Gear (Global Marine)

7.2.1.1 Bottom Trawling

The bottom trawl, also referred to as the bottom otter trawl, consists of a cone-shaped net towed across the bottom by a single vessel. It is one of the most common types of commercial fishing gear in the world and on a global scale it is the type which most often snags cables. Included in this group are single or multiple trawls and shrimp trawls.

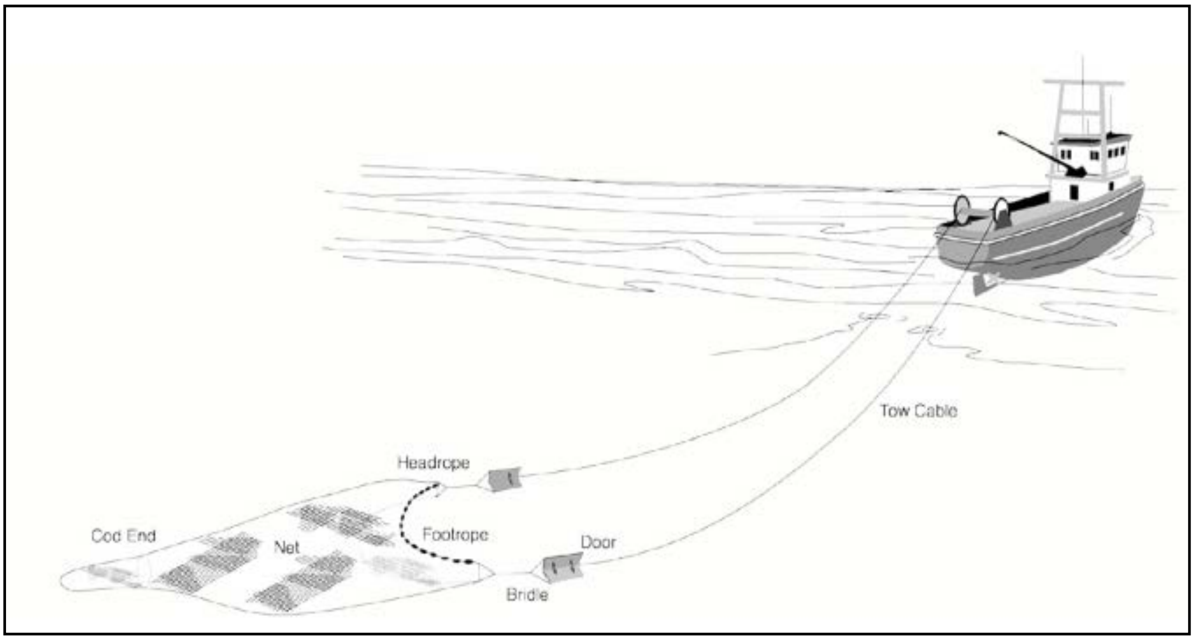

Figure 29: Typical Bottom Trawl Gear & Configuration

A typical configuration of bottom trawl gear is shown in Figure 29. Trawl doors (otter boards) keep the fishing gear on or near the bottom and provide horizontal spread for the net. In most bottom fisheries the intention is to have the door and the footrope skim along in contact with the seabed without digging into it.

When a cable is struck hard by a large trawl door, damage to the cable is likely. The damage is more severe if the door snags the cable and exerts a pulling or lifting force as shown below in Figure 30.

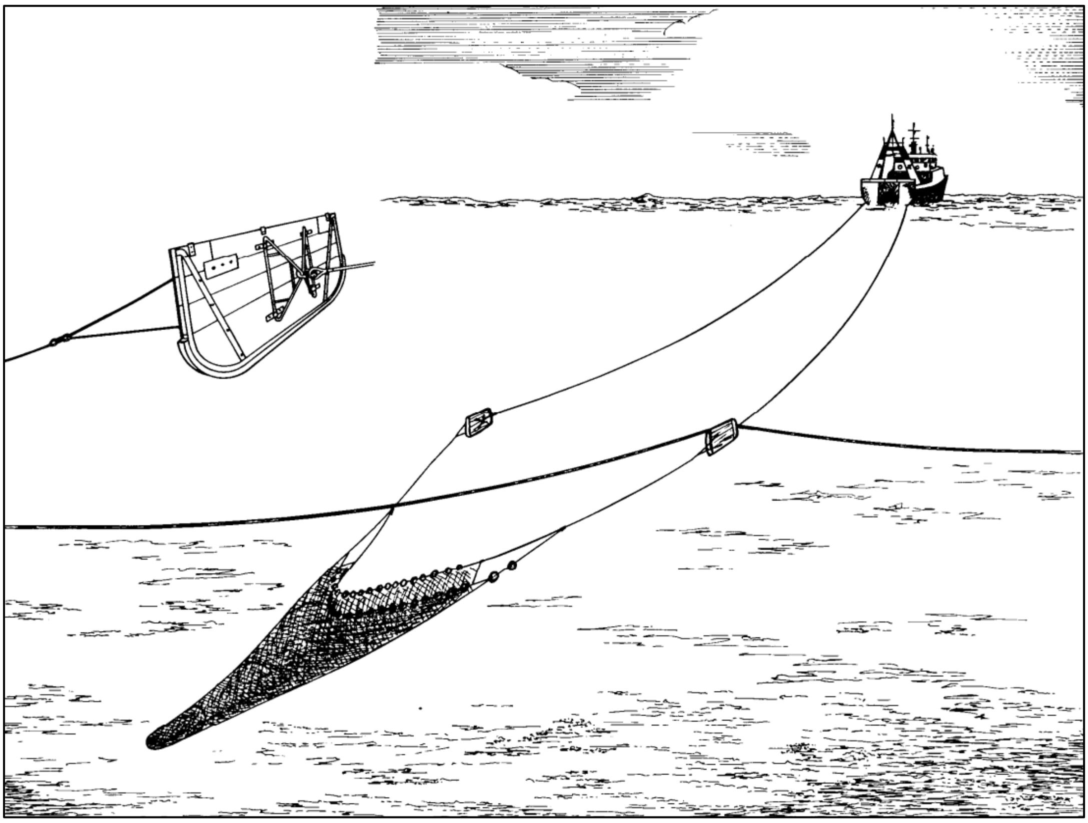

Figure 30: Bottom Trawler Catching Cable (ICPC, 2009)

Other configurations of trawl gear also occur. One of the most common is the beam trawl where a rigid beam between two shoes replaces the otter boards to keep the net open. This gear is particularly common in the flatfish fishery around the UK. When a cable is struck by or caught on beam trawl gear this has a similar effect to that described for the otter trawling above.

Most bottom trawling takes place in water depths of less than 100m.

7.2.1.2 Scallop Dredging

As with bottom trawling, scallop dredging is also a seabed invasive fishing technique and there is a very high risk of cable damage in areas of scallop dredging especially if only shallow cable burial protection is possible, typically less than 0.2m.

King scallop dredging uses steel dredges with a leading bar fitted with a set of spring loaded, downward pointing teeth. Behind this toothed bar (sword), a mat of steel rings is fitted (Figure 31). A heavy net cover (back) is laced to the frame, sides and after-end of the mat to form a bag. Sets of dredges are shackled to a hollow steel tow bar, which is connected to the main towing warp by a series of chain bridles. Larger vessels generally tow two bars, one on each quarter. Dredge gear is often rigged in a very similar way to beam trawls.

King scallops, which are usually found in sand and light gravel, are raked out by the teeth and swept into the bag. The leading bar of the gear is theoretically designed so that seabed penetration is only approximately 0.1m or less but this often increases in softer seabed areas. Figure 31 illustrates standard scallop dredging gear, terminology and configuration.

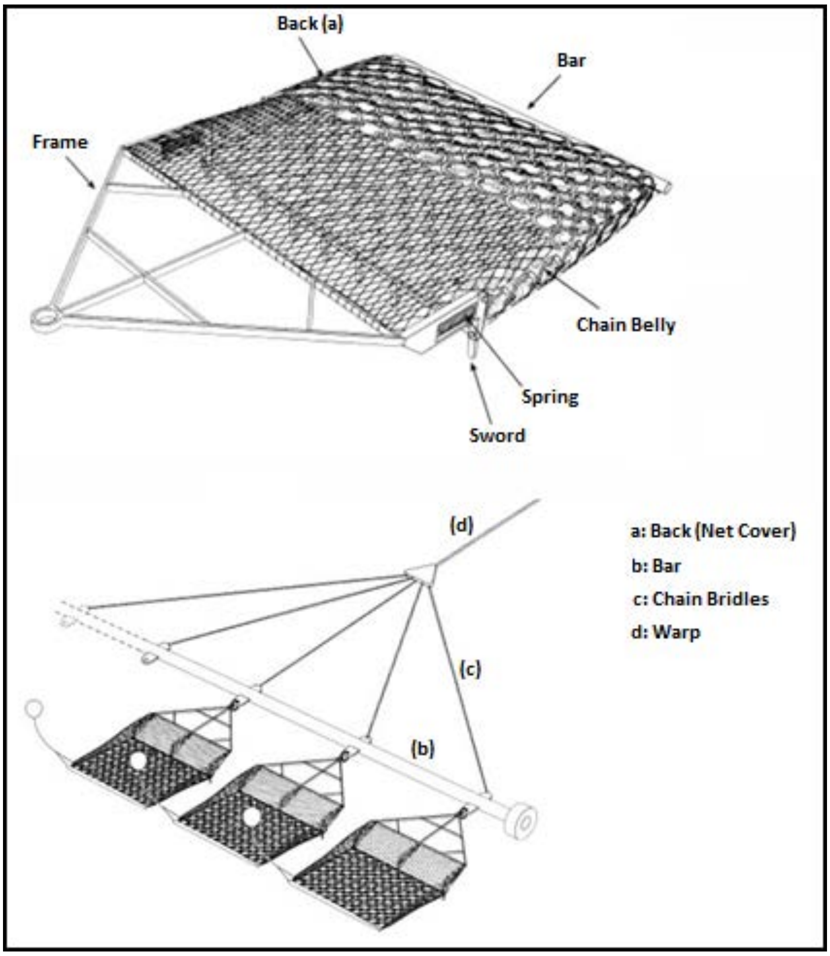

Figure 31: Scallop Dredging Gear

Fishing for queen scallops uses toothless dredges with tickler chains (skid dredges) or beam trawl gear as these scallops tend to swim upward when disturbed and so the teeth on a Newhaven-style dredge are unnecessary.

Figure 32: Scallop Dredging Vessel in Peel, IoM (Global Marine)

7.2.1.3 Potting

Pots are used to trap demersal species such as crabs, lobsters and whelks. Typical pots used in the Irish Sea are shown in Figure 33. Pots are deployed individually or in longer strings, marked with a buoy and secured with an anchor or clump weight.

Figure 33: Potting Vessel in Peel, IoM (Global Marine)

The risk to cables from the potting fishery comes from two sources. The first is during installation when strings of pots can entangle and damage cable burial equipment such as ploughs and ROVs. If the cable is laid over the string during installation it may also be damaged if the pots are subsequently recovered. In the longer term there is an ongoing hazard to the cable from the anchors and weights used to secure the strings of pots.

7.2.1.4 Longlining

Fishing by deep longline methods is another seabed invasive technique although as a potential threat to a submarine cable it is rated as low-medium. Typical longline fishing gear configuration anchors the lines onto the seabed as shown in Figure 25.

The risk to cables could occur if the anchor is either dropped or lowered from above or by the anchor dragging along the seabed and onto the cable. The anchor penetration is likely to be relatively shallow although it should be considered that halibut longline fishing uses 30-60kg anchors that may penetrate the seabed down to 0.5m in soft sediments. Cable burial to at least 1m is typically recommended as providing suitable protection from anchored longlines.

7.2.2 Evidence of Bottom Fishing

One of the purposes of a cable route survey is to map areas where bottom fishing has occurred. This is achieved by interpretation of SSS records.

Evidence of past bottom trawl fishing and shellfish dredging activities are preserved on the seabed as ‘scars’, unless there is rock outcrop. Evidence of relic seabed scars left by the fishing gear dragged along the seafloor are often seen in sidescan sonar data (e.g. Figure 34). In non-cohesive granular soils (e.g. sand or gravel with no clay content) it is possible that scarring evidence will be only temporary as the sediments return to their natural morphology. This is especially the case if the sediments are mobilised by bottom currents and evidence of scarring on sonar records may not be apparent.

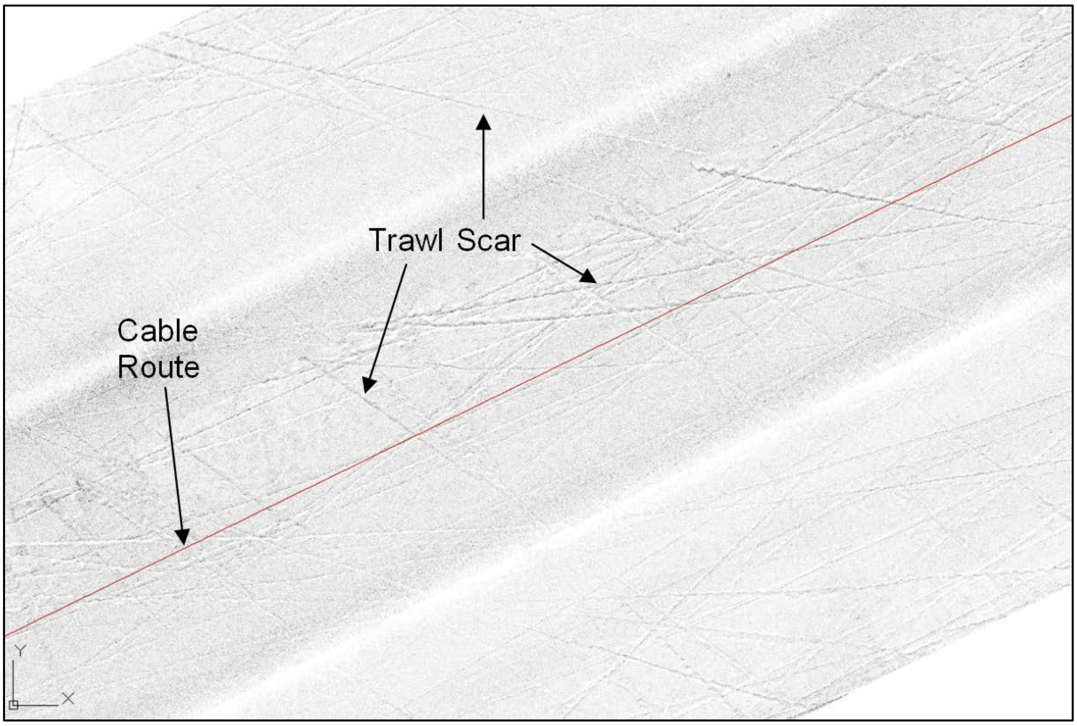

Figure 34: Trawl Scars from SSS Data

7.2.3 Distribution of Fishing Effort and Fishing Fleets

All cable segments designed as part of this study will be affected by fishing activity. These sections are summarised below on a segment by segment basis.

7.2.3.1 Transatlantic Connection

The greatest fishing risk to the Transatlantic Connection segment of the cable system will be from demersal trawling. This is concentrated in the Firth of Clyde, with the cable route passing through a particularly dense concentration south of Arran, and a lesser concentration offshore of the landing point at Irvine (Figure 35). A lesser amount of trawl fishing also takes place between Islay and Northern Ireland.

The cable route also passes north of the greatest concentration of Irish fishing vessels north of the coast (Figure 36). Fishing with passive gear (traps and pots) takes place along the shelf break east of the Rockall Trough, with around 2 hours total effort over the cable route in 2016 from UK vessels.

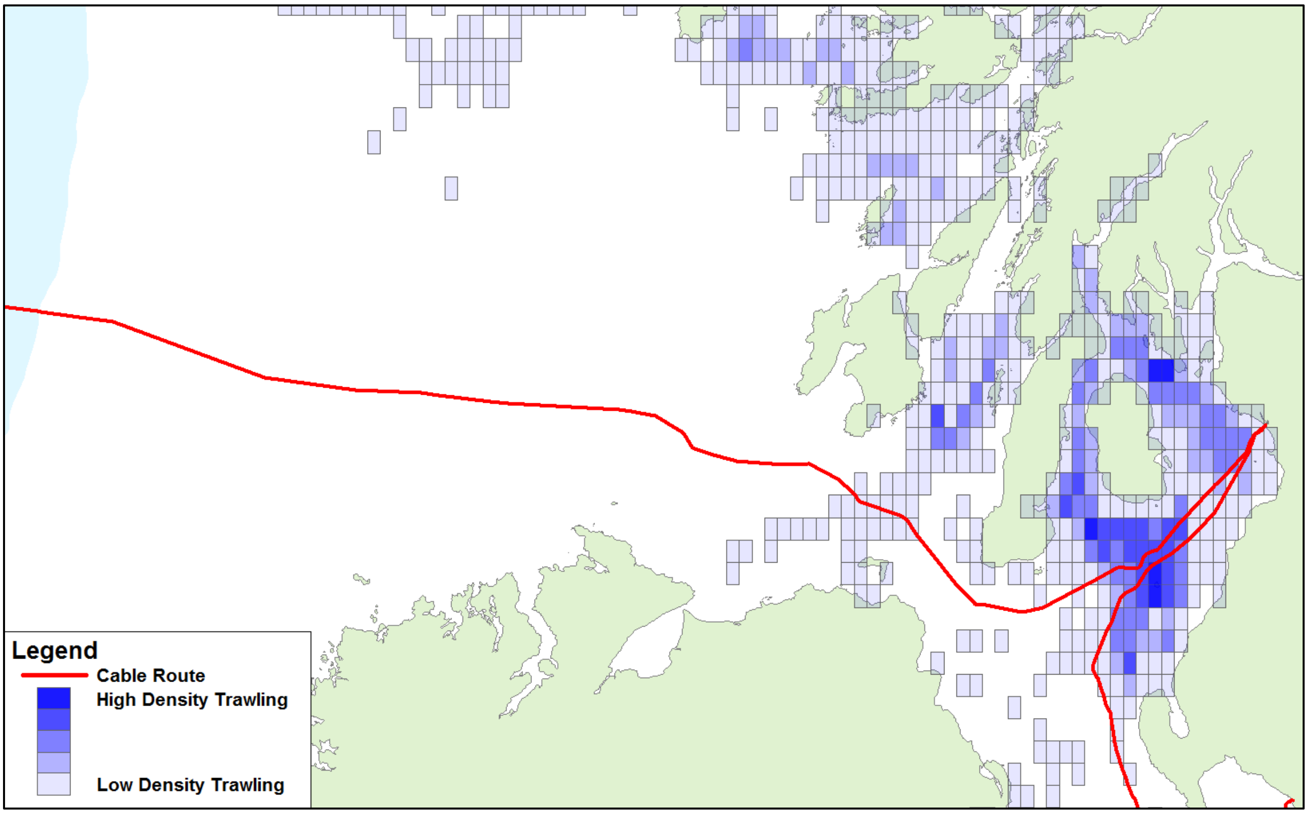

Figure 35: Trawl Fishing West of Scotland 2016 (MMO, 2016)

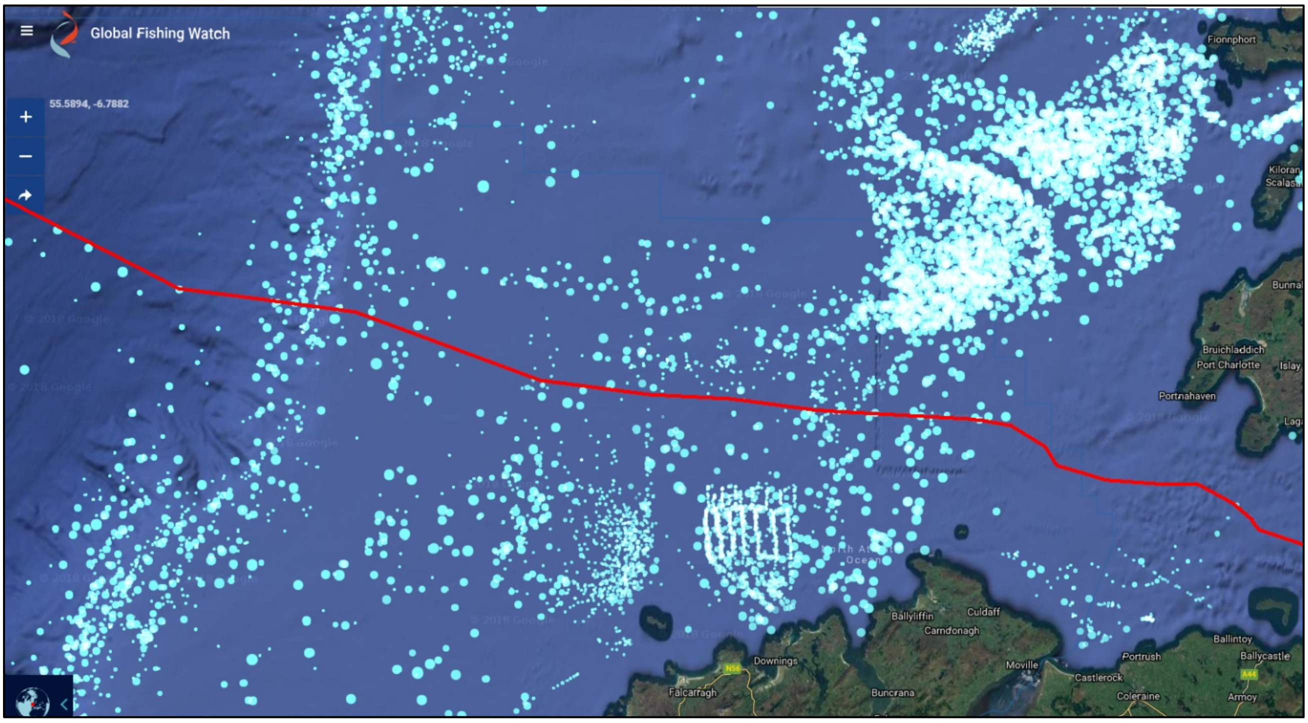

Figure 36: Fishing Density North of Ireland 2017 (Global Fishing Watch, 2018)

7.2.3.2 Scotland to Ireland

The northern section of the Scotland – Ireland route in the Firth of Clyde will experience the same high density of demersal trawling close to the LP and south of Arran (Figure 37).

West of the Rhins of Galloway, to approximately the latitude of Portpatrick, the cable passes through an area with a low density (<6 hours in 2016) of trawling and a low to medium level of dredge fishing by vessels from Northern Ireland (Figure 38). South of Portpatrick the cable is further inside the Beaufort's Dyke dumping ground (Section 7.5.1) and there is no reported bottom contact fishing.

An overview of major fishing grounds in the sea from Irish fisheries observers and VMS logs is given in Figure 39. Only scattered parts of the route are fished by dredging and effort is light but the entire offshore area is trawled. The cable route passes east of the main concentration of trawl fishing in the Irish Sea Prawn Grounds, which is located closer to the Irish coast, and west of a lesser concentration over an area of rocky seabed further south (Figure 40). The remainder of the route is heavily fished until a point around 20km offshore of the LP. This may be related to a reduction in the mud fraction in the seabed which means that it is no longer suitable habitat for prawns.

Inshore of Lambay Island there is a fishery for razor clams that makes use of hydraulic dredges (Figure 41). This overlaps with a pot fishery for lobsters and crabs that extends 4.5km offshore.

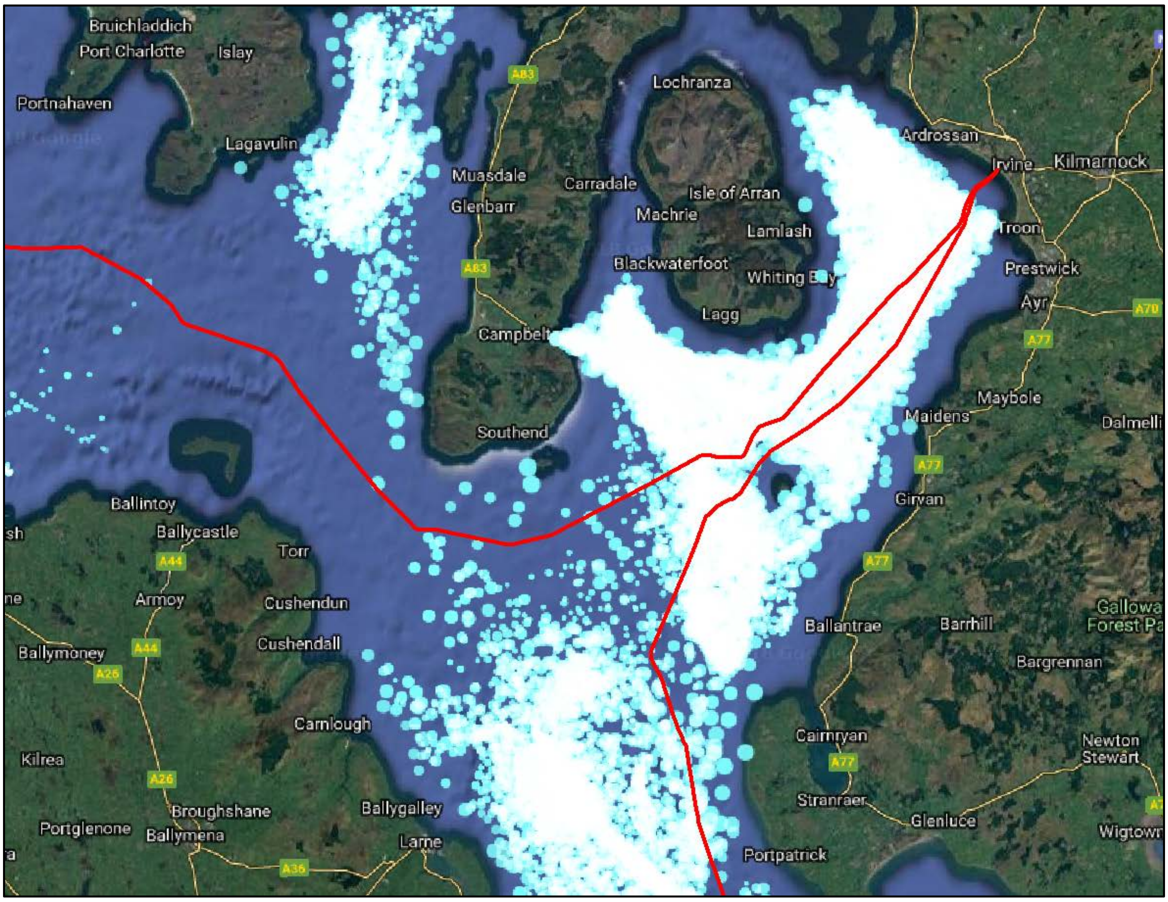

Figure 37: Fishing Density in the Firth of Clyde 2017 (Global Fishing Watch, 2018)

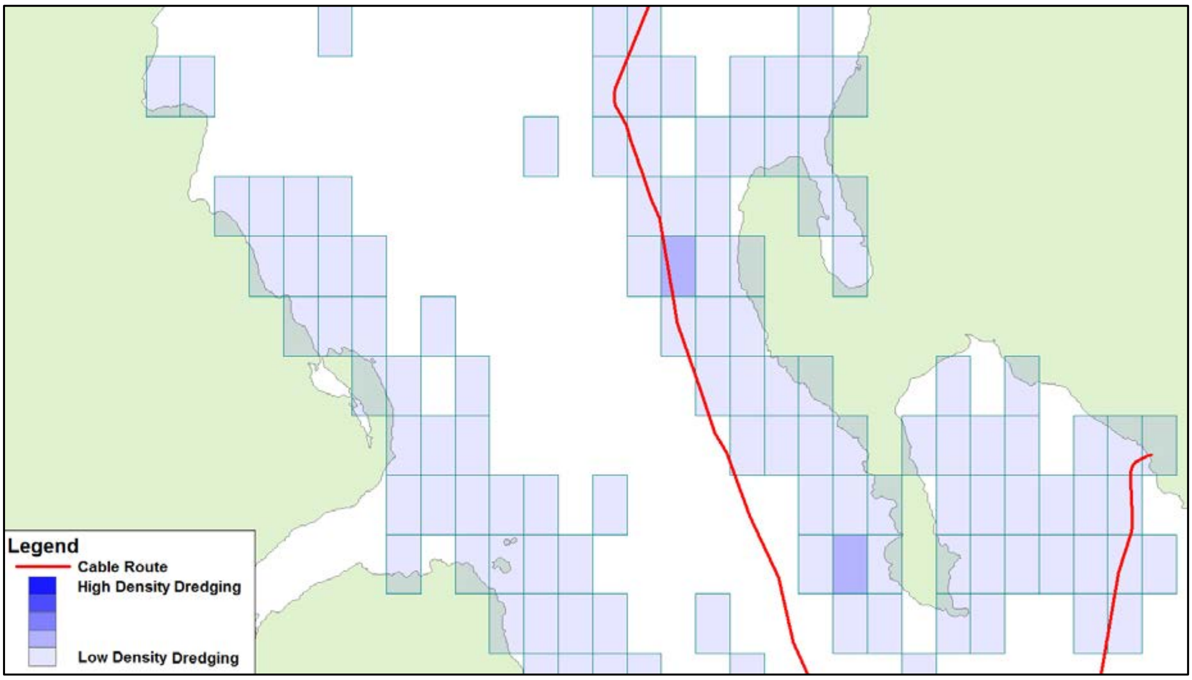

Figure 38: Dredge Fishing West of Stranraer 2016 (MMO, 2016)

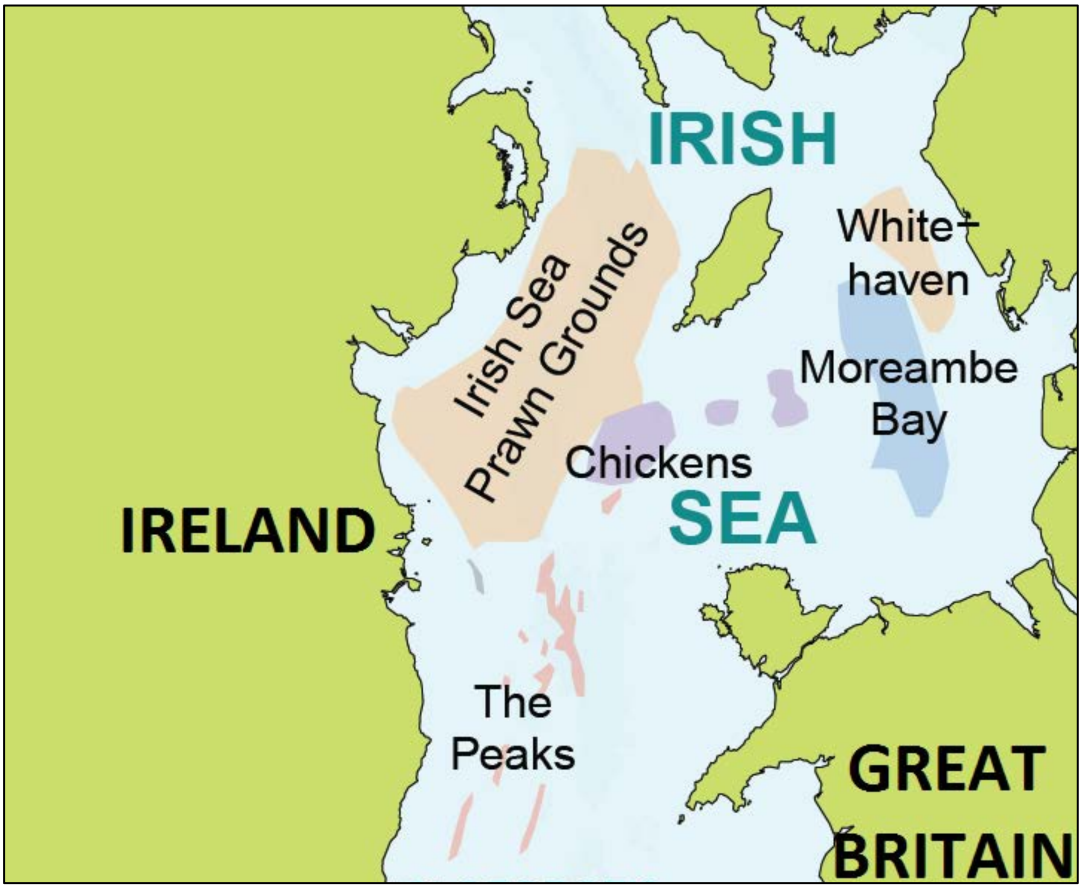

Figure 39: Major Irish Fishing Grounds of the Irish Sea (Marine Institute, 2014)

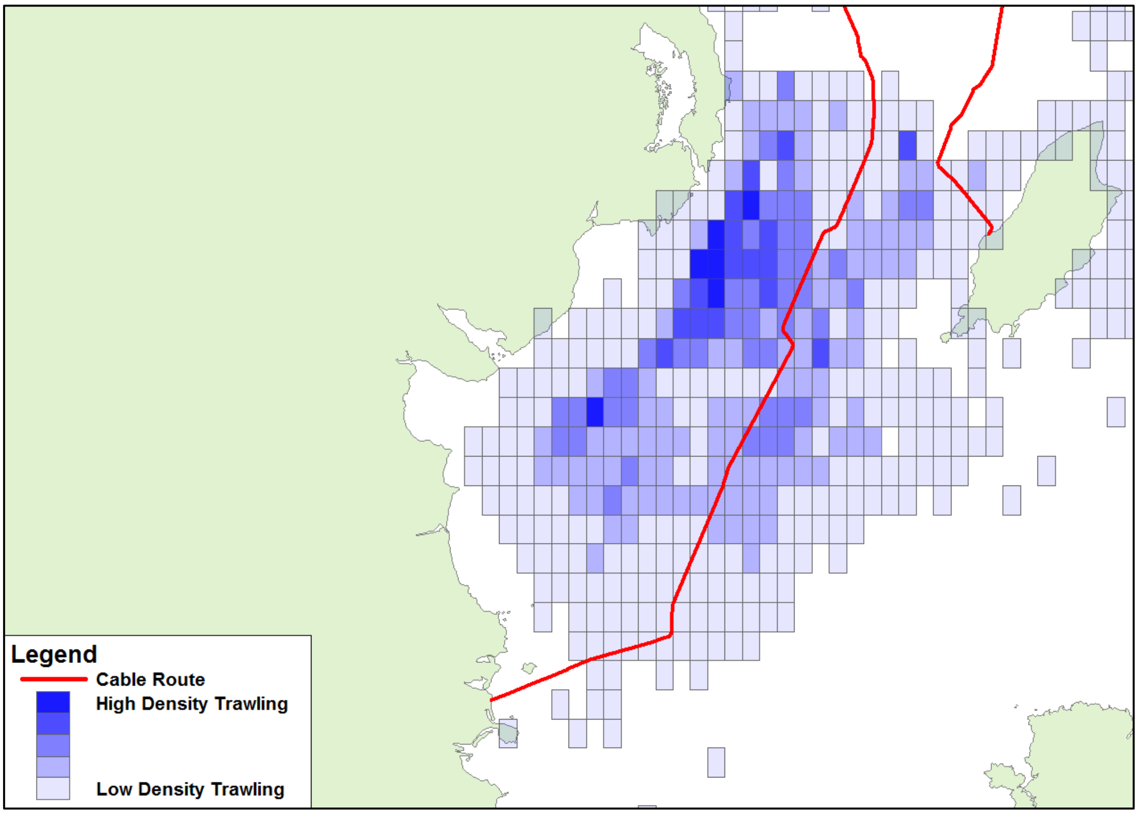

Figure 40: Trawl Fishing in the Western Irish Sea 2016 (MMO, 2016)

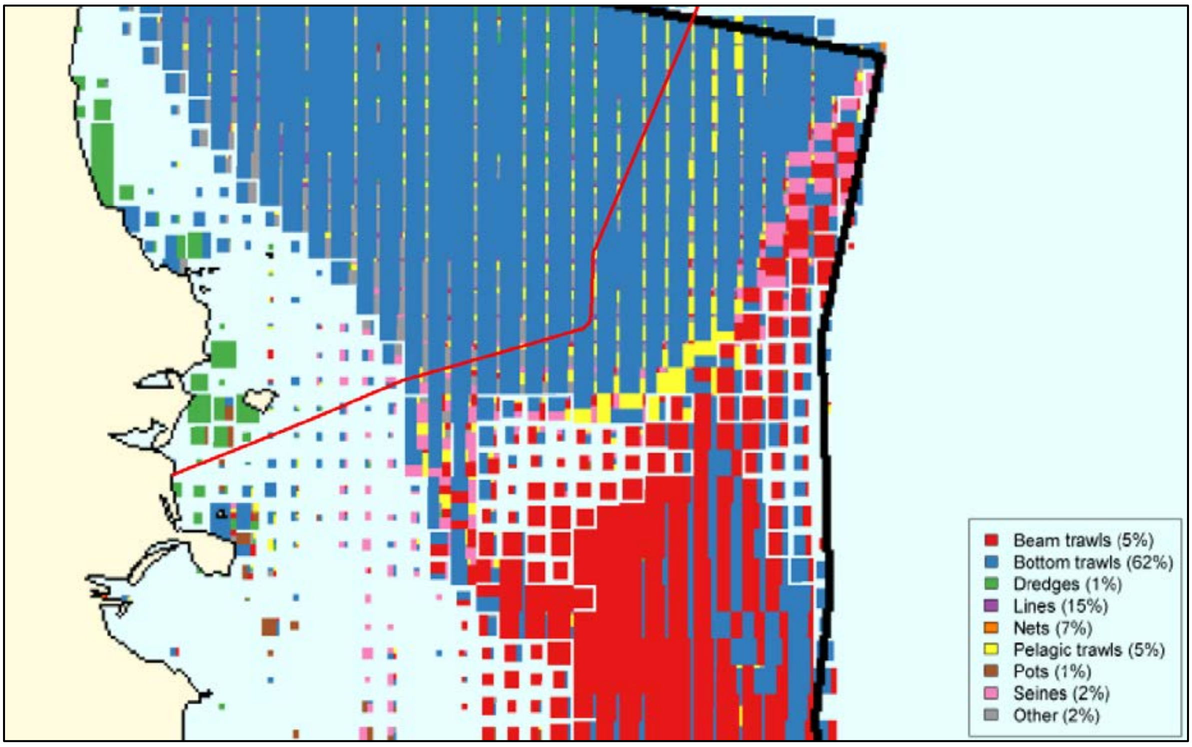

Figure 41: Irish Fishing Effort Close to Portmarnock (Irish Marine Atlas, 2018)

7.2.3.3 Scotland to IoM

Bottom-contact fishing activity north of the IoM is dominated by scallop dredging (Figure 42). This includes the most heavily dredged statistical area in the UK, with 52,198 minutes (870 hours) of activity in an area of 18.1km^2. The cable route avoids this area, although almost the entire cable route experienced some dredging in 2016.

Trawl fishing is much less common north of the IoM. The cable route is expected to be free of trawling in Scottish waters and in the northern part of the route within Manx waters. Closer to the island trawling activity begins to rise. It is heaviest in prawn grounds west of the island (Figure 39) and is relatively light close to the landing at Peel.

A small amount of potting takes place between the Isle of Man and Scotland, clustered around the maritime boundary between the two. It is low intensity, with only 116 minutes of activity in the statistical area closest to the cable route, and the cable avoids all areas fished by potting in 2016.

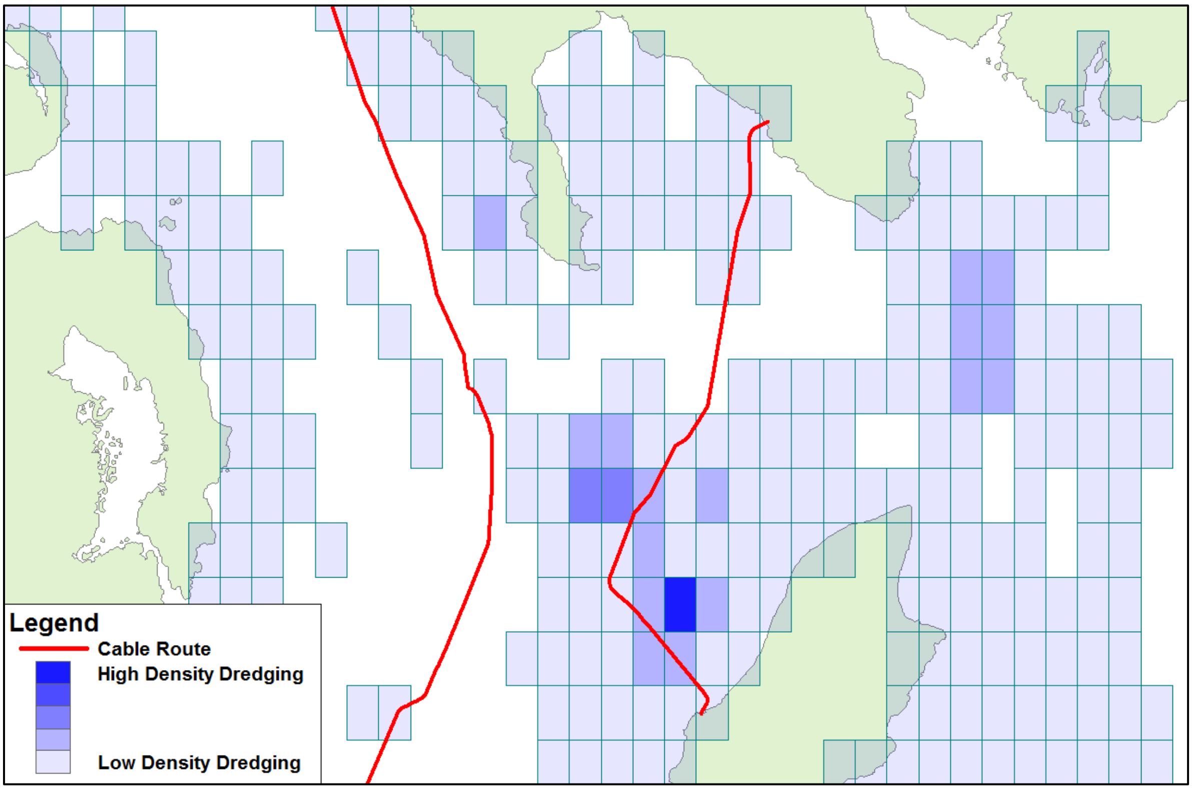

Figure 42: Dredge Fishing North of the IoM 2016 (MMO, 2016)

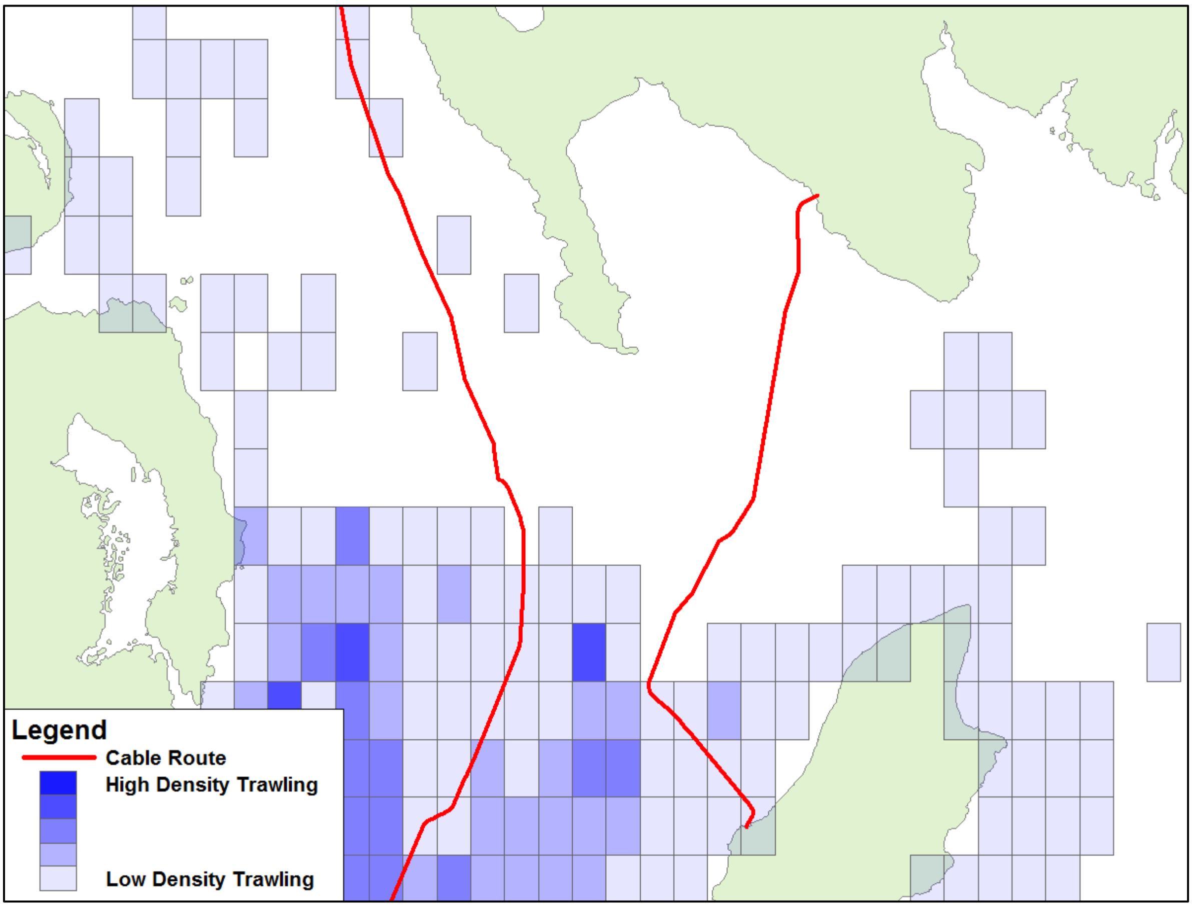

Figure 43: Trawl Fishing North of the IoM 2016 (MMO, 2016)

7.2.4 Summary for Fishing Impact

All segments of the cable system designed during this study will experience some hazard from the demersal trawl fishery, which is extremely widespread across the Scottish and Irish continental shelf. The two segments which enter the Irish Sea will also be at risk from dredging for molluscs. Other fisheries such as potting for crabs or lobsters pose a much lower risk.

FISHING METHOD	HAZARD	RISK LEVEL		
		INTERNATIONAL CONNECTION	SCOTLAND - IRELAND	SCOTLAND - IOM
Bottom trawling	Otter boards may snag cable	High	High	Medium
Scallop Dredging	Dredges may damage cable	High	Medium	High
Hydraulic Dredging	Designed to penetrate seabed	Very Low	Medium	Very Low
Pelagic Fisheries	Not designed to penetrate seabed. May damage cable during installation	Low	Low	Low
Pots and Other Static Gear	Obstacle to burial equipment. Common in the region	Low	Low	Low

Table 28: Summary of Risks to Cable from Fishing

7.3 Shipping and Anchorages

7.3.1 Introduction to Shipping and AIS Technology

Shipping traffic and other marine traffic may have an effect on route survey and installation operations, most notably in the vicinity of the landing site approaches with peaks in traffic during the summer months when fairer weather results in a larger volume of shipping traffic movements. It can also impact on cable security on occasion of emergency anchoring or anchorages near ports at cable LPs. Avoidance of major shipping routes is advisable but not always achievable.

Use of modern geographic information systems and access to AIS data allows us to view the shipping movements in a region and carry out analysis of shipping and its potential impact on the cable route.

AIS is a maritime navigation safety communications system adopted by the International Maritime Organization (IMO) to provide vessel information, primarily for the purposes of maritime safety. AIS data provides a source of information which can be used to spatially represent vessel movements. A network of terrestrial receivers is able to detect AIS signals but they have a limited range of between 15 and 40 nautical miles, depending on the height of the antenna. Satellite receivers are able to extend the coverage of AIS signals beyond the terrestrial network, but their effectiveness is hampered somewhat by their inability to process the large volume of AIS signals within the satellite's reception footprint. A basic overview of AIS coverage in northwest Europe is shown in Figure 44.

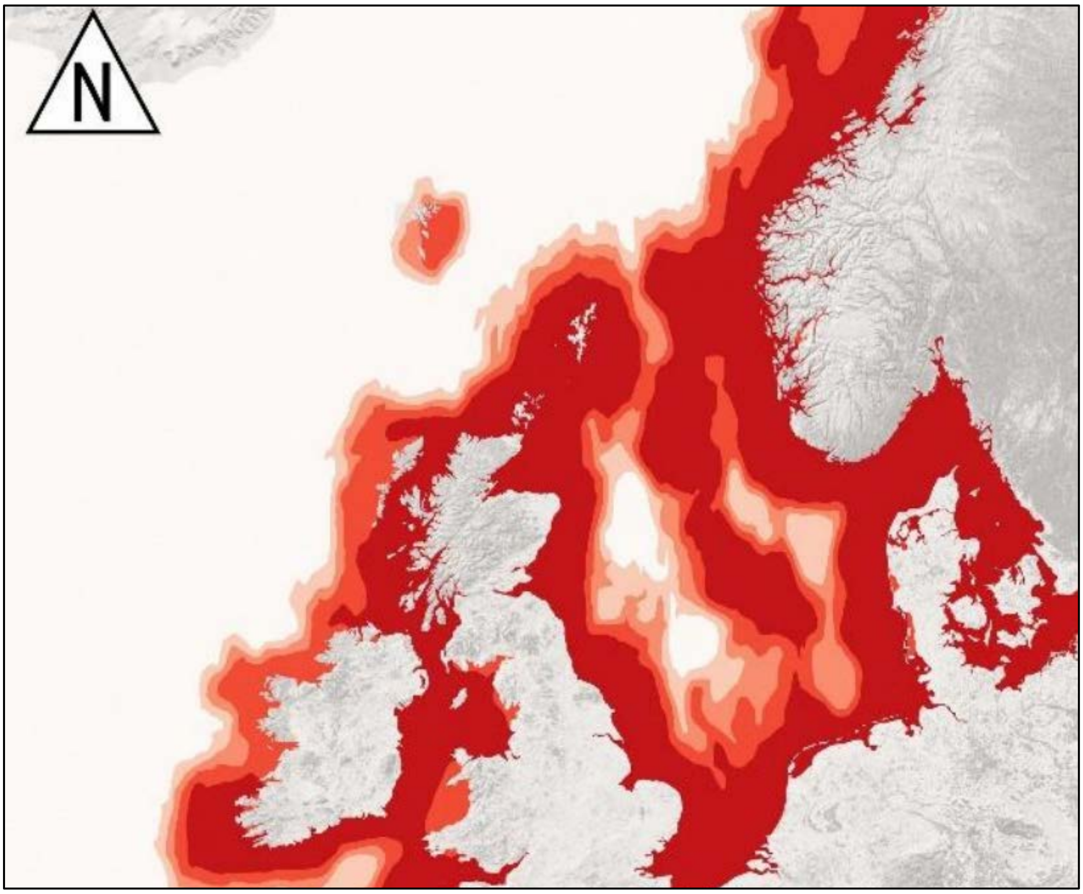

Figure 44: AIS coverage North West Europe (Vespe, et al., 2015)

7.3.2 Risk from Anchors

Anchors can be very damaging to cable systems because of their strength and the depth to which they can penetrate the seabed. Anchors are used for a wide variety of tasks ranging from the positioning of fishing gear through to the mooring of large merchant ships and the permanent fixture of offshore platforms used in the oil and gas industry. It has even been known for a metocean data buoy mooring to drag its anchor and damage a fibre optic cable, although such events are rare. The connection between shipping movements and anchors is simple – the probability of an anchor incident rises in areas where the route is crossed by high levels of traffic, or in close proximity to official and unofficial anchorages.

The risk to the cable from anchors is mainly posed by merchant vessel anchors. These might be deployed directly on top of the cable, although this is a rare occurrence. More likely, a dragged anchor either during deployment and recovery or an anchor deployed in error whilst a vessel is underway may catch the cable.

A risk also exists from vessels deploying anchors when their propulsion system is not working and they lose control of their position keeping. In emergency circumstances like these the anchor may be deployed to prevent a marine incident developing. In such circumstances if the weather is poor or the currents are strong locally the anchor may be dragged over the seabed.

In order to assess the threat to cables from ships anchors it is necessary to examine the design features of anchors, their size and uses. The variations affect the penetration into the seabed. The range of ships anchors in use is vast but the majority are bow type.

In general a ship's anchor in good ground penetrates one fluke length, equivalent to 2.2m for the largest anchors (Figure 45). Of course in soft seabeds greater penetration is to be expected. The penetration of approximately one fluke length in a sandy seabed was confirmed in thorough trials by Deltares in the North Sea (Deltares, 2013).

ANCHOR TYPE	PENETRATION (MULTIPLES OF FLUKE LENGTH)	
	SAND/STIFF CLAY	MUD/SOFT SILT/CLAY
Stockless	1	3
Moorfast, Offdrill 2	1	4
Boss, Danforth, Flipper Delta, GS Type 2, LWT, Stato, Stevfix*, Stevpris*	1	4.5
Bruce*, Bruce TS*, Hook*, Stevmud*	1	5

*Anchors more appropriate to permanent moorings.

Table 29: Anchor Fluke Tip Penetration (Shapiro, et al., 1999)

The risk of an anchor hooking a cable is not only related to its penetration but also the distance over which it disturbs the seabed. The initial drag distance required by an anchor to develop its full holding capacity is therefore an important parameter governing the risk to submarine cables. In this respect many anchors are similar in taking 20 to 30 times the fluke length to reach 90% of their full pull out strength. This means that the chance of hooking a cable increases with anchor size by virtue of both its penetration and drag distance.

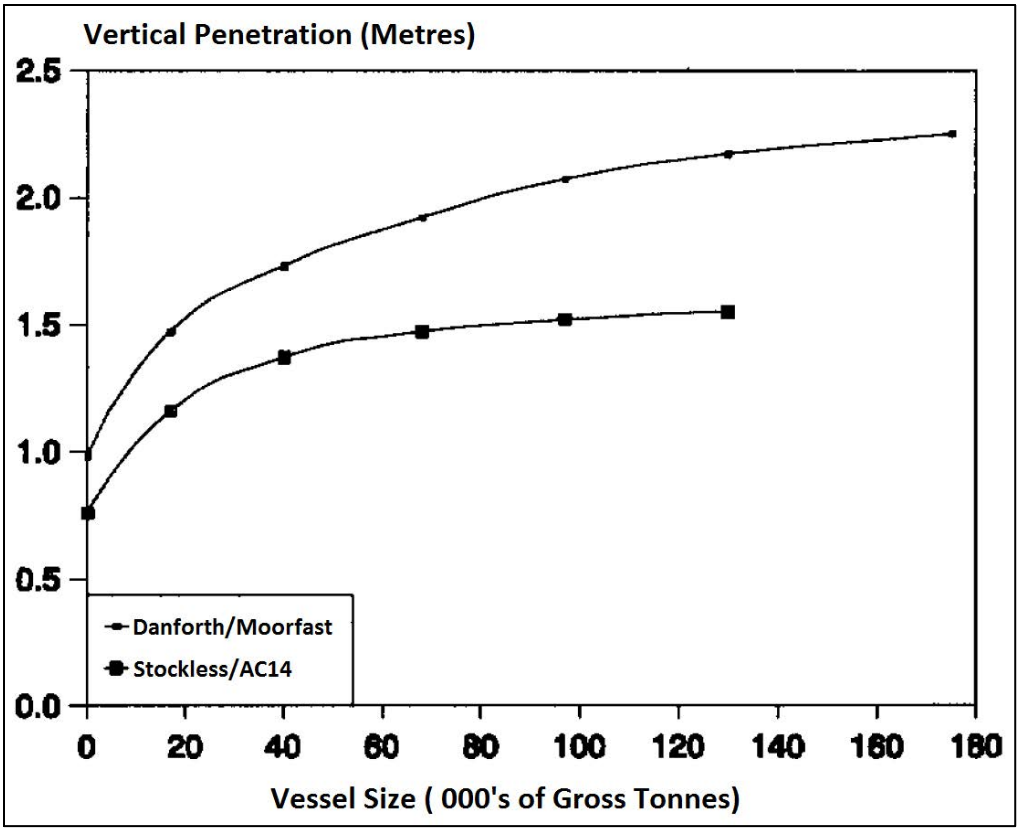

Figure 45: Anchor Penetration (m) vs Vessel Size (GT) in Firm Ground (Shapiro, et al., 1999)

An important consideration when assessing the potential risk from ships anchors is the depth of water in which the threat exists of an anchor engaging a cable. Due to the finite length of anchor chain used on vessels, it is unlikely that shipping anchor incidents will occur in water depths greater than 50m, which is a typical upper limit on the depth of water for merchant vessels anchoring, unless it is in an emergency situation.

7.3.3 Anchorages

As explained in Section 7.3.2 anchors are a direct threat to submarine cables, especially large vessel anchors. There are no charted anchorages that would pose a risk to the proposed cable routes.

The cable passes north of a small vessel anchorage offshore of Port William in approximately 3m water depth. According to a local planning officer of the Dumfries and Galloway Council, this anchorage is not used by leisure craft but it occasionally used by locally based small fishing vessels that range from 7 - 11m in length. This anchorage is a short term anchorage that ensures safe passage into Port William Harbour when the light or tidal conditions do not permit safe entry. Small vessel anchors are not expected to be a significant risk to the cable if burial is achieved to beyond 0.5m. If this burial cannot be achieved then consideration should be given to protecting the cable with articulated pipe (AP) near to the anchorage.

The burial of the cable near to the Scottish, Irish and Manx coasts is expected to be sufficient to protect it from smaller recreational vessels that may anchor outside of designated anchorages.

7.3.4 Shipping

The Irish Sea, North Channel and northwest of Scotland are very busy areas for shipping traffic, where vessels are engaged in the transportation of goods and people combined with marine industries such as fishing, oil and gas, transport and marine renewable power.

All three of the proposed cable routes are unavoidably located in an area of intense shipping traffic all year round (see Figure 46). The approaches to Dublin, Belfast and the Firth of Clyde are the regions where shipping traffic is most concentrated. It would be impossible to avoid these regions and shipping remains a continuous although very low risk to the proposed cable system.

The LP option in Port William is the area where vessel intensity is the lowest and this is primarily due to the fact that there are no large trading ports situated within Luce Bay. As the route progresses further offshore of Luce Bay the route will inevitably cross the international shipping lane that connects northwest England with Ireland and the rest of the Atlantic.

The LP in Portmarnock, Ireland has avoided the primary shipping approaches into Dublin which has somewhat reduced the potential risk however as shown in Figure 47, the region is still extremely busy. Offshore of Ireland, the cable is routed in-between two small dots where AIS traffic is abnormally low, surrounded by a ring of higher traffic. This is because there are two charted wrecks (in water depths of 92 and 67m) and the activity seen suggests that the bottom trawling industry is relatively concentrated in this region due to aggregations of fish around the wrecks. The cable route has avoided this area by 2km.

As shown in Figure 48, if the cable is going to be routed from Dunnet Bay, it will need to cross an intensely busy shipping lane that connects the North Sea with the Atlantic Ocean however, the surface area of the cable route that crosses this shipping lane is relatively low. The Ullapool LP is situated within a very narrow channel that leads into Loch Broom thus shipping traffic is also high in this region however it is still judged to be a viable LP for a cable system.

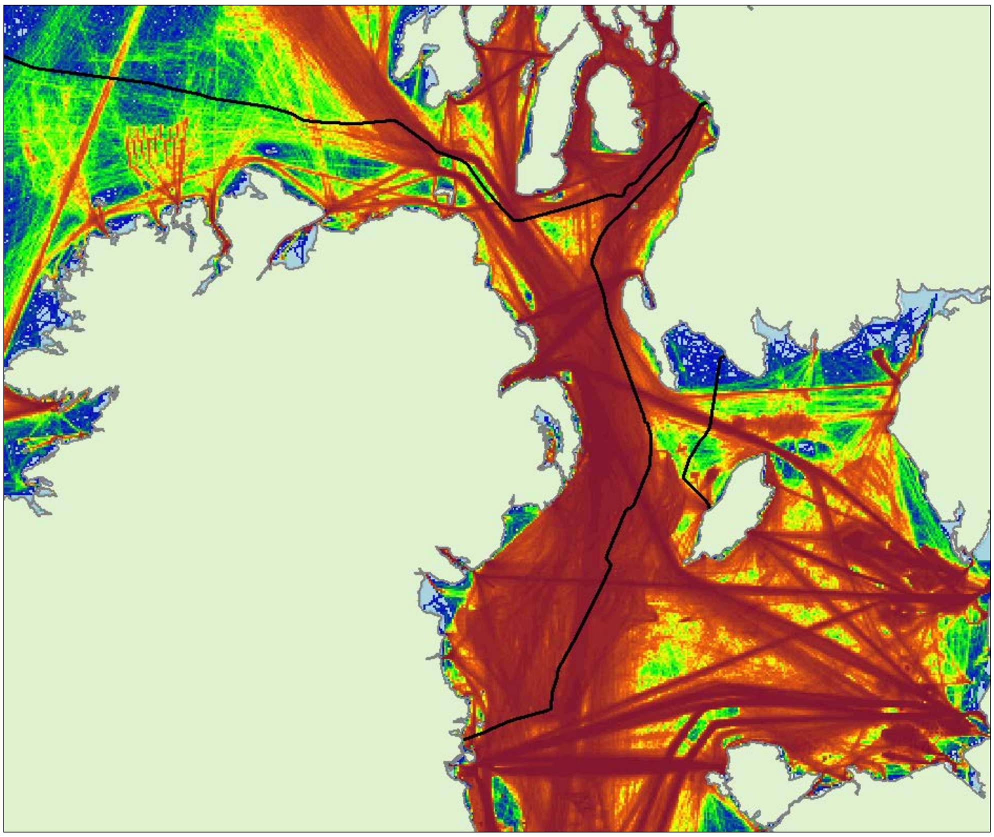

Figure 46: Irish Sea Marine Traffic (MarineTraffic, 2015)

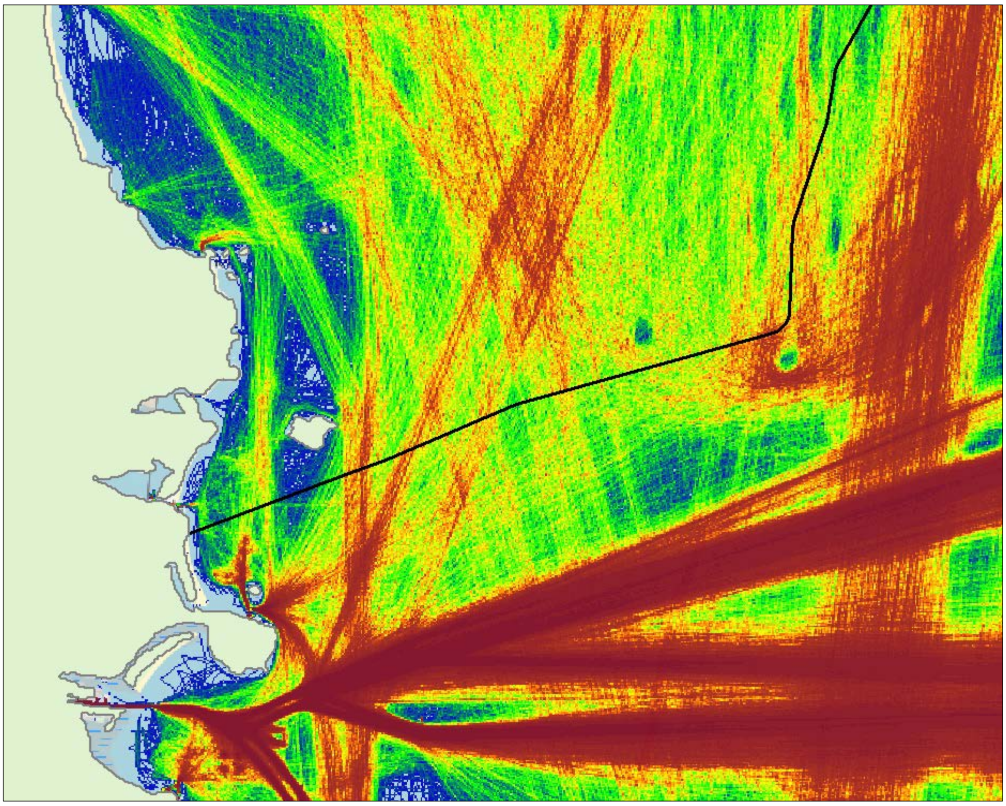

Figure 47: Dublin Marine Traffic (MarineTraffic, 2015)

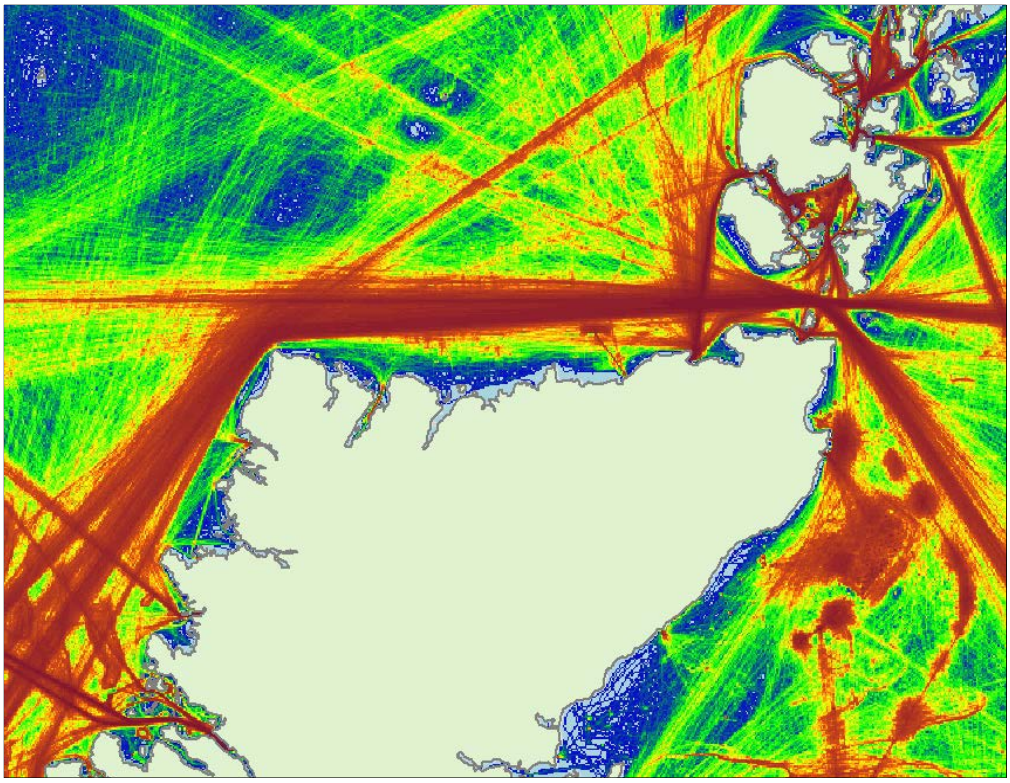

Figure 48: Northern Scotland Marine Traffic (MarineTraffic, 2015)

7.4 Wrecks and Obstructions

Wreckage presents an abrasive threat, and may hold the cable in suspension from the seabed. Subsequent secondary entanglement with fishing gear is another risk to a cable laid over wreck sites. It is also possible that shipwrecks found in shallow water areas may be considered of archaeological importance.

Wrecks and obstructions are widespread in the region of interest. There are particularly high densities in the sea-lanes to Glasgow from America, in the north-western Irish Sea and in the approaches to Dublin. The following wrecks databases were searched and the data are presented below:

- SeaZone Wrecks Database winter 2015 edition.
- Veridian Systems Worldwide Wreck database 2007 edition.

Data on offshore wrecks from the SeaZone database in the region found a total of 19 objects within 750m of the cable routes compared to five in the Veridian database, however the Veridian database records some wrecks which are not found in the SeaZone catalogue. Data from all the sources are combined in the table below to ensure the best achievable capture of wreck locations.

The positional accuracy of these records is variable due to the variety of survey techniques used. Unknown or mispositioned wrecks may be found during the cable route survey. If so, careful route planning and route development work should be considered to avoid disturbing wrecks. GM advise that any shipwrecks found during survey operations are avoided by a distance of at least 1 x water depth, preferably at least 500m.

ROUTE	DATABASE	TYPE	NAME	LATITUDE	LONGITUDE	WATER DEPTH	CABLE OFFSET
Scot - IoM	SeaZone	Wreck	Eileen	54.227°N	004.685°W	0m	301m
	SeaZone	Wreck	Scallywag	54.667°N	004.626°W	24m	549m
	SeaZone	Obstruction	N/A	54.228°N	004.694°W	5m	291m
Transatlantic Connection	Veridian	Wreck	Unknown	55.262°N	005.380°W	37m	726m
	SeaZone	Obstruction	N/A	55.570°N	006.953°W	32m	260m
	SeaZone	Wreck	Unknown	55.196°N	005.558°W	100m	526m
	SeaZone	Obstruction	N/A	55.308°N	005.159°W	31m	744m
	SeaZone	Obstruction	N/A	55.313°N	005.153°W	50m	743m
	SeaZone	Obstruction	N/A	55.333°N	005.127°W	55m	660m
	SeaZone	Obstruction	N/A	55.349°N	005.092°W	51m	360m
	SeaZone	Wreck	Copia	55.557°N	004.772°W	48m	595m
Scot - Ireland	SeaZone	Wreck	Unknown	55.561°N	004.745°W	44m	345m
	Both	Wreck	Bonvilston	55.073°N	005.356°W	61m	736m
	Veridian	Wreck	Sanolhurst	55.033°N	005.333°W	10m	749m
	SeaZone	Wreck	Unknown	55.022°N	005.348°W	100m	508m
	Veridian	Wreck	Unknown	54.952°N	005.288°W	22m	685m
	SeaZone	Wreck	Unknown	54.299°N	005.745°W	73m	603m
	Both	Wreck	Audentia	54.284°N	005.106°W	127m	631m
	SeaZone	Wreck	Lustre	54.167°N	005.217°W	90m	273m
	SeaZone	Wreck	Unknown	53.509°N	005.757°W	73m	603m

Table 30: Wrecks and Obstructions

7.5 Dredging and Dumping Zones

Dredging and dumping operations have a direct impact on the seabed and therefore are a potential threat to the cable’s route survey, installation and future security and any area where dredging takes place should be avoided. The most up to date hydrographic charts were reviewed and no known or charted offshore dredging takes place near the cable landing at Irvine in Scotland, the Firth of Clyde or its associated route into Portmarnock, Ireland where many other cables share the same LP. This is also the case for the cable route from Port William to the IoM with the exception of the maintenance of navigational channels and ports (IoM Government, 2013). In 2014/2015, 18,000 tonnes of silt were removed from within Peel Marina however; no works have been conducted where existing cables are present.

As long as the cable is clearly marked on admiralty charts following installation, the risk of dredging in this area is negligible. All areas that have been charted for dumping have also been avoided, with the exception of Beaufort’s Dyke.

7.5.1 Beaufort's Dyke

Beaufort's Dyke is the most significant bathymetric feature that is crossed by the Scotland to Ireland cable route and is essentially a submarine depression that has a maximum water depth of 312m. Between 1918 and 1976 over 1.3 million tonnes of ordinance and UXO are thought to have been dumped in Beaufort's Dyke making this area one of the largest munitions dumping areas in the world. The Scotland to Ireland cable system routes straight through the dyke and will be surface laid over the region to avoid disturbing any UXO. As UXO and munitions are no longer dumped in this area, this is a suitable area for the cable to be surface laid across. Any significant bathymetric variations discovered during the survey should be highlighted to avoid cable free spans but the seabed is likely to be very smooth due to the influence of the currents over the past 100 years. For UXO risk in Beaufort's Dyke, see Section 7.9.1.

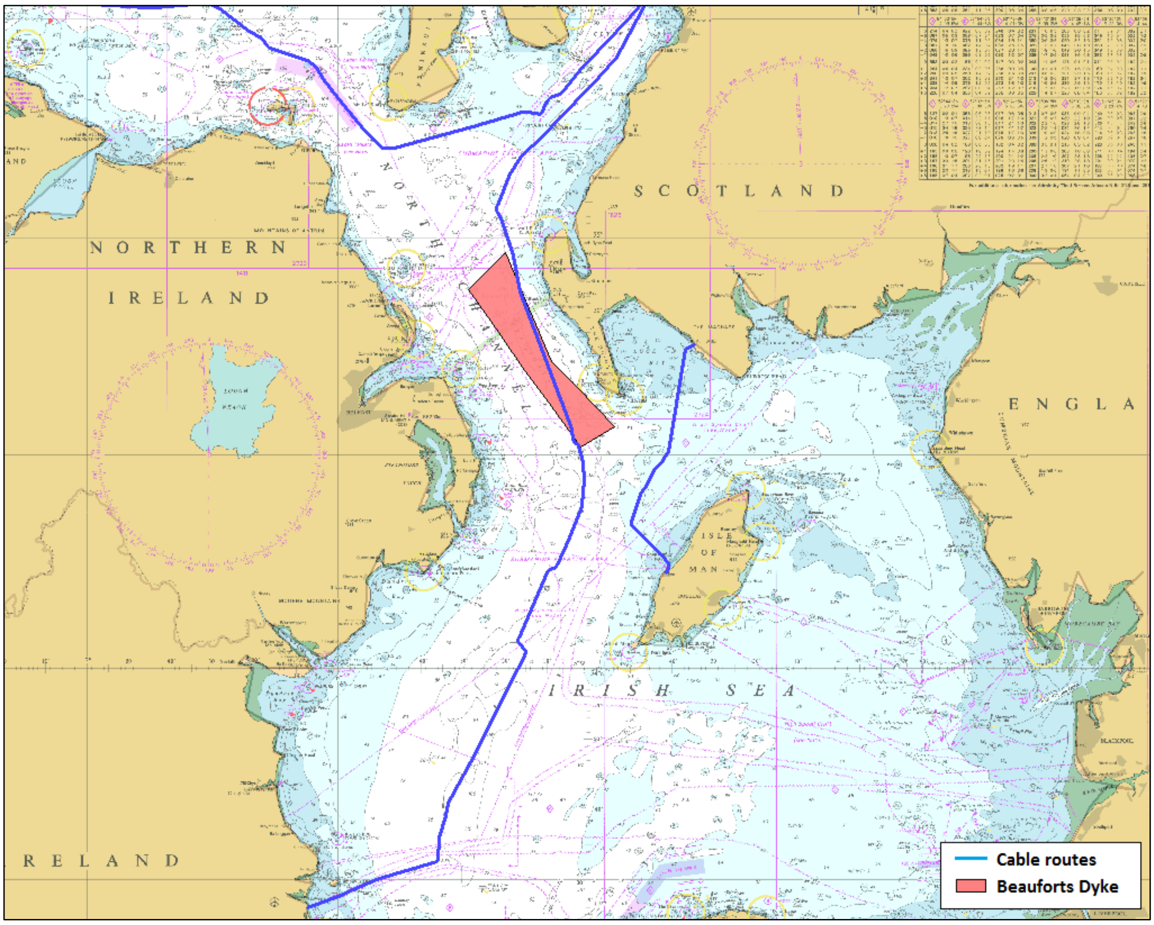

Figure 49: Beaufort's Dyke Munitions Dumping Area 1918 - 1976

7.6 Renewable Energy

The offshore renewable industry is expanding and has become a common use of today's sea, particularly in Europe; therefore a spatial review is required along the entirety of the cable route and the other alternative LP options to highlight any potential conflicts with any existing or proposed renewable energy infrastructure. Figure 50 shows the latest and most up to date renewable energy zones in the Irish Sea with spatial data sourced from the Crown Estate and Scottish Crown Estate.

None of the three cable route options conflict with any existing or proposed offshore wind farm areas nor do they conflict with any of the alternative LP options. The proposed Dublin Array Offshore Wind Farm located on Kish Bank will be the nearest wind farm to the Scotland - Ireland route option, planned for operation in 2019 – 2021. The wind farm will be installed approximately 11km south east of Dublin Bay (see Figure 50) with its export cables intended to land near Carrickmines substation which is around 21km south of proposed LP at Portmarnock (Dublin Array, 2016).

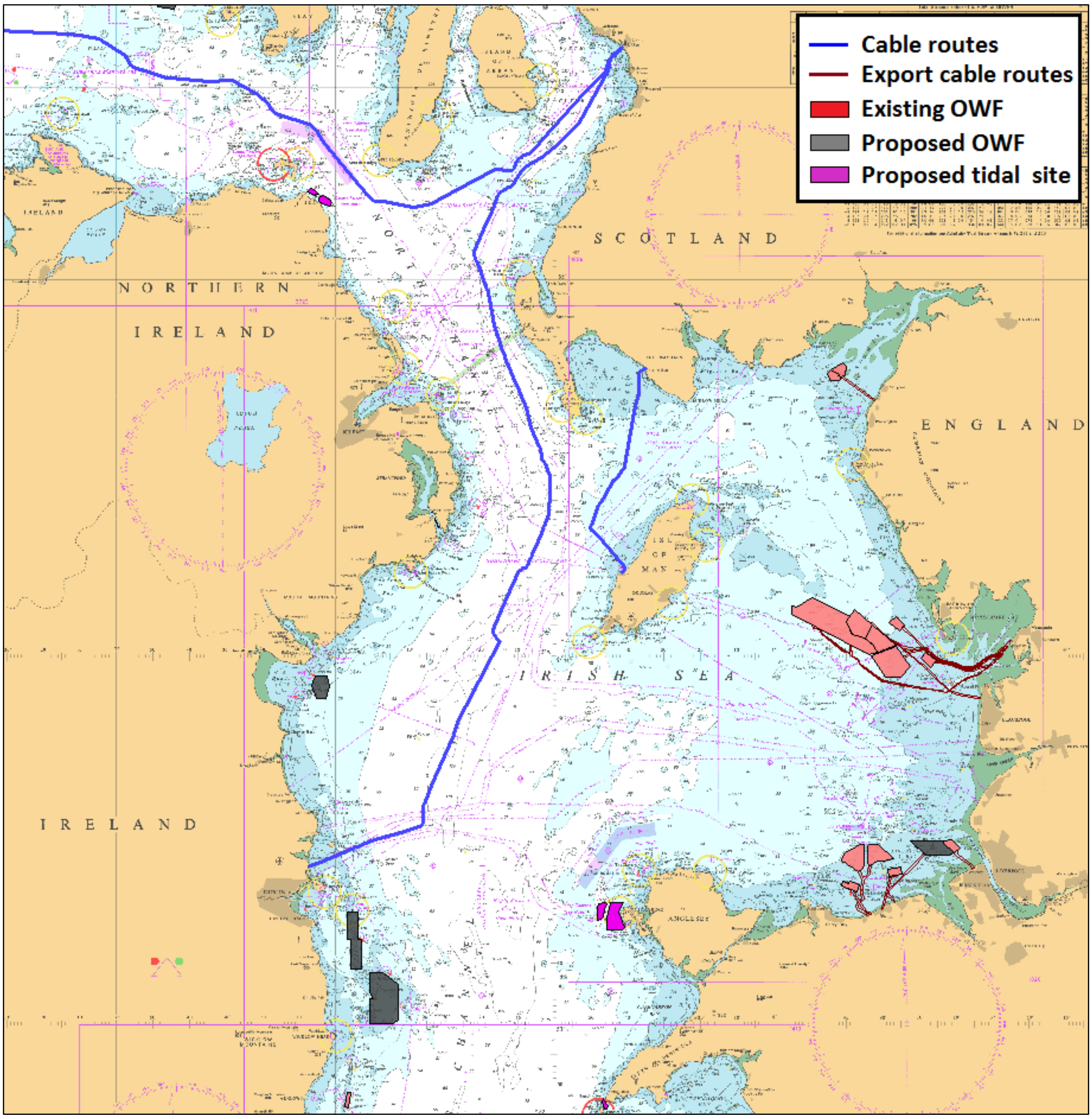

Figure 50: Planned and proposed OWF developments in the Irish Sea and North Channel

As the Irish Sea is naturally sheltered from Atlantic swell, there are no sites designated for wave energy in the Irish Sea or within the North Channel. The Transatlantic Connection route runs approximately 9km to the northeast of the Fair/ Torr Head tidal lease site situated in the northeast of Northern Ireland however the cable route will not conflict with the project and is very unlikely to be installed before 2020.

7.7 Hydrocarbon Exploitation

7.7.1 Oil and Gas Developments

The hydrocarbon industry has a large footprint in the marine environment and any areas where hydrocarbon activity or infrastructure is located should be avoided as much as possible. This will avoid any potential conflicts at a later date however it is impossible to completely avoid all infrastructure such as pipelines. The hydrocarbon industry is relatively limited in the region with the majority of activity and exploration located in the east of the Irish Sea offshore of Liverpool Bay. The industry has therefore had little effect on the actual routeing of the cable however the cable routes avoid all historic drilling well heads by at least 1km. The most up to date spatial data sourced from Oil&GasUK was used during the implementation of this study and in the production of Figure 51 below.

7.7.2 Lease Blocks

The Irish and UK (including the Isle of Man) continental shelves have been divided up into lease blocks to facilitate the exploration and production of oil and gas fields. The current cable routes will not pass through any blocks that are operated or owned by any companies which suggests that any significant reserves are absent in this region. Prior to survey and installation, a review of all operational hydrocarbon blocks is required in the event that after the draft of this study, a company has conducted further exploratory drilling or has started operating an additional hydrocarbon block. When provided with the final cable RPL prior to installation but post survey, block operators should be able to indicate whether there will be any drilling activity close to the cable in the near future, in which case the cable may need to be rerouted accordingly.

7.7.3 Drilling Activity

Both exploratory and production wells exist in close proximity to the cable route. Well heads pose a similar threat to a submarine cable as an isolated rock outcrop. They can potentially damage installation equipment such as a plough or cause abrasion of the outer cable layers leading to faults if the cable is laid over the wellhead. There is the additional hazard of spudcan depressions left by the drilling rig which may damage or trap a plough or cause the cable to remain in suspension. Where the well locations are known they have therefore been avoided by at least 1km to allow the cable to be rerouted freely within the survey swathe. Where this has introduced a significant deviation to the route it is detailed in Section 10.7. Care should be taken during the marine survey to identify any unmarked wells in side scan sonar and magnetometer recordings. The cable should then be rerouted to avoid any additional wells that are found. A database of known well locations held by Oil&GasUK was reviewed in relevance to the cable route which has avoided all wells by at least 1km.

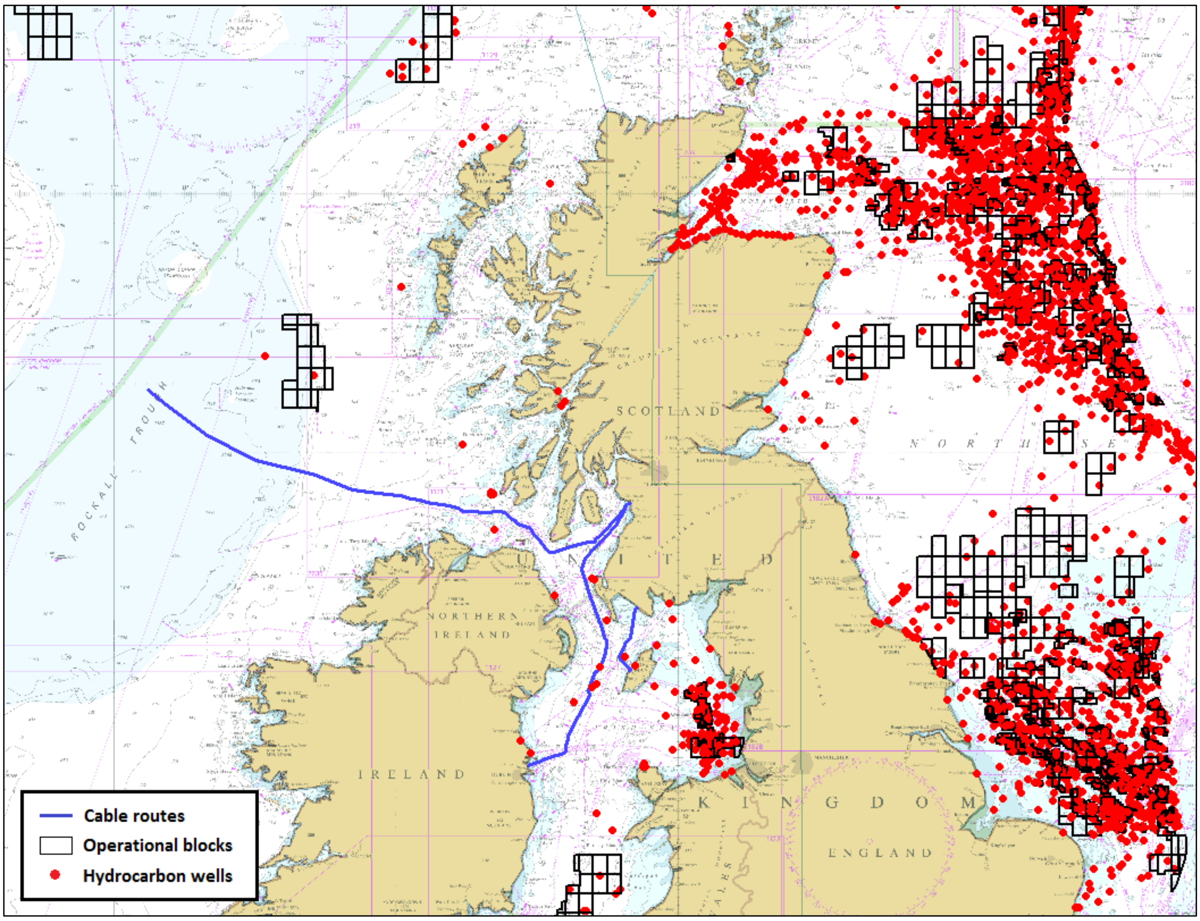

Figure 51: Hydrocarbon blocks and wells

7.7.4 Pipelines

There are various pipelines in this region that have been considered when designing the cable routes. An overview of the pipelines in the region assembled from all sources including UKHO charts and Oil&GasUK is shown in the charts included as Appendix 13.11. For the Scotland to Isle of Man route there are two pipeline crossings, for Scotland to Ireland, there are three pipeline crossings and for the Transatlantic Connection route there are zero pipeline crossings.

Each of these crossings (see Table 31 below) will require detailed engineering. Sample crossing methodologies for these pipelines are given in Section 10.6.4 but the exact protection required will need to be negotiated with the individual pipeline owners and confirmed in a crossing agreement prior to installation. The ICPC guidelines for carrying out pipeline crossings can be found in ICPC Recommendation No. 3.

CABLE ROUTE	FLUID	DIAMETER	CROSSING LOCATION		OPERATOR
			LATITUDE	LONGITUDE	
Scotland – Isle of Man	Gas	24”	54°19.9133’N	04°49.1780’W	Gas Networks Ireland
Scotland – Isle of Man	Gas	30”	54°18.9103’N	04°47.4094’W	
Scotland - Ireland	Gas	24”	54°58.4814’N	05°18.5947’W	Premier Transmission
Scotland - Ireland	Gas	30”	54°03.2515’N	05°16.2839’W	Gas Networks Ireland
Scotland - Ireland	Gas	24”	53°35.0431’N	05°36.0781’W	Gas Networks Ireland

Table 31: Active pipeline crossings

7.8 Submarine Cables

Submarine cables are the most common type of infrastructure encountered on the seabed. There are numerous existing and out-of-service (OOS) cables that will inevitably be crossed by the proposed cable systems. Broadly, these can be broken down into fibre optic cables, OOS cables, power cables and umbilical cables. Umbilical cables are closely related to the oil and gas industry and due to there being a relatively low level of activity and associated infrastructure in this area; no umbilical cables have been crossed by any of three proposed cable systems.

Crossing agreements should be negotiated for all in-service cables crossed, details of the installation procedure should also be forwarded to the relevant companies once finalised.

As shown in Table 32 below, the Transatlantic Connection and Scotland to Ireland cable routes cross several known telegraph cable and coaxial routes but no crossing agreements are necessary and these will be cleared for installation of the two new cables.

7.8.1 Telecommunication Cables

The details of crossed telecommunications cables are contained in Table 32 and Table 33 below. Full coordinates and crossing angles are supplied as part of the crossing list in the RPLs in Appendix 13.10. In summary, the Scotland to IoM cable system has no in service or OOS cable crossings, the Scotland to Ireland cable system has 12 in service and 5 OOS crossings and the Transatlantic Connection Cable system has 5 in service and 3 OOS crossings.

Contact details given in Table 32 and Table 33 below are to the best of GMG’s knowledge however it is recommended that any initial contact is prefaced with a request to be directed to the right person.

Global Marine are aware of several planned cable systems in this area and these are included in the RPLs an crossing lists in Appendix 13.10 however the positions of these crossings should be regarded as speculative.

CABLE ROUTE	NAME	CROSSING TYPE	COORDINATES	OWNER/CONTACT
Scotland to Ireland Cable	Lanis Seg C	Fibre Optic	55˚33.4708’N 04˚45.1432’W 55˚14.3430’N 05˚13.0674’W	Vodafone Jon Ford Mob: +44 (0) 7776 165571 Jon.ford@vodafone.com
	Scotland – Northern Ireland 2		55˚03.0310’N 05˚21.5123’W	Richard Hill BT Subsea Centre of Excellence Mob: +44 (0) 7711 191849 Richard.4.Hill@BT.com
	Lanis Seg C		55˚00.5874’N 05˚19.9235’W	Vodafone Jon Ford Mob: +44 (0) 7776 165571 Jon.ford@vodafone.com
	Knock Bay-Whitehead	OOS Telegraph	54˚52.8906’N 05˚16.6629’W	Unknown - no crossing agreement required
	Port Kale-Whitehead		54˚50.0988’N 05˚15.0783’W	
	Donaghadee-Port Kale No3		54˚49.2529’N 05˚14.5793’W	
	Donaghadee-Port Kale No1		54˚48.0489’N 05˚13.8693’W	
	Scotland-Northern Ireland 1	Fibre Optic	54˚46.5816’N 05˚12.7813’W	Richard Hill BT Subsea Centre of Excellence Mob: +44 (0) 7711 191849 Richard.4.Hill@BT.com
	Donaghadee-Port Kale No2	OOS Telegraph	54˚44.0313’N 05˚10.9556’W	Unknown - no crossing agreement required
	Hibernia Seg A	Fibre Optic	54˚32.8132’N 05˚03.8946’W	Peter Maxwell VP Network Delivery and Support Hibernia Networks Tel: +353 1 867 3652 Email: peter.maxwell@hibernianetworks.com
	LANIS Seg B		54˚20.5989’N 05˚03.2356’W	Vodafone Jon Ford Mob: +44 (0) 7776 165571 Jon.ford@vodafone.com

	MANX IOM-NI		54°16.1379’N 05°06.3894’W	Richard Hill BT Subsea Centre of Excellence Mob: +44 (0) 7711 191849 Richard.4.Hill@BT.com
	Ballyhornan-Port Erin No3	OOS Coaxial	54°07.9653’N 05°14.2111’W	Unknown - no crossing agreement required
	Hibernia seg C	Fibre Optic	53°34.0366’N 05°36.1383’W	Peter Maxwell VP Network Delivery and Support Hibernia Networks Tel: +353 1 867 3652 Email: peter.maxwell@hibernianetworks.com
	Sirius South		53°33.5569’N 05°36.1670’W	Virgin Media
	Hibernia seg C		53°29.0682’N 05°54.5052’W	Peter Maxwell VP Network Delivery and Support Hibernia Networks Tel: +353 1 867 3652 Email: peter.maxwell@hibernianetworks.com
Transatlantic Connection Cable	Lanis Seg C	Fibre Optic	55°33.4281’N 04°45.6937’W	Vodafone Jon Ford Mob: +44 (0) 7776 165571 Jon.ford@vodafone.com
			55°17.1932’N 05°13.0256’W	
	Sirius North		55°17.2587’N 05°14.7013’W	Virgin Media Peter Jamieson Mob: +44 (0) 148432 0021 Peter.jamieson@virginmedia.co.uk
	Hibernia Seg A		55°12.3307’N 05°48.1366’W	Peter Maxwell VP Network Delivery and Support Hibernia Networks Tel: +353 1 867 3652 Email: peter.maxwell@hibernianetworks.com
			55°26.7905’N 06°17.6094’W	
	TAT 1 South	OOS Coax	55°50.3388’N 09°16.3719’W	Unknown - no crossing agreement required
	TAT 1 North		55°56.5050’N 09°59.7014’W	
	CANTAT 1		56°04.1211’N 10°26.0722’W	

Table 32: Submarine Cable Crossings

7.8.2 Power Cables

The details of crossed power cables are contained in Table 33 below. Full coordinates and crossing angles are supplied as part of the crossing list in the RPLs in Appendix 13.10.

CABLE ROUTE	NAME	CROSSING TYPE	COORDINATES	OWNER/CONTACT
Transatlantic Connection Cable	Western Link Pole 2	In-service power	55°28.6031'N 04°52.9485'W	National Grid +44 (0) 20 7004 3000
	Western Link Pole 1		55°28.5928'N 04°52.9718'W	
Scotland Ireland Cable	Moyle Interconnector Pole 2		55°01.7929'N 05°20.6208'W	Mutual Energy +44 (0) 28 9043 7530
	Moyle Interconnector Pole 1		55°00.9471'N 05°20.1315'W	
	Western Link Pole 2		54°14.0272'N 05°08.8748'W	National Grid +44 (0) 20 7004 3000
	Western Link Pole 1		54°14.0200'N 05°08.8995'W	
	East West Interconnector		53°34.6860'N 05°36.0995'w	

Table 33: Power Cable Crossings

7.9 Military Activities

Scotland's seas and coasts are important military training exercise, test and evaluation facilities. Figure 52 shows that the majority of Northwest Scotland is an exercise area, within exercise areas, activities may be subject to temporal restrictions. Development and use that either individually or cumulatively obstructs or otherwise prevents the defence activities supported by an exercise area may not be permitted (Scottish Government, 2014). Although this large exercise and submarine training ground covers the majority of the proposed LP's for the SFT cable system, the short-term installation of the cable and its potential long-term presence of the seabed will not hinder Ministry of Defence (MOD) operations. Proposals for development and use should be discussed with the MOD at an early stage of the process. The MOD should also be included in the distribution list on the notification to mariners prior to all operations in Scotland to reduce any offshore conflicts of interest.

MOD West Freugh is situated within the north of Luce Bay and is a weapons, test and evaluation range. Various military exercises currently take place at West Freugh which is a controlled environment that provides the opportunity to conduct a variety of ground and airborne activities. This MOD site is a former Royal Air Force station although its runways are now disused and unlicensed. The range area includes much of the sea area of Luce Bay and is clearly marked as 'Firing Practice Area' on hydrographic charts.

The MOD West Freugh firing range, lack of significant port infrastructure and shallow water depths limit vessel activity within Luce Bay. This is expected to marginally increase the security of the Scotland to Isle of Man Cable. If the proposed cable were to land at Port William, it will be important to ensure that the MOD and range operator QinetiQ are accurately notified of all survey, installation and potentially maintenance operations.

Port William is situated approximately 25km east of MOD West Freugh and therefore avoids the majority of the activity however there is an elevated Unexploded Ordnance (UXO) risk in this region.

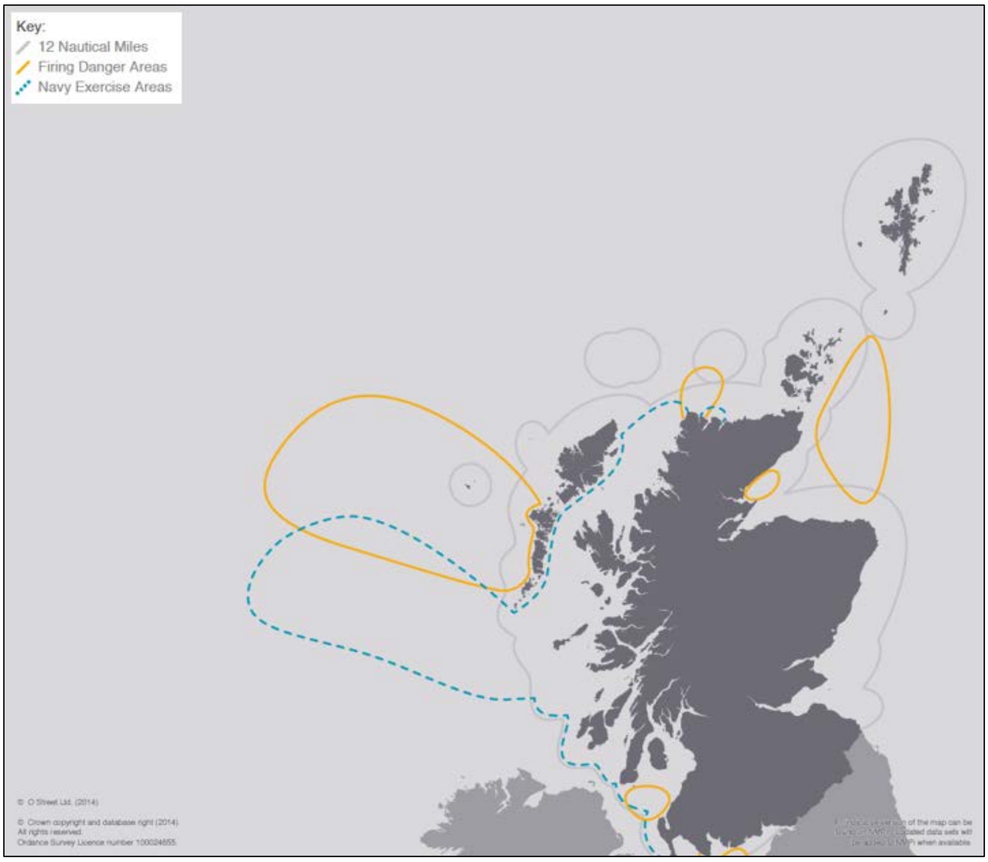

Figure 52: Military Practice Areas, Scotland (Scottish Government, 2014)

7.9.1 Unexploded Ordnance

Unexploded Ordnance (UXO) is a risk that must be highlighted for proposed cable systems in many areas however this risk is somewhat elevated in UK waters due to the fact that the area has been an active theatre of war. Since the late 19th century these engagements have had the potential to leave UXO on the seabed in the form of high explosive shells, torpedoes and sea mines. Typical high explosives do not significantly degrade over time and in fact can become more sensitive to disturbance (PMSS, 2011).

Another source of UXO is from historic disposal grounds for unwanted ammunition. Between 1918 and 1976 over 1.3 million tonnes of ordinance and UXO are thought to have been dumped in Beaufort's Dyke in the North Channel making this area one of the largest munitions dumping areas in the world. Due to various factors including poor positioning systems, ordnance dumped outside of the Dyke and the effect of bottom currents today, ordnance can be found in a wide area around the Dyke. As shown in Figure 53, the principle risk area is still within Beaufort's Dyke itself however there is also a medium risk of UXO to the north and south. During the cable route survey, any magnetometer anomalies or suspicious objects seen in side scan imagery should be avoided.

The Scotland to Ireland cable system routes straight through the dyke and will be surface laid over the region to avoid disturbing any UXO (see Figure 53). As UXO and munitions are no longer dumped within the dyke, this is a suitable area for the cable to be surface laid across.

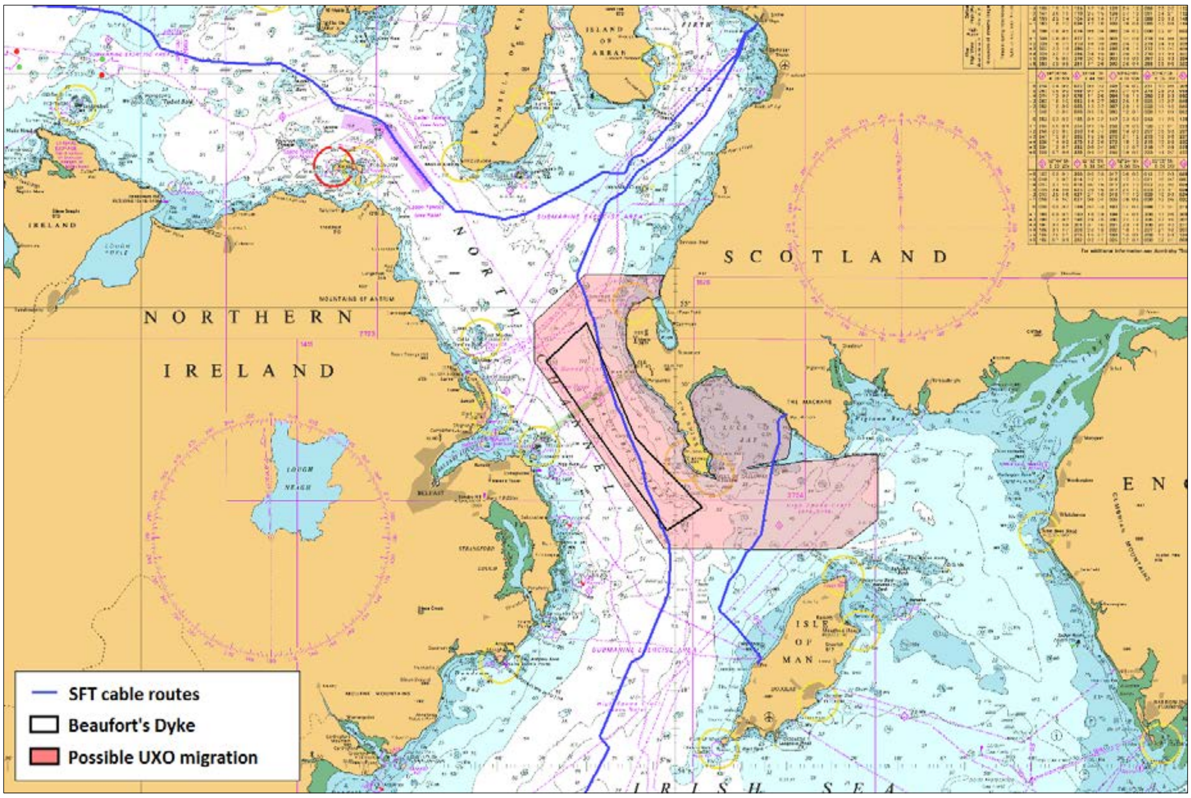

Figure 53: Beaufort's Dyke and UXO migration

As explained in Section 7.9, the MOD West Freugh is a modern firing range that often uses the marine area of Luce Bay which is where the Port William LP is located. The bay therefore has a significant UXO risk and must be evaluated prior to cable operations. In order to mitigate risk, it is important that the survey highlights any magnetometer anomalies or suspicious objects observed on the seabed.

7.10 Summary of Anthropogenic Impact

There are several potential risks presented to the SFT cables by anthropogenic hazards. They may affect cable security as well as survey and installation operations. The below table summarises the key anthropogenic issues affecting the route, and categorises the risk level as Low, Medium or High. These risks are mainly confined to relatively shallow areas rather than the deep water of the Rockall Trough.

HAZARD	IMPACT	MITIGATION	RISK LEVEL
Fishing	Trawl fishing has been identified as the biggest risk to the cable. Otter boards and beams may snag cables. Scallop dredging is also a significant risk.	The cable should be buried and appropriately armoured.	High
Shipping	The Irish Sea and other areas studied are high traffic areas. There will be a significant risk from anchor dragging.	The cable should be buried. The routes have been designed to minimise the traffic lanes crossed where possible.	Medium

Anchorages	The only anchorage near to the cable route is a small vessel anchorage at Port William. Anchors can snag on the cable and damage or sever it.	The cable should be buried. AP should be applied if burial cannot be achieved.	Low
Wrecks	All known wrecks are avoided. Wrecks pose an abrasion risk to the cable and a risk of damage to burial equipment.	If uncharted wrecks are found during the survey, separation of 1 x WD or a minimum of 500m should be sought between the wreck and the route.	Low
Dredging and Dumping	There is dredging activity at all ports in the region, but none close to the proposed cable routes. For Beaufort's Dyke dumping ground see Military and UXO below.	After installation, the cable must be clearly marked on admiralty charts.	Very Low
Renewable Energy	All three of the cable route options and associated LP options do not conflict with any existing or proposed offshore wind farm areas.	After installation, the cable must be clearly marked on admiralty charts.	Very Low
Hydrocarbon Exploitation	The hydrocarbon industry and its associated infrastructure is relatively limited in the Irish Sea, North Channel and Northwest Scotland. All three of the proposed cable routes avoid all existing wells by at least 1km. There are various pipeline crossings along the proposed cable routes.	No significant mitigation is required. After installation, the cable must be clearly marked on admiralty charts. If any pipelines or additional hydrocarbon infrastructure is proposed, crossing agreements and early consultation with the cable owner will be required.	Low
Submarine Cables	There are numerous in-service and out-of-service (OOS) cable crossings. Crossing agreements should be reached with the respective owners prior to installation of the proposed cable systems	Additional cable protection measures have been recommended for crossings.	Low
Military Activities & UXO	The cable routes cross several firing and exercise areas which pose minimal risk. The Scotland – Ireland route crosses the Beaufort's Dyke Dumping Ground.	Scrutinise survey results for potential UXO and adjust the route and burial plans as necessary. Surface lay the cable through the Beaufort's Dyke Dumping Ground.	Medium

Table 34: Summary of Anthropogenic Impacts

8.0 PROTECTED AREAS

8.1 Introduction

Marine Protected Areas (MPAs) can cause significant delay to a project by extending permitting timelines and may introduce additional requirements, such as an Environmental Impact Assessment (EIA) for the cable. This section considers the protected areas and other designations that are crossed by the planned cable routes or could potentially be influenced by cabling operations. A review of all protected area designations that may be crossed by routes to any of the alternative LPs will also be undertaken in case the preferred LP options are discounted later.

At Irvine Beach North LP, the preferred Scottish LP for the Transatlantic Connection and Scotland to Ireland cables, the proposed cable route in the nearshore and at the landing does not cross any protected areas which will reduce risk and ease the permit application process. The offshore routes of the Transatlantic Connection and Scotland to Ireland cables have been route engineered to avoid most protected area designations however; some are unavoidable and will inevitably be crossed.

For Port William which is the preferred LP option for the Scotland to Isle of Man cable, the proposed cable route unavoidably crosses an MPA and Site of Community Importance (SCI) designation that share the same boundaries and encompass the entire bay however the impact of the cable is anticipated to be minimal and short term. The generally benign nature of a cable system and associated installation will mean that there is very little impact on the local environment and biodiversity of the Irish Sea and the North and West waters of Scotland.

This section aims to identify the offshore marine protected areas relevant to the three offshore cable routes before reviewing the protected areas near the preferred and alternative LPs.

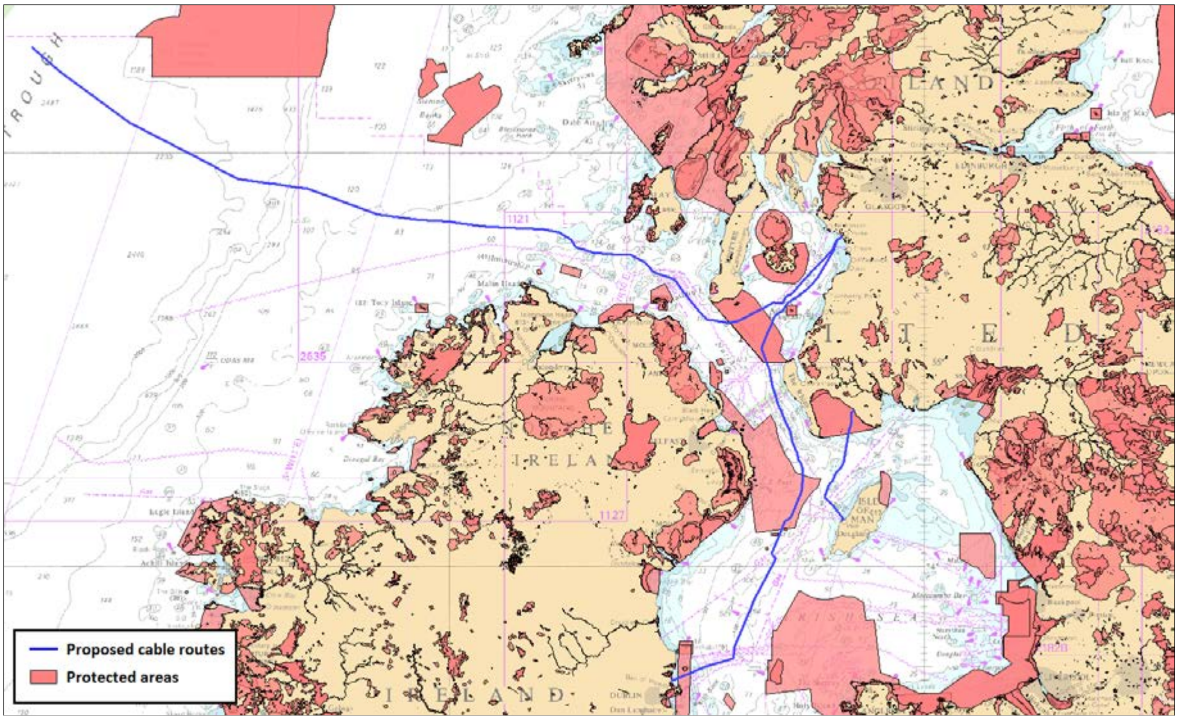

Figure 54: Protected Area Overview

8.2 Transatlantic Connection

The Transatlantic Connection route has been designed to run from the Inner Firth of Clyde into the North Channel before orientating northwest into the Atlantic Ocean. As shown in Figure 54 above, the cable crosses one relatively large protected area that spans from the Kintyre Peninsula to the

Rhins of Galloway Peninsula encompassing the entire entrance to the Firth of Clyde called the Clyde Sea Sill MPA.

Below the Clyde Sea Sill MPA, the water shallows dramatically where the dynamic and cooler North Channel waters meet the less saline waters of the Clyde leading to a creation of a front (Scottish Natural Heritage, 2018). Where salinity fronts develop, circa littoral and offshore sand and coarse sediment communities exist. This includes species such as clam shells, polychaete worms, starfish, brittle stars and the hermit crab. As the boundaries of this MPA span the entire width of the Firth of Clyde, the cable system has not been able to avoid the area however; it is very unlikely that the benign nature and low surface area associated with a cable system would cause any negative impact to this ecosystem. It should also be noted that various subsea cables and pipelines currently exist through this MPA suggesting that the Scottish authorities would permit a cable installation in these waters.

8.3 Scotland to Ireland Cable System

The Scotland to Ireland cable system has been route engineered from the Inner Firth of Clyde and heads southeast through the North Channel into the eastern Irish Sea before landing at Portmarnock near Dublin. The route crosses three designations in total however no designations are expected to be negatively impacted by the cable or its operations.

As shown in Figure 55 below, the cable route avoids the Ailsa Craig MPA and special protection area (SPA) designation situated within the Firth of Clyde by 350m. The Ailsa Craig MPA and SPA is protected for its species of nesting and wintering seabirds including one of the largest colonies of the Gannet (*Morus bassanus*). Other species include the Lesser Black-backed gull (*Larus fuscus*) and various other European, West African and Mediterranean colonies (JNCC, 2018). It is likely that even if the cable route were to transit through the protected area designation, the impact from a short term and slow moving vessel would be almost negligible. As shown in Figure 54 above, the cable crosses one relatively large protected area that spans from the Kintyre Peninsula to the Rhins of Galloway Peninsula encompassing the entire entrance to the Firth of Clyde called the Clyde Sea Sill MPA.

Below the Clyde Sea Sill MPA, the water shallows dramatically where the dynamic and cooler North Channel waters meet the less saline waters of the Clyde leading to a creation of a front (Scottish Natural Heritage, 2018). Where salinity fronts develop, circa littoral and offshore sand and coarse sediment communities exist. This includes species such as clam shells, polychaete worms, starfish, brittle stars and the hermit crab. As the boundaries of this MPA span the entire width of the Firth of Clyde, the cable system has not been able to avoid the area however; it is very unlikely that the benign nature and low surface area associated with a cable system would cause any negative impact to this ecosystem. It should also be noted that various subsea cables and pipelines currently exist through this MPA suggesting that the Scottish authorities would permit a cable installation in these waters.

The North Channel Site of Special Scientific Interest (SSSI) is a relatively shallow body of water situated to the east of Northern Ireland. The boundaries of the site are extensive and therefore the cable route has not been able to avoid this designation. The slow moving, short term and benign nature of a cable installation would not cause any detriment to the porpoise species which this designation primarily protects however; it is possible that a marine mammal observer (MMO) would be required on board the survey or installation vessel to ensure that this is the case, particularly for the associated sound pollution.

Just to the south of the North Channel SSSI, the cable route has avoided various small reef complex designations. Should the survey show more reef complexes near the planned cable, micro routing may be required to avoid them.

As the cable approaches its LP in Portmarnock, it crosses the Rockabill to Dalkey Special Area of Conservation (SAC), a strip of dynamic inshore and coastal waters in the western Irish Sea. The SAC extends approximately 40km in length which includes a range of shallow marine habitats, including diverse seabed structures of reefs, inlets and islands. Extensive surveys of the Irish coast have indicated that the greatest resource of reef habitats within the Irish Sea is found fringing offshore islands which are concentrated along the Dublin coastline (Department of Arts, Heritage and the Gaeltacht, 2016). These reef habitats include a range of species such as *Fucus spiralis, Fucus serratus, Halidrys siliquosa and Pomatocereos triqueter*, which are tolerant to tidal currents. Annex II species such as the harbour porpoise (*Phocoena phocoena*), grey seal (*Halichoerus grypus*), harbour seal (*Phoca vitulina*) and bottlenose dolphin (*Tursiops truncates*) have been identified in this conservation band. The proposed cable route will unavoidably cross the northern section of this conservation area.

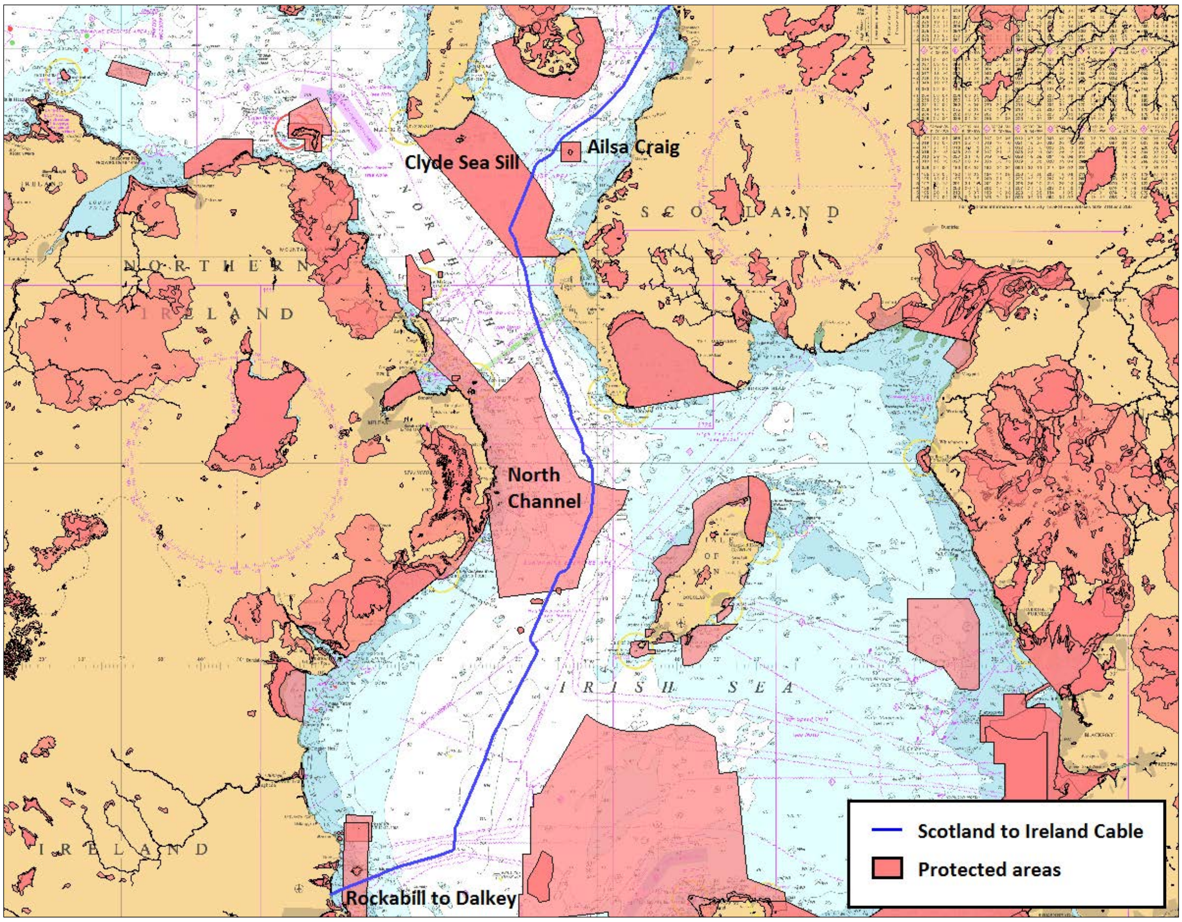

Figure 55: Protected area overview of the Scotland to Ireland cable route

8.4 Scotland to Isle of Man Cable System

The Scotland to Isle of Man cable system has been route engineered from Port William and heads southwest into Luce Bay and the western Irish Sea before landing near Peel on the west coast of the Isle of Man. The proposed cable route unavoidably crosses the Luce Bay and Sands MPA and SCI/SAC designation that both share the same boundaries and encompass the entire bay (see Figure 56). The entire shallow embayment is protected for its mosaic of subtidal, intertidal and surrounding terrestrial habitats which are generally more sheltered in comparison to the rest of the surrounding Scottish coastline. The majority of the intertidal zone of Luce Bay is composed of small to medium sized boulders resting on sediment. The larger boulders on the lower shores have spaces beneath and between them for under boulder communities such as sea squirts, sponges and crustose corraline algae (Scottish Natural Heritage, 2006). The subtidal sediment near boulders contains epifauna such as crabs, prawns and juvenile lugworms (*Arenicola marina*). As for the deeper sections of Luce Bay, the seabed hosts rich communities of polychaetes, brittlestars and bivalves as well as the bay being a nursery ground for plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangus*), herring (*Clupea harengus*) and cod (*Gadus morhua*) (Scottish Natural Heritage, 2006).

The short term survey and installation operations associated with the Scotland to Ireland Cable System will have little influence on the local biodiversity in this region. The cable would be plough buried within the bay resulting in some short term seabed disturbance and sediment suspension however the seabed will quickly return to its natural state followed by recolonization of the benthic communities post installation. The generally benign nature of a cable system and associated installation will result in very little impact on the local environment and its biodiversity.

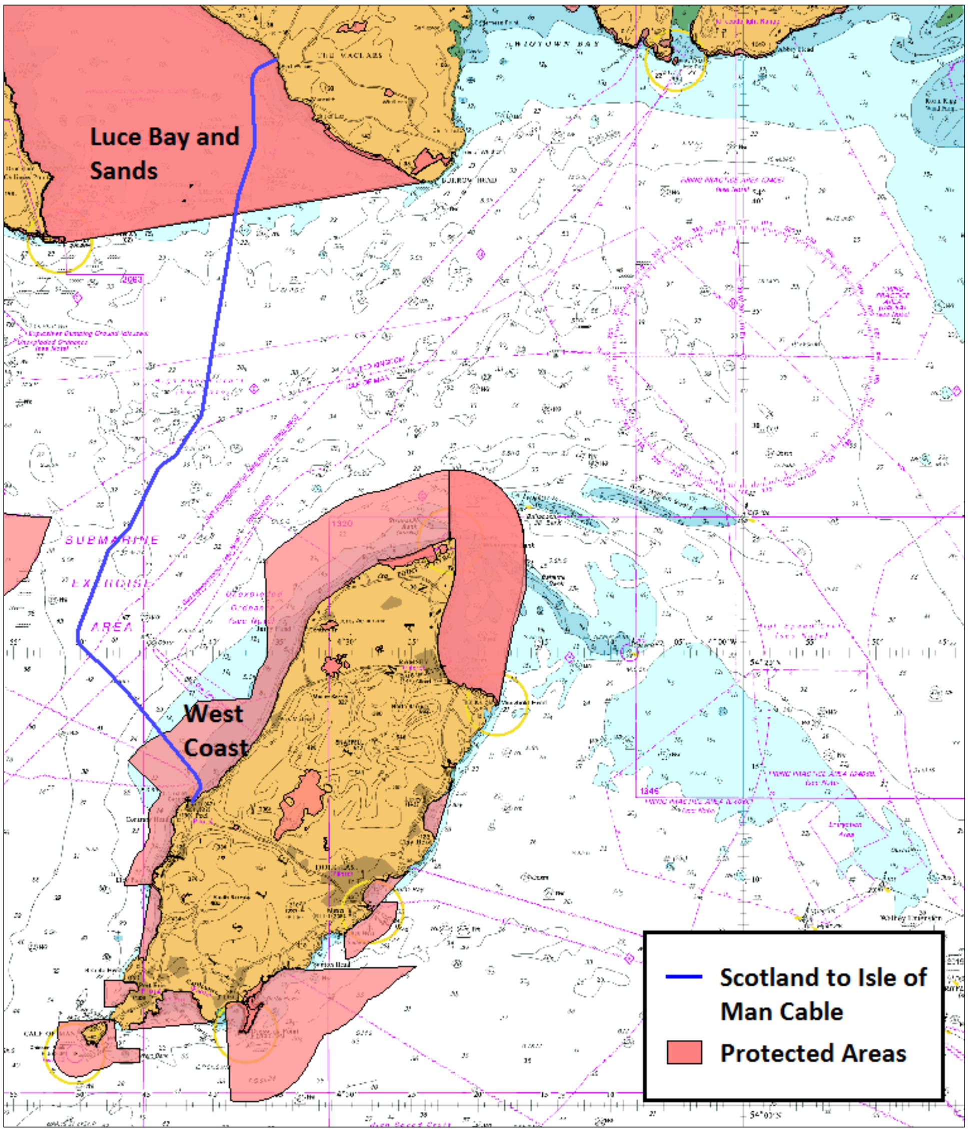

Figure 56: Protected area overview of the Scotland to Isle of Man cable route

Peel has been selected as the preferred LP option for the Scotland to Isle of Man cable system and the cable will unavoidably cross the West Coast Marine Nature Reserve. This is the largest designation on the island and has only just been designated as a protected area in Q3 2018. As this designation is so recent, there is no available information on the exact species or biotopes the MNR aims to protect; however some of the other MNR's on the island such as the Ramsay MNR, situated in the north east of the Isle of Man limits trawling and benthic-damaging activity. Specific management plans for each MNR will be developed over the coming years with significant input from a variety of stakeholders (ManxGov, 2018).

8.5 Dunnet Bay Landing Point

There are three protected area designations that would be crossed by the proposed cable system if it landed within the centre of Dunnet Bay and are listed below:

- North Caithness Cliffs MPA
- North Caithness Cliffs SPA
- Dunnet Links SSSI

The North Caithness Cliffs MPA and SPA share the same boundaries and are broken down into five segments along the north coast of Caithness in northern Scotland, the central segment of this designation encompasses Dunnet Head and the majority of the bay. These segments are primarily sea cliff areas composed of ledges and stacks which provide good nesting spots for seabirds such as gulls and auks. During the breeding season, the area is home to 110,000 seabirds including puffins, razorbills and kittiwakes and is also an important nesting site for the peregrine falcon (*Falco peregrinus*) (Marine Conservation Society, 2018). The large range of biodiversity has resulted in this area being designated a special protection area (SPA) for birds. The short timescales and slow moving nature of a cable installation vessel will not influence the local bird species. Any nesting or wintering areas will also be situated nearer the cliffs and rocky coastline of Dunnet Head rather than within the bay itself.

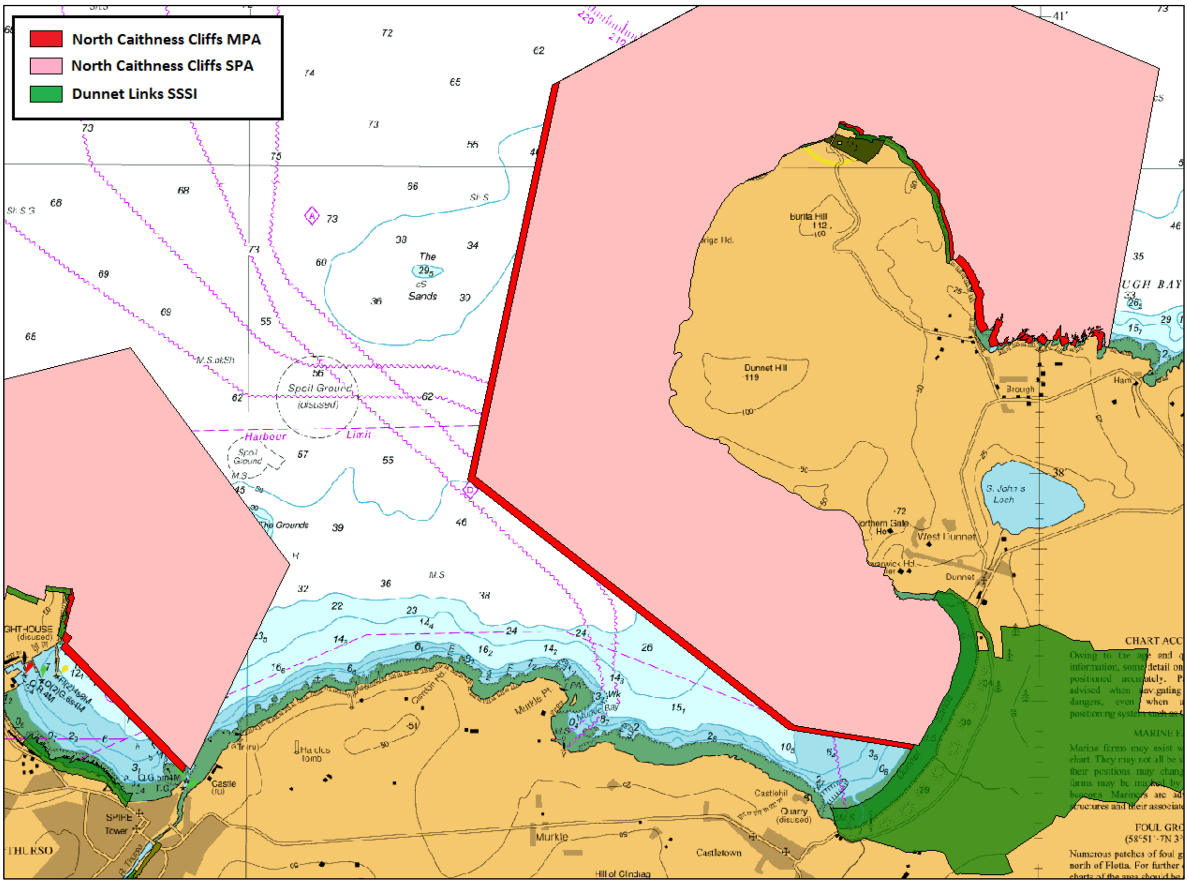

Figure 57: Dunnet Bay protected area overview

Dunnet Links Site of Special Scientific Interest (SSSI) is designated for its nationally important sand dunes and links grassland. The sand dunes on this site are the largest and most active dune system in Caithness. If Dunnet Bay is selected as the preferred LP option, a HDD shore end installation will be conducted which will go underneath the dunes. The environmental impact is therefore negligible.

8.6 Ullapool Landing Point

There are two protected area designations that would be crossed by the proposed cable if it landed at Ardmair Bay or Ullapool Point which are:

- Inner Hebrides and the Minches SAC
- Wester Ross MPA

The Inner Hebrides and the Minches SAC covers a vast area of the northwest Scottish coastline that aims to protect the harbour porpoise (*Phocoena phocoena*) and its associated habitat. The site for harbour porpoise has been chosen because it incorporates virtually all of the top 10% of persistent high density areas identified for harbour porpoise and the conditions are suitable for this species of marine mammal to be present within any part of the site at any time (JNCC, 2016). The level of noise pollution associated with the survey and subsequent installation of the cable may be subject to an EIA however this will be at the discretion of the authorities during the pre-application phase of the project.

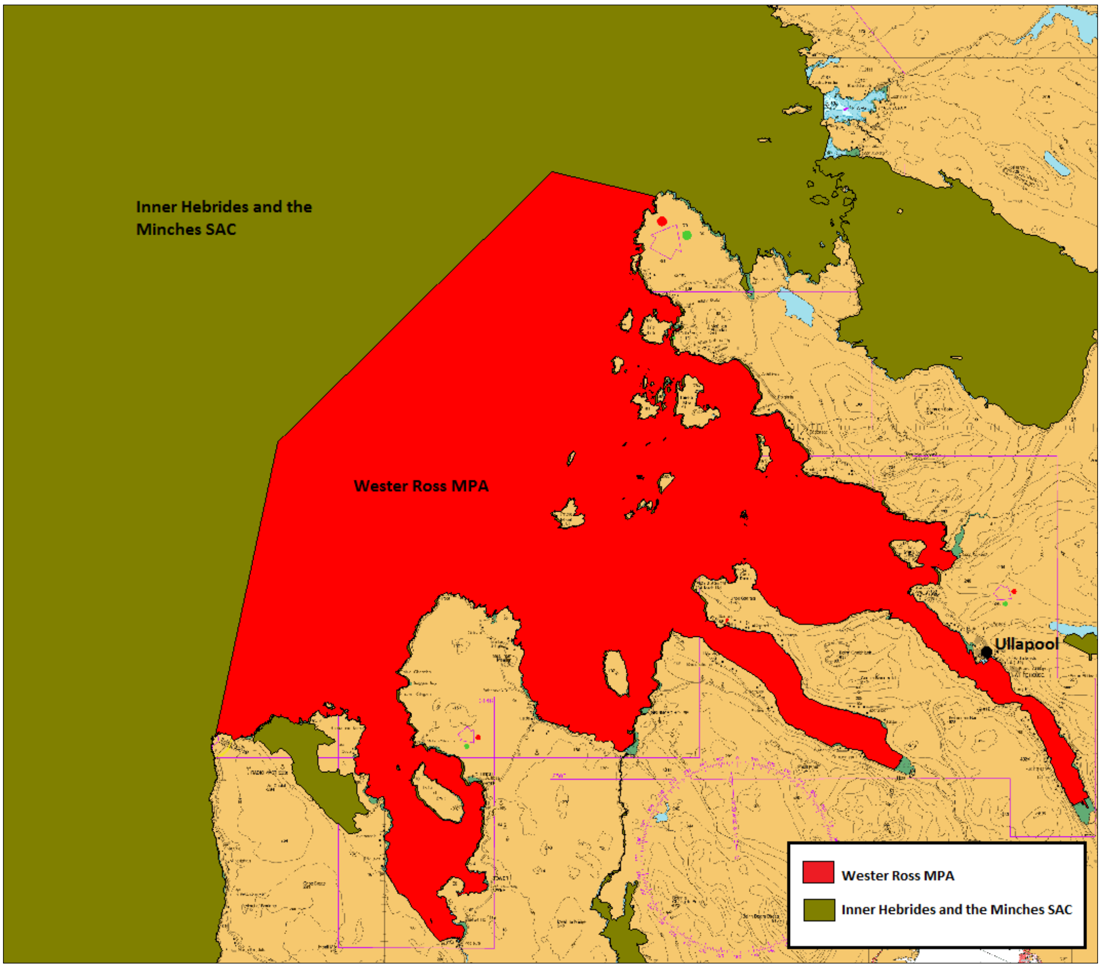

Figure 58: Ullapool protected area overview

The Wester Ross MPA encompasses seabed features shaped by Scotland's glacial past which include a large biodiversity of mearl beds, northern feather sea star aggregations and flame shell beds. In deeper parts of the MPA, Norway lobsters can be seen guarding the entrances to their burrows amongst dense forests of seapens. The short term survey and installation operation associated with the proposed cable system will have little influence on the local biodiversity in this region. The cable would be buried which would result in some short term seabed disturbance and sediment suspension however the seabed will quickly return to its natural state followed by recolonization of the benthic communities post installation.

8.7 Muasdale Landing Point

If the proposed Transatlantic Connection cable lands at Muasdale, the marine route would avoid all marine protected area designations. The nearest protected area is the Glenacardoch SSSI, a land-based designation that is situated on the headland to the west of the proposed terrestrial routes to the BT exchange. This protected area is primarily designated for its geological status and will therefore not be influenced by a marine fibre optic cable landing.

8.8 Irvine Landing Point

Irvine North LP is the preferred LP option for the proposed Transatlantic Connection and Scotland to Ireland cable system. This LP is preferable for many reasons, one of which is that there are no protected areas in the nearshore. This will reduce risk and ease the permit application process. There are various nature reserves and SSSI's designations scattered further inland of Irvine however the terrestrial route will very likely avoid these designations as well.

Irvine Central LP is one of the alternative LP options in Irvine, should the northerly option be discounted, the central LP would be the next LP considered. The LP has a dune ecosystem in between the beach and BMH however there are two narrow (approximately 1m width) access paths through the dunes. A member of the North Ayrshire Planning Department stated that these dunes are at an early embryonic stage and are therefore not protected in comparison to the heavily protected dune ecosystem at Dunnet Bay. It may therefore be possible to land the cable via a traditional shore end rather than HDD at this location.

8.9 Girvan Landing Point

There are no marine or land-based protected areas at the proposed Girvan LPs. The nearest protected area to Girvan is the Girvan to Ballantrae Coast SSSI, however this designation covers the rocky shoreline to the south which will not influence the routeing or operations associated with a marine cable installation.

8.10 Portpatrick Landing Point

There are no marine or land-based protected areas near the town of Portpatrick. In the unlikely event that Portpatrick is selected as the preferred LP area, Morroch Bay SSSI would be the nearest protected area to Portpatrick and is situated 2.5km to the south of the town.

8.11 Port William Landing Point

There are two protected area designations that would be crossed by the proposed cable should it land at Port William and these are listed below:

› Luce Bay and Sands SCI/ SAC
› Luce Bay and Sands MPA

The proposed cable landing at Port William unavoidably crosses the Luce Bay and Sands MPA and SCI/SAC designation that both share the same boundaries and encompass the entire bay. The entire shallow embayment is protected for its mosaic of subtidal, intertidal and surrounding terrestrial habitats which are generally more sheltered in comparison to the rest of the surrounding Scottish coastline. The majority of the intertidal zone of Luce Bay is composed of small to medium sized boulders resting on sediment. The larger boulders on the lower shores have spaces beneath and between them for under boulder communities such as sea squirts, sponges and crustose corraline algae (Scottish Natural Heritage, 2006). The subtidal sediment near boulders contains epifauna such as crabs, prawns and juvenile lugworms (*Arenicola marina*). As for the deeper sections of Luce Bay, the seabed hosts rich communities of polychaetes, brittlestars and bivalves as well as the bay being a nursery ground for plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangus*), herring (*Clupea harengus*) and cod (*Gadus morhua*) (Scottish Natural Heritage, 2006).

The short term survey and installation operation associated with the Scotland to Ireland Cable System will have little influence on the local biodiversity in this region. The cable would be plough buried within the bay resulting in some short-term seabed disturbance and sediment suspension however, the seabed will quickly return to its natural state followed by recolonization of the benthic community post installation. The generally benign nature of a cable system and associated installation will have very little impact on the local environment and its biodiversity.

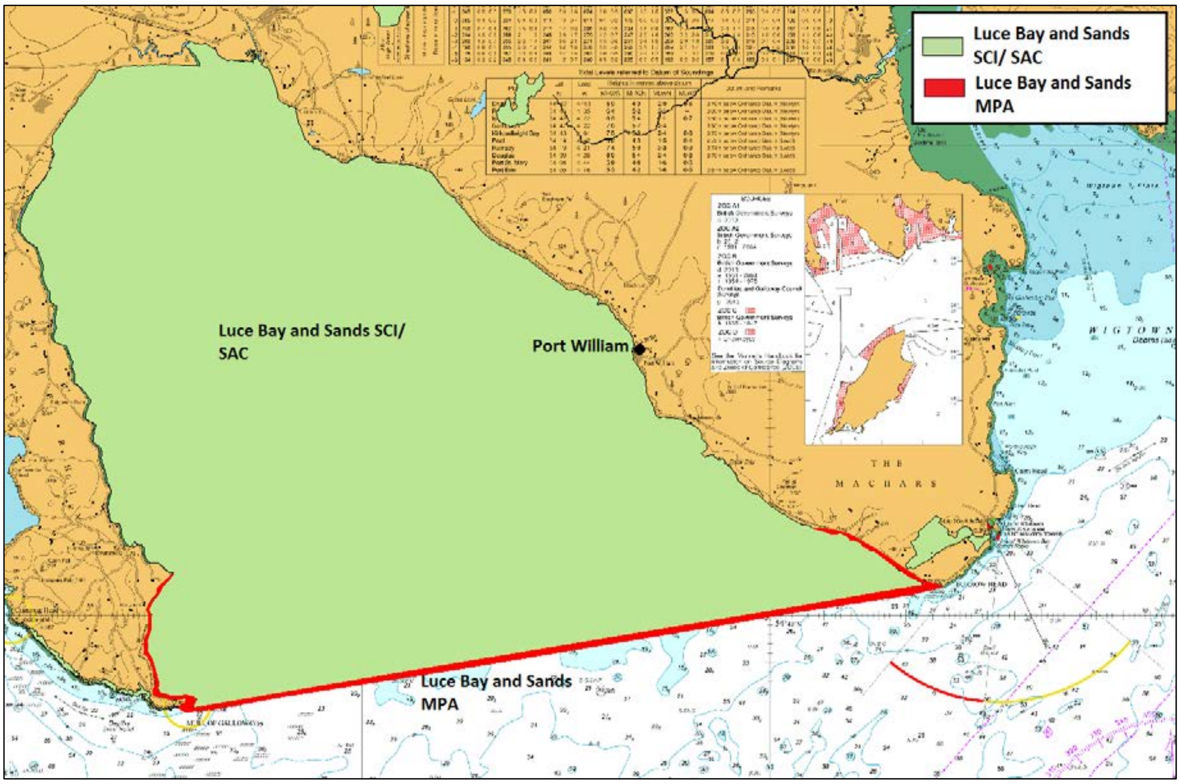

Figure 59: Port William protected area overview

8.12 Isle of Man

The Isle of Man has various Marine Nature Reserves (MNR's) scattered around its coastline and the specific MNR that is crossed is dependent on the LP. Peel has been selected as the preferred LP option for the Scotland to Isle of Man cable system and will unavoidably cross the West Coast Marine Nature Reserve. This is the largest designation on the island and has only just been designated as a protected area in Q3 2018. As this designation is so recent, there is no available information on the exact species or biotopes the MNR aims to protect; however some of the other MNR's on the island such as the Ramsay MNR, situated in the north east of the Isle of Man limit trawling and benthic-damaging activity. Specific management plans for each MNR will be developed over the coming years with significant input from a variety of stakeholders (ManxGov, 2018). It has therefore been assumed that the West Coast MNR that will be crossed by the proposed cable will follow the same trend and restrict environmentally damaging activity. This MNR designation is anticipated to not be an issue as a marine cable installation is very benign, short-term and has a low surface area impact on the seabed that would soon recolonise post burial. Few viable landing points exist on the Isle of Man that would not require crossing a protected area.

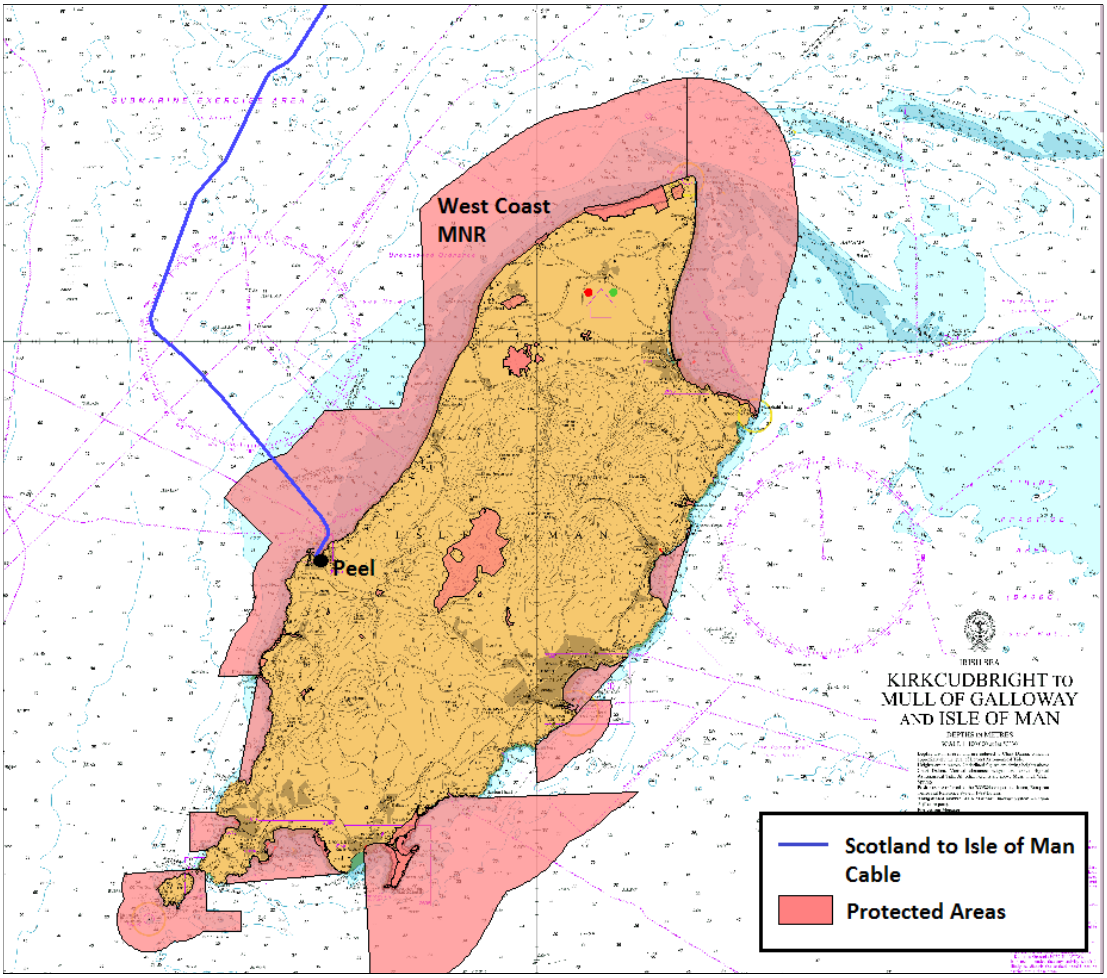

Figure 60: Protected area overview in the Isle of Man

8.13 Ireland Landing Point

As the cable approaches its proposed LP in Portmarnock, it crosses the Rockabill to Dalkey Special Area of Conservation (SAC), a strip of dynamic inshore and coastal waters in the western Irish Sea. The SAC extends approximately 40km in length which includes a range of shallow marine habitats, including diverse seabed structures of reefs, inlets and islands. Extensive surveys of the Irish coast have indicated that the greatest resource of reef habitats within the Irish Sea is found fringing offshore islands which are concentrated along the Dublin coastline (Department of Arts, Heritage and the Gaeltacht, 2016). These reef habitats include a range of species such as *Fucus spiralis, Fucus* *serratus, Halidrys siliquosa and Pomatocereos triqueter*, which are tolerant to tidal currents. Annex II species such as the harbour porpoise (*Phocoena phocoena*), grey seal (*Halichoerus grypus*), harbour seal (*Phoca vitulina*) and bottlenose dolphin (*Tursiops truncates*) have been identified in this conservation band. The proposed cable route will unavoidably cross through the central section of this conservation band.

Portmarnock is also the LP for Sirius South and Emerald Bridge One which also cross through the Rockabill and Dalkey SAC.

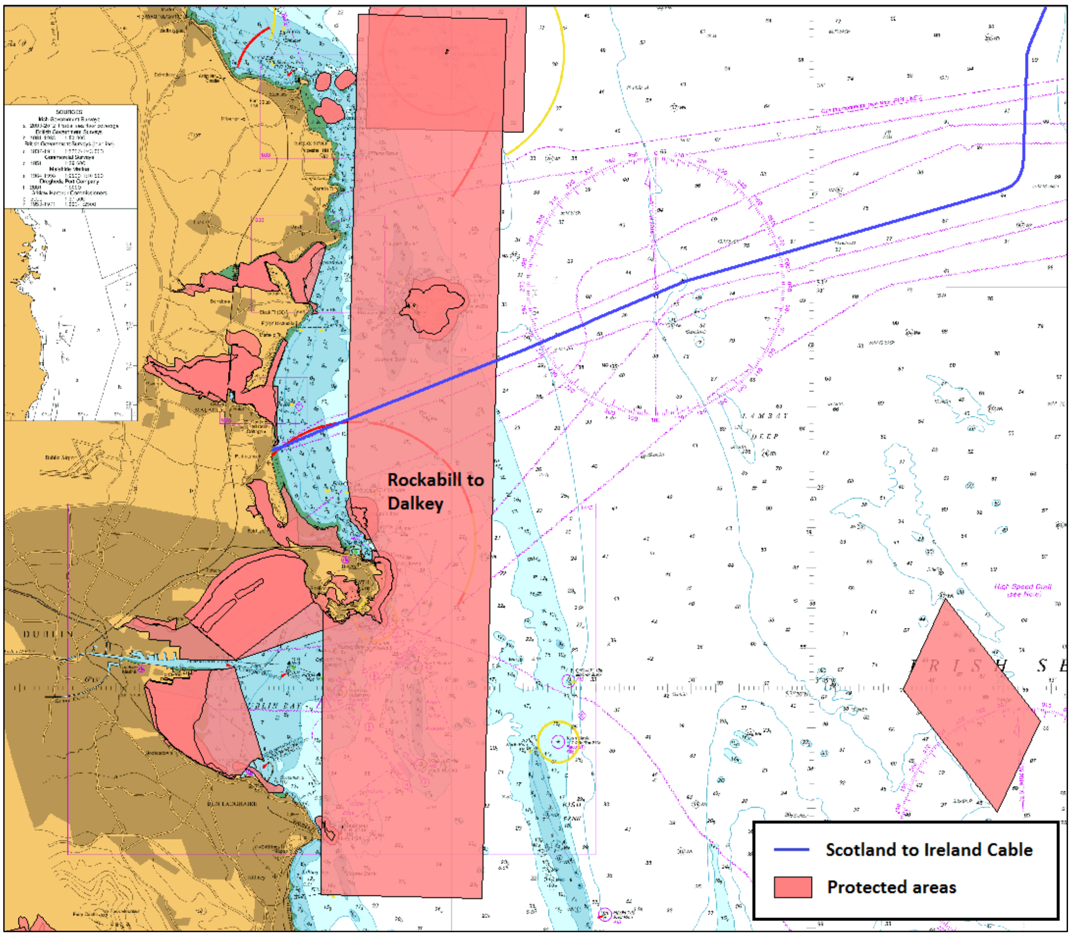

Figure 61: Protected area overview, Ireland

8.14 Summary for Marine Protected Areas

All three of the proposed SFT cable system routes have been engineered to avoid the majority of the offshore and coastal protected areas however some offshore designations have been crossed. The impact on these areas is expected to be negligible due to the relative short-term installation period, low surface area affected and the benign nature of the cable itself. Only short-term sediment suspension and noise pollution associated with burial will impact the MPAs that the cable crosses and re-colonisation is likely to take place swiftly post-lay.

The noise pollution from the cable-laying vessel may deter marine species locally however it is anticipated that the impact would be minor, particularly given the already high traffic in Irish Sea and North Channel. A suitably qualified Marine Mammal Observer (MMO) may be required on board the survey and installation vessels during cable operations as a condition of a licence being granted.

A summary of the key species associated and vulnerability to cable operations are given in Table 35 below.

SPECIES TYPE	KEY SPECIES	STATUS	VULNERABILITY TO CABLE OPERATIONS
Birds	Guillemot *Uria aalge*	This species can be found on rocky headlands and cliffs of the UK with a higher population situated in the north of Scotland.	No anticipated impact as the cable laying operation will be short term. The primary impacts to these bird species are from pollution, agricultural pollution and offshore renewable energy generation. Breeding usually occurs during early spring (May) and would potentially be the month of highest vulnerability to cabling operations (particularly work on the beach) however the impact is still anticipated to almost negligible.
	Gannet *Morus bassanus*	The population status of this species is currently in steady decline. This species of diving seabird is primarily vulnerable to oil pollution and declining fish stocks	
	Lesser black-backed gull *Larus fuscus*	This species of bird are not threatened and have a stable population	
	Peregrine falcon *Falco peregrinus*	This bird of prey is not a threatened species however are vulnerable to pesticides.	
	Kittiwake *Rissa tridactyla*	The kittiwake is a globally threatened species that is primarily threatened from oil pollution and over-fishing.	
	Puffin *Fratercula arctica*	Puffin populations are declining primarily due to food availability.	
	Razorbill (*Alca torda*)	The Razorbill population is listed as 'near threatened'. They breed in early spring on rocky cliffs and coastlines and tend to avoid human activity.	
Marine Mammals and Basking Sharks	Bottlenose Dolphin *(Tursiops truncates)*	These species are not classified as 'near threatened' however all marine mammals and basking sharks in the Irish Sea are protected.	Vulnerability to cabling operations is low. Species may potentially be affected from shipping disturbance and short-term noise pollution however more serious impacts such as collision are very unlikely.
	Common Dolphin *(Delphinus delphis)*		
	Grey Seal *(Halichoerus grypus)*		
	Common Seal *(Phoca vitulina)*		
	Harbour Porpoise (*Phocoena phocoena*)		
	Basking Shark *(Cetorhinus maximus)*		
Benthic/ seabed	*Fucus spiralis*	These species are not classified as threatened however greatly support.	There may be some localised disturbance and suspended sedimentation but this will be
	Fucus serratus		

	Halidrys siliquosa		inconsequential due to the relatively small surface area of the SFT cable routes. After burial operations recolonization will occur and the seabed would turn back to its natural state.
	Pomatocereos triqueter		
Fish	Plaice *Pleuronectes platessa*	All these species of fish are classified as 'least concern' with the exception of cod, which has a 'vulnerable' status.	Luce Bay is a nursery ground for these species of fish. A slow moving cable installation vessel will have no impact on the local fish species which will simply just avoid human activity.
	Whiting *Merlangius merlangus*		
	Herring *Clupea harengus*		
	Cod *Gadus morhua*		

Table 35: Summary of key protected species along the CC2 route (Birdlife International, 2016) (Evans & Baines, 2010) (Natural England, 2011).

MPA KEY FACTOR	IMPACT	MITIGATION	RISK LEVEL
Protected Areas	Protected areas can cause significant delay to a project by extending permitting timelines and may introduce additional requirements, such as such as an Environmental Impact Assessment (EIA) for the cable. Where possible, the proposed cable routes have avoided protected areas however some have unavoidably been crossed.	Where possible, the proposed cable routes have avoided protected areas however some have unavoidably been crossed. Any mitigation conditions issued as conditions of the marine licencing should be followed to ensure that any impact is reduced as much as possible.	Low
Protected Species	The cable will be low impact with some transient noise and disturbance during survey and installation, both of which are common in this region. The low surface area and benign nature of a subsea cable system will have little impact on the local benthic community.		

Table 36: Summary for Marine Protected Areas

9.0 PERMITTING

9.1 Introduction

Three different entities have varying responsibilities during the permitting process:

› Purchaser - The ultimate owner of the system.
› Supplier - The organisation supplying the cable system.
› Installer/Contractor - The organisation installing the cable (may also be the supplier) and/or a third party contracted by the installer.

For submarine telecommunication cables installations like the proposed SFT fibre optic cable system, four types of permissions are typically required:

› Operator's Licence – the licence to operate a submarine cable system. Obtained by the Purchaser, or its in country subsidiaries as appropriate, and issued by the Licensing Authority (usually a Government Department) of the country in which the installation is proposed.
› 'Permits in Principle' or Route/System/Landing Permits - the permission, or approval, to install a cable system within a country's territorial waters (TW), possibly its exclusive economic zone (EEZ), and along a terrestrial route to the Terminal Station. Usually issued by a Government Department following consultation. The Purchaser, or its in-country subsidiary, in usual circumstance must remain responsible as the signatory of such approvals as they will apply for the lifespan of the cable system.
› Operational Permits - those permits necessary for survey, installation and maintenance operations by the installer/contractor who is employed on site (whether marine or terrestrial) to carry out day-to-day operations. Marine operational permits will usually be the responsibility of the marine installer (or its subcontractors) and terrestrial operational permits will be the responsibility of the purchaser, land works subcontractor or nominated in-country landing party.
› Permissions from other interested marine users. Although not detailed in this Section, these will include crossing permissions from other cable and pipeline owners. Such permissions may either be a simple written 'Agreement to Cross' or a more complex legal 'Crossing Agreement'. This choice will be entirely dependent on the requirements of the company whose interests are to be crossed and the negotiations between the purchaser and that relevant company.

9.2 Landings and Maritime Boundaries

Based on the RPLs in Appendix 13.10, the following section will discuss the proposed cable system, re landing sites and traversed marine geopolitical boundaries:

COUNTRY	LANDING	TERRITORIAL WATERS	CONTIGUOUS ZONE	EEZ
Scotland	Irvine	x	-	x
Ireland	Dublin	x	x	x
Isle of Man	Peel	x	-	-

Table 37: Maritime Boundary Summary

The definition of these maritime boundaries is provided by reference to the United Nations Convention on the Law of the Sea (UNCLOS). Ratification to UNCLOS by each of the preceding countries is referred to in the following country discussions. Reference may also be made to Article 79 of UNCLOS, which relates to 'Submarine cables and pipelines on the continental shelf':

- *All States are entitled to lay submarine cables and pipelines on the continental shelf, in accordance with the provisions of this article.*
- *Subject to its right to take reasonable measures for the exploration of the continental shelf, the exploitation of its natural resources and the prevention, reduction and control of pollution from pipelines, the coastal State may not impede the laying or maintenance of such cables or pipelines.*
- *The delineation of the course for the laying of such pipelines on the continental shelf is subject to the consent of the coastal State.*
- *Nothing in this Part affects the right of the coastal State to establish conditions for cables or pipelines entering its territory or territorial sea, or its jurisdiction over cables and pipelines constructed or used in connection with the exploration of its continental shelf or exploitation of its resources or the operations of artificial islands, installations and structures under its jurisdiction.*
- *When laying submarine cables or pipelines, States shall have due regard to cables or pipelines already in position. In particular, possibilities of repairing existing cables or pipelines shall not be prejudiced.*

Each country is therefore likely to have varying consent requirements depending on the nature of the legislation that it has adopted either in order to enact Article 79 of UNCLOS in domestic legislation or as a result of existing domestic legislation in the case of the UK which is not a signatory to the convention but has ratified and adopted the principles. As a result, the geographic extent of each country's permitting control [i.e. out to its Exclusive Economic Zone (EEZ – normally 200 nautical miles or equidistant line with adjacent marine state) or just to its Territorial Waters (normally 12 nautical miles) will vary. For example in Scotland, the Marine Scotland Act applies to 12NM, and from 12NM to the extent of EEZ the Marine and Coastal Access Act is in force which adopts the principles and freedoms for submarine cables under UNCLOS.

Ireland has signed (Jul 29, 1994) and ratified (Jun 21, 1996) UNCLOS and has adopted the principles into national legislation, exercising sovereign rights within territorial waters, and allowing freedom to lay and repair submarine cables within EEZ.

9.3 Project Significant Influencing Factors

9.3.1 Scotland

- Where a marine licence is granted there is a presumption in favour of burial. If any parts of the cable are proposed to be unburied, robust justification must be provided to support this to Marine Scotland in the application.
- Pre-application consultation is critical to the success of the permitting process. Involving key stakeholders through early consultation, and a strategic public consultation meeting is vital.
- Statutory consultees must also be notified at least 12 weeks prior to application submission as part of the Pre-Application Consultation (PAC). Incorporating any comments early, particularly from Scottish Natural Heritage (SNH) will ensure that the application proceeds smoothly when Marine Scotland undertakes their own 28 day statutory consultation period within the 14 week approximate timescale for application.
- Fisheries Liaison representative should be appointed at an early stage. This should be someone or an organisation who represents the fishing industry for example Port Hill Marine, or someone recommended by the SFF or local council near to the landing site.

- Fisheries are a significant influencing group in the licensing process and the importance of strategic engagement cannot be emphasised enough.
- Annual rental will be applicable from Crown Estate Scotland. The heads of terms for the lease can be seen as Appendix 13.3 and are subject to individual discussions with CES.
- A full Environmental Impact Assessment (EIA) will not be required, as submarine cables are not listed in the EIA Directive. However it is recommended that environmental considerations are taken into account in the application through an Environmental Impact Statement (EIA) or similar robust review of environmental factors.
- In 2019 CES will be conducting a review of the standard terms for cables which could impact the standard heads of terms offered. The heads of terms are included as Appendix 13.3.
- Some organisations choose to take on an Option agreement which provides more certainty over the seabed/route whilst project development is completed. Others choose to enter into a Licence once project development is complete. If the latter, all the same requirements of an Option still have to be evidenced, including consents, for example.
- Model Option and Licence agreements are included as Appendix 13.8 and 13.9 for information.
- CES will also carry out checks into the financial standing or credit rating of the developer applicant.

9.3.2 Ireland

- Annual licence fees can be high in Ireland – this should be discussed with the Foreshore Unit to ascertain the estimated amounts.
- The National Monuments Service will be consulted during the application and may request a representative for Underwater Archaeology is present or designated during operations. This will be subject to individual licensing discussions.
- An EIA will likely be required for the project in Ireland.
- Public notices will need to be issued to inform any public consultation that takes place. Early stakeholder engagement is recommended to ensure a smooth process.

9.3.3 Isle of Man

- The permitting process since the changes to the infrastructure licensing regulations are untested for submarine cables as far as Global Marine is aware at present.
- Early liaison with the authorities is recommended to establish a plan and a structure for the process that will be followed with agreed timescales.
- Providing early information regarding cable installation procedures, and the likely small scale environmental impacts would also assist with a straightforward process as it is not a frequent type of project and government personnel are unlikely to have experience of previous cable installations.
- An EIA will be required in the Isle of Man.
- Annual license fees may be required.

9.4 Limitations

This study has been written using information acquired from:

- GMG previous installation experience.
- GMG existing data and internet data searches.
- GMG correspondence with relevant authorities/agents.

The regulations and permissions discussed are considered to be correct at the time of writing of this Section. Governments and Administrative Departments controlling and enforcing these regulations are beset by changes in the requirements caused by the number of cable applications, differing local and national requirements, changing laws/regulations and the political situation at any time. New regulations are being developed all the time to deal with the submarine cable industry. It follows that verification of the regulations will always be a requirement before every survey, installation and maintenance operation. The Purchaser and/or Contractor should contact, and maintain contact with, the permitting agencies to ensure accurate information regarding permits is held for each specific project or operation. This Section should therefore not be seen as a complete or exhaustive list of regulations and permissions. The timeframes to obtain permits have been indicated wherever possible but it has not been possible to determine all timescales for obtaining permissions.

Note that this study is only responsible for defining marine permitting requirements. Any terrestrial permitting requirements included are only those identified as a result of the marine permitting investigation. The in country landing party will be responsible for identifying in detail all necessary terrestrial permit requirements.

9.5 Scotland

9.5.1 Marine Scotland – Marine and Coastal Access Act 2009

9.5.1.1 Marine Scotland Act 2010

Under Section 20(1) of the Marine Scotland Act 2010 (0-12NM), a marine licence is required if a person or organisation intends to undertake certain activities within the 12NM limit in Scotland. These include:

- *The deposit of a substance or object in the sea or under the seabed*
- *The construction, alteration or improvement of works in the sea or under the seabed*
- *The removal of a substance or object from the seabed*
- *Dredging*
- *The incineration of a substance or object*

Certain activities related to submarine cable installation come under the marine licencing regulations, and a marine licence will be required for this project. A Marine Licence under the Marine and Coastal Access Act can be granted in the UK by Marine Scotland (MS), The Marine Management Organisation (MMO), or by the Department for Business, Energy and Industrial Strategy (BEIS) for certain projects. However for telecommunications cables within 12NM of Scotland a marine licence will be granted under the Marine Scotland Act 2010. Outside of 12NM, within UK EEZ, a marine licence is not needed for the cable itself, but a separate marine licence will be needed under the Marine and Coastal Access Act for any additional cable protection such as rock placement or mattressing. Note the differing legislation, though the processes will be identical and applications submitted at the same time.

There is a clear process to obtain a marine licence in Scotland, and more information including application guidelines and the necessary processes to be followed can be found at: http://www.scotland.gov.uk/Topics/marine/Licensing/marine

There is an obligation under the Marine and Coastal Access Act (2009) that a marine licence for submarine cables will be granted. The licence may however be granted subject to various conditions that will have to be fulfilled to meet the commitments of the licence which will depend upon the consultation responses received – some of which will be taken into account. These could be operational conditions which the vessel and installation operations could be required to adhere to and so details of any such requirements will need to be passed on to the cable installation contractor to ensure the licence terms are met. Non-compliance could invalidate the terms of the licence and have further consequences to the project or applicant.

If the application falls within a harbour area, the local harbour/port authority and the local authority planning department will be consulted as necessary.

If the application falls within, or is close to, a Ministry of Defence (MOD) installation, officials will consult with the relevant local MOD contact.

A meeting was held with Marine Scotland. Minutes are in Appendix 13.4.

9.5.1.2 Pre Application Consultation (PAC)

Pre application consultation is a critical part of the licensing process, and a robust plan for good public and statutory consultation should be implemented as early as possible in the project. Statutory consultees must be informed about the project 12 weeks in advance, and public consultation should take place no later than 6 weeks in advance of application.

A Pre Application Consultation (PAC) event is required as well as public notification through local newspapers, council, social media etc. Ideally this public meeting will be held close to the landing point in an accessible location and meeting place, which has been suitably promoted to ensure good attendance. Understanding local concerns and hearing and taking on board local views is key to a successful project approval process.

Fisheries Liaison is also crucial and as well as the public and statutory consultation, implementing a rigorous fisheries liaison plan is also important. Understanding local fisheries concerns are helpful to establishing a good relationship – potential to provide them a corridor, with the ability to make some routing suggestions where appropriate may be a method of fostering good relationships as has happened on previous projects. ‘Boots on the ground’ fisheries liaison is also highly recommended to speak to fishermen in person. Local companies who know the local fishing community can provide this as a service. Scottish and Southern Electricity (SSE) have previously conducted highly effective engagement events for recent projects which were commended by Marine Scotland, and information is publicly available on their methods to gain insight into the methods used.

The information that Marine Scotland require as an output from the PAC is set out in the regulations. There is a specific form highlighting the required information. MS recommend that the information from the form is used, but that the report is presented in a separate document – it is not mandatory to use the form provided. To understand which groups to invite for consultation and to pre-application public events, it would be useful to consult scoping advice from previous projects in the area which are publicly available on request from Marine Scotland. This would show which groups/individuals had responded locally to put together an engagement plan.

9.5.1.3 Fees

There is a fee for the application process which is calculated based upon the project value and is determined based upon the licensing authority recovering a proportion of the costs incurred in the process of licensing the project. Details of the fee structure can be seen on the Marine Scotland website.

9.5.1.4 Contacts

MS-LOT (Marine Scotland Licencing Operations Team)
Marine Scotland
PO Box 101
375 Victoria Road
Aberdeen
AB11 9DB
Tel: +44 (0)1224 295579
Email: MS.MarineLicencing@scotland.gsi.gov.uk

9.5.1.5 Survey

The cable route survey will not require marine licensing. However a European Protected Species (EPS) licence to be permitted to disturb certain protected species could be required depending on the type of survey equipment that will be used – for instance sub bottom profile or other noise generating operations. Scottish Natural Heritage has further information on EPS and noise levels requiring assessment and can provide further advice on this in order to determine whether or not an EPS licence will be necessary. EPS licensing takes approximately 8 weeks if it is a project requirement. If work takes place within an SAC for protected species then an EPS licence will be mandatory.

Further information on EPS licensing: https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/licensing/european-protected-species-licensing

A small works survey licence is also required from Crown Estate Scotland with a fee payable on a sliding scale starting at £500.

9.5.1.6 As-laid data

Following completion of marine installation activities, as-laid data must be submitted to the UKHO Source Data Receipt Team at the following address:

Contact: sdr@ukho.gov.uk

9.5.2 Crown Estate Scotland

Crown Estate Scotland own approximately 50% of the foreshore and most of the territorial waters of Scotland. As such they provide leases to developers to utilise the seabed and charge annual rents.

Crown Estate Scotland provide licences to give developers the property rights they need to lay, maintain and operate cables and pipelines on the seabed up to 12 nautical miles from the shore. This includes oil and gas pipelines, electricity and telecommunication cables. A licence application should only be submitted once works are fully planned. It typically takes between three and six months to complete the application process. Consents from the Scottish Government will also be required, but the processes should be able to take place in parallel. If new infrastructure is to be close to existing agreements, then crossing and proximity agreements will be required with existing tenants near the works and it is likely that these will need to be agreed prior to the lease being fully granted.

An option agreement can be granted in advance of a licence and this gives rights over the option area and sets out the conditions which the developer must meet for the licence. The licence terms are updated from time to time. Fees have been set following consultation with industry and third party experts and are charged consistently except where specific circumstances merit a slight departure. Further information on fees is in the Heads of Terms documents included as Appendix 13.3.

Decommissioning must also be taken into account at the time of application. CES want to ensure that they are not left with ongoing liability for an abandoned cable at the end of the life of the system, and require evidence of a decommissioning plan to be submitted during the process. Decommissioning plan guidance can be seen as Appendix 0.

Telecoms cables are defined by CES as either those that run from Scottish landfall to international destinations or that transit Scottish waters without making landfall.

CES should also be informed of cables and pipelines in the sea between the 12 and 200 nautical mile limit, as other activities may be impacted (email details to marine@crownestatescotland.com).

Template licence documentation is available to prospective applicants. Please email marine@crownestatescotland.com if you would like the documentation or for any other enquiries.

9.5.3 Operational Permits

There is no statutory requirement for any specific permit for a cable vessel to operate in UK EEZ, however notifications to local sea users of cable operations will keep the area clear for safety.

The UKHO must be notified in order to arrange notice to mariners. Navigational warnings will be broadcast by the UKHO if requested to notify any other sea users that submarine cable operations will be taking place in the area and the operations will be included in the Kingfisher Fortnightly Bulletin. Several weeks prior to the installation, the installer should ascertain exactly who to notify and arrange for a notification to be made via email, fax or by mail as appropriate. Interested sea users who should be notified can include the MoD, coastguard, fisheries, Northern Lighthouse Board and information should be requested to be disseminated to ensure other sea users are aware.

9.6 Ireland

9.6.1 Foreshore Unit

A foreshore licence is required for the development of a submarine telecommunication cable. The duration of these is usually 35 years with a 5 yearly rental review. There is a period of public consultation, and an environmental impact assessment may also be required. An application is necessary both for site investigation (survey) and installation of the cable. The process from commencement of application to gaining consent can take between 3 and 9 months.

The application process is defined as follows:

- The application is reviewed by internal and external advisors including Engineering staff, Sea Food Control Division and the Marine Survey Office, DEHLG Heritage Service, local harbour authorities and regional fisheries boards.

- Applicant given permission to advertise the project in a locally read newspaper and to put plans on public display.
- Plans are displayed for 21 days for non-EIS projects (see link below for information on projects requiring Environmental Impact Assessment or Environmental Impact Statement). This allows the public to make representations/objections on the development.
- Applicant given an opportunity to comment on the public representations/objections received.
- Final report is made to the Minister.
- Minister makes decision on whether to grant or refuse a foreshore consent application.

The consenting process guidance can be seen in full on the Foreshore Unit website: http://www.housing.gov.ie/planning/foreshore/applying-consent/consent-process-explained

An Environmental Impact Statement can be required to be submitted alongside the application under the European Communities (Environmental Impact Assessments) Regulations 1989 to 2001. The requirement for this is decided on a case by case basis following liaison with the Ministry.

Besides the licence rent, there are no other fees associated with application. Prior to application consultation with the ministry is advisable. For more information please visit:

http://www.housing.gov.ie/planning/foreshore/foreshore-consenting

9.6.1.1 Stakeholder Liaison

Prior to submitting the application, the applicant may conduct a preliminary round of consultations. This is not a requirement but it may facilitate the later review of the application. It may also alert the applicant to special studies required by particular government agencies, such as environmental or archaeological studies, thereby informing the process and understanding any potential cost implications. The responses to the initial consultations should be included in the application package. Please see Appendix 13.6 which is the recommended consultee list and contact details from the foreshore unit.

9.6.1.2 Appropriate Assessment

Under the Habitats Directive, if the landing or route fall within a Natura 2000 protected area, then the impacts may need to be reviewed through the process of Appropriate Assessment. In Ireland, the Natura 2000 network of European sites comprises Special Areas of Conservation (SACs, including candidate SACs), and Special Protection Areas (SPAs, including proposed SPAs).

https://www.npws.ie/protected-sites/guidance-appropriate-assessment-planning-authorities

Contact:

Marine Planning - Foreshore Unit

Department of the Environment, Community and Local Government

Newtown Road

Wexford

foreshore@environ.ie

Regional: Dublin, Kilkenny, Louth +353 (0)53 911 7371

9.6.1.3 Underwater Archaeology

The National Monuments Service are a statutory consultee for the Foreshore Unit and can have certain conditions that they require to be met if the development has the potential to impact underwater cultural heritage. An archaeologist present during operations, or person designated to deal with any items found could be a requirement during operations subject to consultation with the appropriate authorities. Further information can be seen at the link below:

https://www.archaeology.ie./underwater-archaeology/planning-and-development

9.6.2 Operational Permits

Marine Notices are information notices issued by the Department of Transport Tourism and Sport (DTTAS) to publicise important safety, regulatory and other information relating to maritime affairs in Ireland.

They are circulated to a wide range of individuals and organisations, including State agencies, the fishing industry, international shipping, and water-based recreational interests.

To provide notification, details should be sent using the appropriate form to marinenotices@dttas.ie. The Marine Notice form can be found at the following link:

http://www.dttas.ie/maritime/maritimesafetydirectorate/marinenotices/currentmn/current-marine-notices

Nigel Grogan,
Maritime Safety Policy Division,
Irish Maritime Administration,
Leeson Lane,
Department of Transport, Tourism & Sport,
DO2 TR60,
Dublin 2.
MarineNotices@dttas.ie
Ph: 01 678 34 17

9.7 Isle of Man

9.7.1 Marine Infrastructure Management Act

Previously under the General Authorisation Regime for Submarine Cables, there was well defined legislation to cover several aspects. Under the Marine Infrastructure Management Act 2016, this has been streamlined to create a single process for marine infrastructure projects.

The Marine Infrastructure Management Act 2016 received Royal Assent in May 2016. It came into force in 2017, though the regime is currently untested for submarine cables and the plan and process should be confirmed at an early stage with the Department of Infrastructure.

The process is intended to streamline and coordinate permitting for marine infrastructure developments providing a ‘one stop shop’. This means that the consent will cover all aspects related to the project as a whole to include all marine structures as well as any terrestrial works integral to the project. In effect this will create a system similar to a Development Consent Order (DCO) in the UK for major infrastructure projects.

Due to the requirement for an EIA under the Submarine Cable Act 2003, it is likely that an EIA will also be a requirement under the new consenting regime contained in the Marine Infrastructure Management Act 2016. Please see the link below for the specific guidelines for developers and Appendix 13.7 for the application form.

https://www.gov.im/about-the-government/departments/infrastructure/harbours-information/territorial-seas/guide-to-developers/

As this is a new and as yet untested process, the timescales in obtaining consent are undetermined, and so it will be important to coordinate with the authorities at the start of the process to establish timescale expectations in relation to the project.

Under the existing 'Submarine Cables (Fees) Regulations 2012' a one off fee of £23,750 is payable to the Department of Infrastructure on the making of an application for an authorisation. Any ongoing seabed lease fees are subject to negotiations with the Department during the application process. The fee structure under the new legislation is not known.

9.7.1.1 Contacts

Ian Brooks
Legislation and Policy Officer
Legislation and Policy Unit,
Strategy, Policy and Performance Division
Department of Infrastructure
Sea Terminal Building
Douglas
Isle of Man
IM1 2RF

Tel: (01624) 685901
Fax: (01624) 686443
Email: Ian.brooks@gov.im

Mark Kenyon
Ports Manager
Sea Terminal
Douglas
Isle of Man
IM1 2RF
Tel: (01624) 685184
Email: Mark.kenyon@iom.gov.im

For further information visit:

https://www.gov.im/about-the-government/departments/infrastructure/harbours-information/territorial-seas/primary-marine-legislation/

9.8 Permit Matrix Overview

SCOTLAND			
Permit Title/Activity	Regulator or Agency	Expected Timeframe	Activity
Operator's Licence			
Telecommunications Licence	OFCOM	-	Operation of a telecommunications network
Permits in Principle			
Marine Licence for Cable installation within 12NM	Marine Scotland (Marine Scotland Act)	12 weeks pre-application 14 weeks from submission (no statutory maximum)	Cable installation
Marine licence for additional cable protection works within 200NM	Marine Scotland (Marine and Coastal Access Act)	12 weeks pre-application 14 weeks from submission	Additional cable protection (Rock placement, mattressing)
Marine Licence	Crown Estate Scotland	Undefined depending on negotiations	Seabed lease
Harbour Works Licence (if applicable)	Harbour Authority	-	Any works within harbour limits
Survey Permits			
European Protected Species Licence (if applicable)	Marine Scotland	8 weeks	Disturbance of any European Protected Species
Operational Permits			
Notifications	UKHO SFF Kingfisher Northern Lights Coastguard Marine Scotland	4-6 weeks in advance of operations commencing (non-statutory)	Marine operations

IRELAND			
Permit Title/Activity	**Regulator or Agency**	**Expected Timeframe**	**Activity**
Operator's Licence			
Telecommunications Licence	Commission for Communications Regulation (Comreg)	-	Operations of a telecommunications network
Permits in Principle			
Foreshore Licence	Foreshore Unit	3-6 Months	Requirement for EIA on case by case basis
Operational Permits			
Marine Notice	Maritime Safety Policy Division	2 Weeks	Safety notice issued as Notice to Mariners
Notifications	Various government, , NGO, environmental and fisheries agencies as well as the coast guard and Kingfisher	4 weeks prior to operations	Coordinated approach with IOM and Scotland suggested

ISLE OF MAN			
Permit Title/Activity	**Regulator or Agency**	**Expected Timeframe**	**Activity**
Operator's Licence			
Telecommunications Licence	Isle of Man Communications Commission	-	Operation of telecommunications network
Permits in Principle			
The Marine Infrastructure Management Act 2016 – Streamlined Consent regime	Department of Infrastructure	Undefined	New legislation to provide 'one stop shop' – to be introduced in 2017
Operational Permits/Notifications			
Notifications	Marine Operations Centre (Coastguard), fisheries, Kingfisher	4 weeks prior to operations	Coordinated approach with Ireland and Scotland suggested

10.0 CABLE ROUTE ENGINEERING

10.1 Introduction

The Route Position Lists (RPLs) presented and referred to as the proposed routes in this study are the following files:

SFT Transatlantic Connection RPL 0-02 181112.xlsx

SFT Scotland - Ireland RPL 0-02 181112.xlsx

SFT Scotland - IoM RPL 0-02 181112.xlsx

The RPLs and planning charts use the WGS84 geodetic datum.

Cable route engineering assesses all potential influences on the cable. Data are combined to achieve the optimum cable route, minimising any threats, particularly those deemed high risk and/or high impact.

Global Marine achieves this using customised GIS technology known as GeoCable™. The combination of all information sources into one system provides a clear picture of the locations and combinations of risks to the cable and the options available to avoid or mitigate the risk. Alternatively, routeing of cables into areas likely to maximise protection through burial can also be considered. Final planning using MakaiPlan™ allows accurate infill slack values to be inserted into the RPL based on the expected morphology of the seabed to improve cable lay planning.

The primary rationale for cable route engineering is to avoid areas likely to pose a threat to system security. Sometimes risks cannot be avoided due to the additional cable length required resulting in excessive cost, or other constraints present which take priority. In these cases the route normally seeks areas conducive to burial as the primary protection measure or an increase in armouring protection is specified if within deployment depth limitations. Where neither is possible the route usually tries to limit the length of cable over which the risk is present.

Sections 10.3 to 10.7 describe the following:

- An overview of the fault history of the region and risks likely to impact on the cable.
- The cable specifications available for this study.
- A description of other components.
- Recommendations for additional protection measures.
- A detailed description of the route.

10.2 Cable Fault Analysis

Global Marine maintains a cable fault database with over 5,400 records worldwide. The new cables will be located in the Irish Sea and western Scottish shelf areas (Figure 62) and there is considered to be extremely good coverage of historical cable faults in this area.

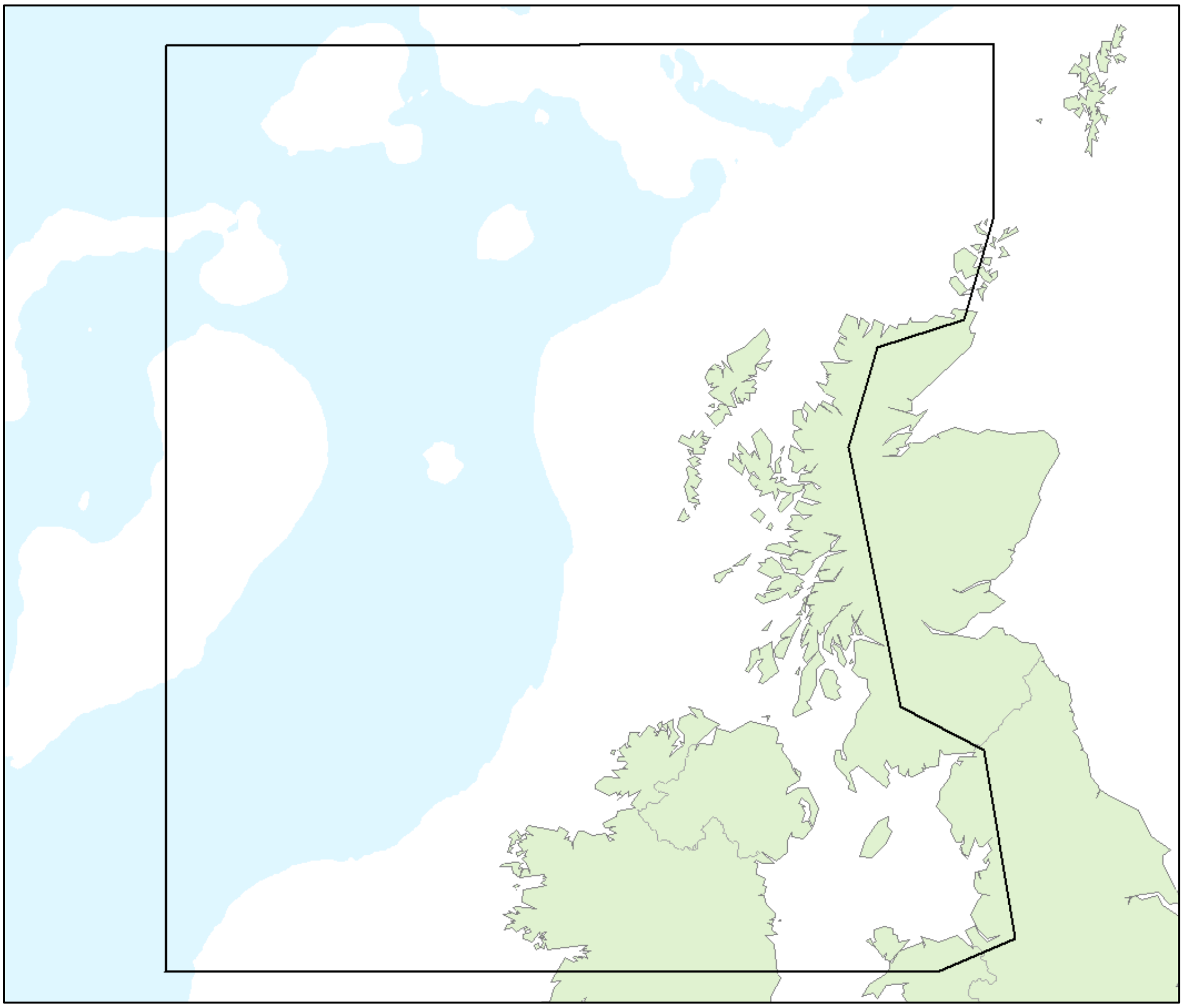

Figure 62: Area of Interest for Faults

The Global Marine database holds 178 records of faults on telecommunications cables in this area, of which 117 are records of faults on modern fibre optic cables and can be considered good analogues to the new cables. The results of the analysis of these fiber optic faults are displayed in Figure 63. At the highest level it can be seen that approximately three quarters (76%) of faults suffered by cables in this region are caused by external actors. Of the remaining quarter most (16%) were caused by internal faults in cable components whilst for 8% of the total the fault cause was unknown. The unknown faults probably have a similar external/internal breakdown ratio to the known fault causes as this is similar to the global prevalence of fault causes.

The fault causes differ from the global average in the sheer prevalence of fishing faults, 56% in this area compared to 39% globally. This reflects the intensive fishing industry in the region and the fishing risk remains high across the continental shelf (Section 7.2). Most fishing faults occur in water depths of <100m, reflecting the usual depths to which demersal trawling and dredging are carried out (Figure 64).

Anchor faults are responsible for 14% of faults in the area, similar to their global average. Anchors are a risk along large sections of the cable routes as designed due to the shallow water depths in the region. The deepest known anchor fault in the area occurred at 151m depth, with the majority occurring in less than 50m of water.

There is a low level of corrosion, seismic and other natural faults. This is likely to be due to the relatively well-understood marine environment around the UK. It should be noted that the cable route as designed crosses parts of the shelf west of Scotland on which there is expected to be a slightly elevated level of abrasion risk and appropriate armouring will be required (Section 10.7.1).

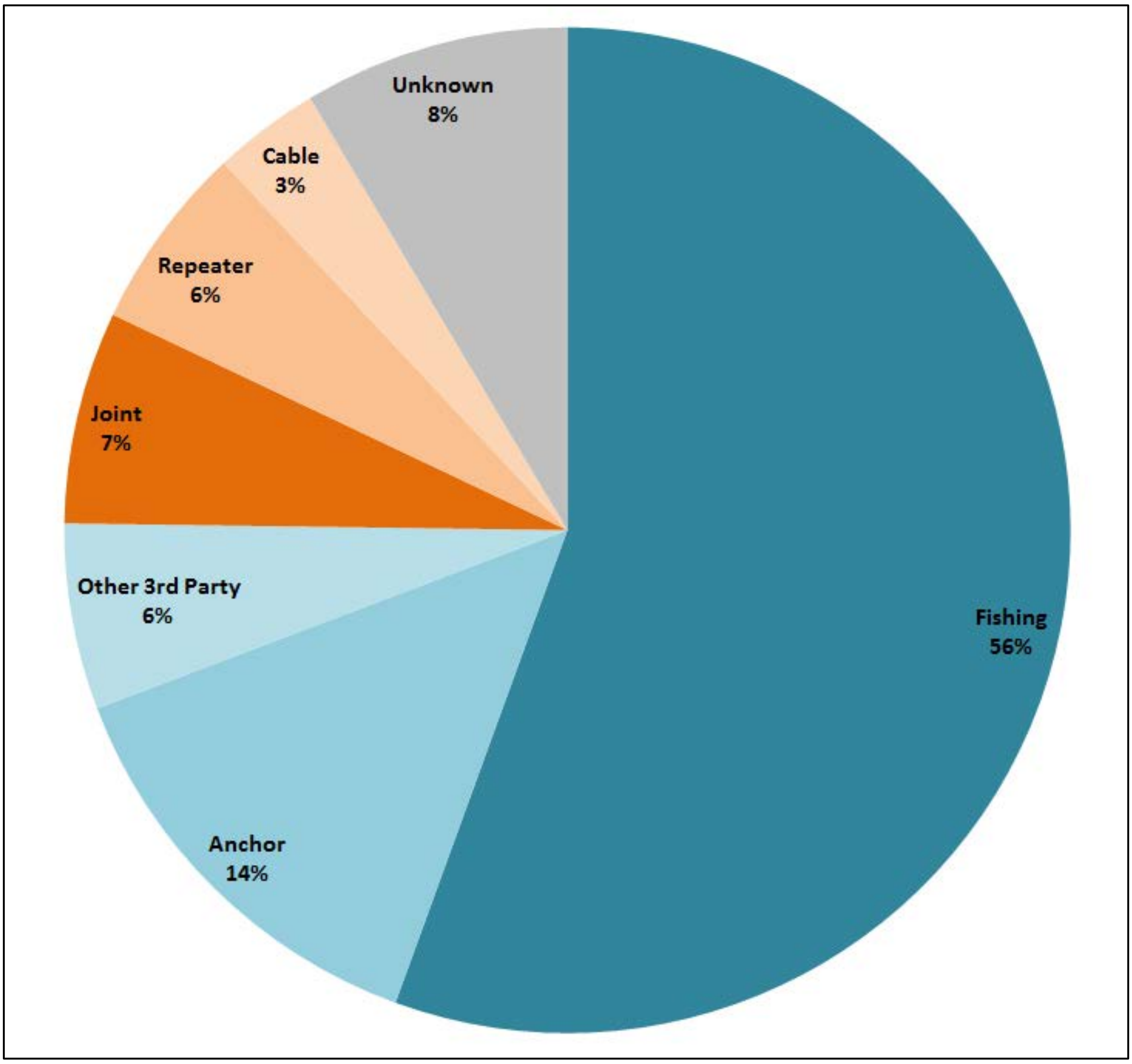

Figure 63: Causes of Cable Faults

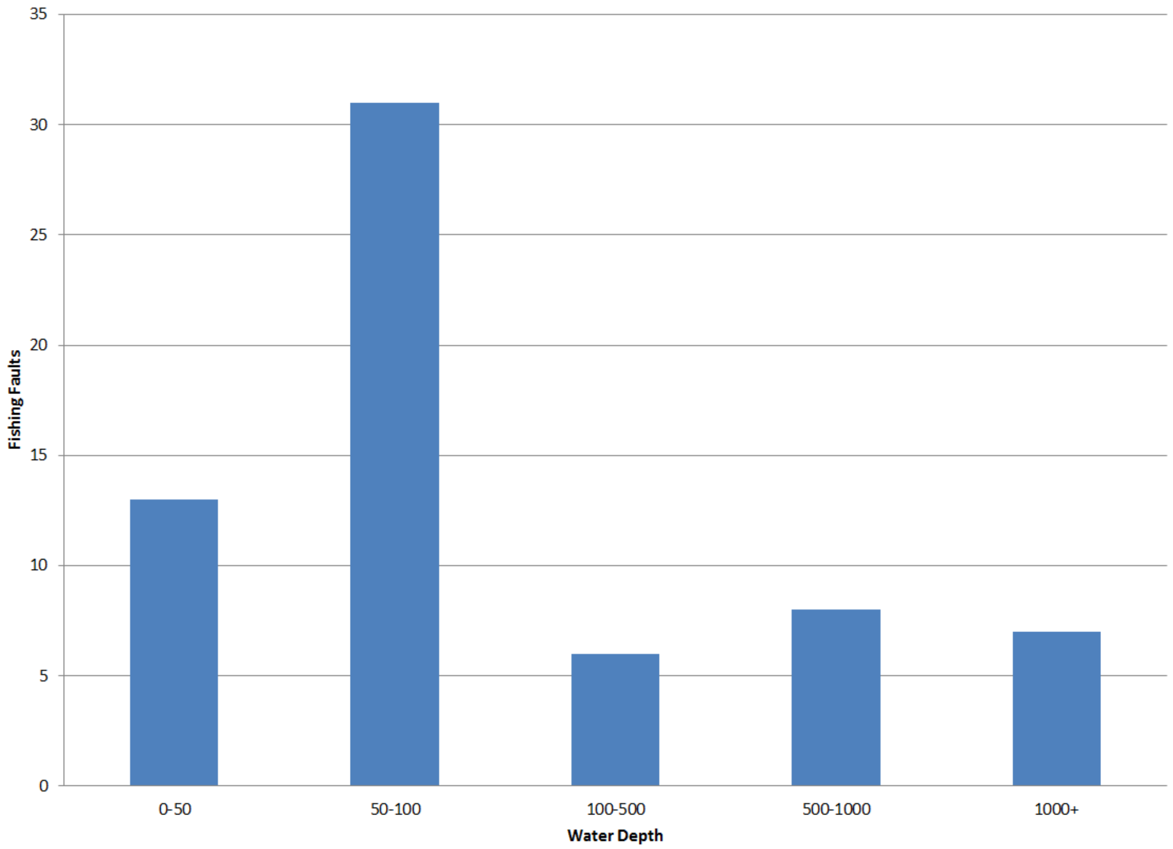

Figure 64: Fishing Faults related to Water Depth

From this analysis it is clear that by far the greatest threat to the future security will be from fishing activity, covered in Section 7.2 of this report. Anchoring, whether deliberate or unintentional, will also be a significant source of risk and is discussed in Section 7.3. Other potential sources of cable faults are widespread but unlikely to occur. Following the recommendations of this report (Section 1.1) will reduce the chances of damage to the cables.

10.3 Cable Specification

At the planning stage the importance of a cable's physical characteristics are primarily related to the strength of the basic cable core and the application of armour wires. The primary function of cable armour is to protect the fibre package by resisting the effects of localised external aggression and reducing damage to the fibre optic package.

The fibre optic communication cable used in this report is a generic type. The DTS RPL and Straight Line Diagram (SLD) specify the cable type to be used at each point along the route based on achieving target burial protection and adoption of the DTS cable protection recommendations.

A summary of the technical specifications for all the cable types used is given in Table 38, as the selected armouring may change along the route depending on the results of the marine survey. If target burial is judged to not be achievable after marine survey, then increasing the armouring should be considered to provide increased protection from external faults.

ABV.	CABLE TYPE	TYPICAL DEPLOYMENT ENVIRONMENT	CABLE DESIGN	MAX. DEPLOYMENT/ RECOVERY DEPTH (m)
LW	Lightweight	Intended for use in deep ocean benign environments.	Basic cable core	8,000
LWP	Lightweight Protected	Intended for use in deep ocean environments with a risk of abrasion.	Basic cable core with an additional layer of aluminium tape and HDPE protection.	7,000
SA	Single Armoured	Intended for surface use or buried where increased protection required compared to LW or where additional protection from burial negates the need for additional armour layers. Suitable for plough deployment.	Basic cable core with a single layer of armour wires.	3,000 (2,000 buried)
DA	Double Armoured	Intended for use in areas where moderate protection is required, typically system shore ends. Suitable for plough deployment.	Basic cable core with a double layer of inner and outer armour wires.	2,000
RA	Rock Armoured	Shallow water environments where high levels of abrasion and third party interaction (particularly crush) expected. Typically deployed in areas where burial protection is not possible For use in high energy environments where the seabed is rocky or there is a very high risk of fishing related damage.	Basic cable core with a significant double layer of inner 5.0mm and outer 6.0mm armour wires with a high pitch for crush and abrasion resistance.	500

Table 38: Report Cable Types

10.4 Branching Units

The configuration of the system is given in the RPLs and charts in the appendices. These show the branching units that have been included in the proposed Scotland - Ireland route to allow future spurs to be laid to Northern Ireland and the Isle of Man.

Submarine telecom cable branching units normally have a Y port layout, where two ‘leg’ cables exit from one end and the other ‘trunk’ cable from the opposite end. Figure 65 below shows the physical layout of a typical BU and its ports.

Figure 65: HMN BU 1650 Branching Unit

Ideally, a BU will be laid out on the seabed in a Y-shape, with the legs arranged symmetrically and at an angle of at least 60° from each other, as shown in Figure 66 below. This configuration is the easiest way to deploy a BU successfully and has been used as a guide when designing the Scotland - Ireland route.

Potential BU joint positions and jointing cable allowances have been included in the RPLs. For the DTS RPLs the joints have been assumed to be 80m from the BU itself. Although the length of the tails attached to the BU may vary, it is advisable that no joints be carried out prior to the installation. This will allow the installation vessel to adjust the cable allowance used based on factors such as the jointing space's distance from the stern.

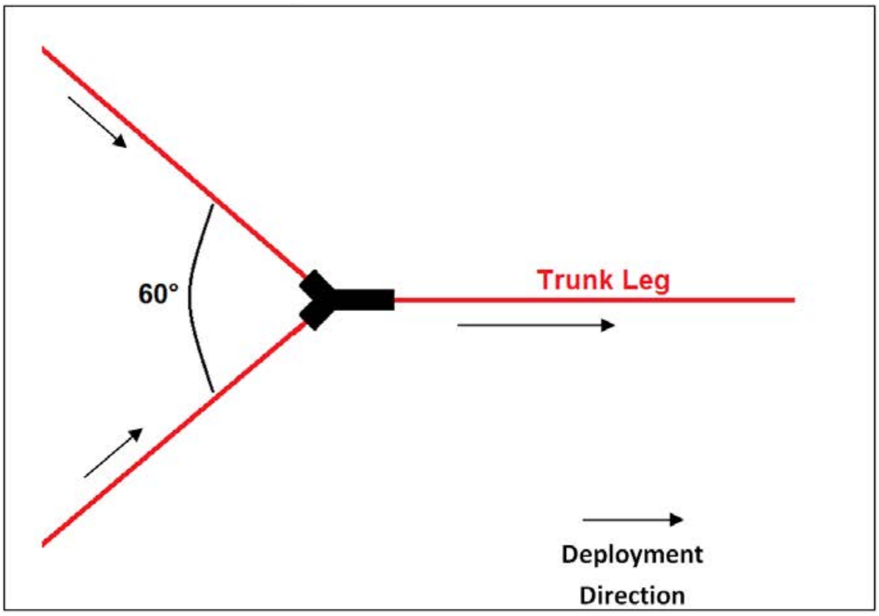

Figure 66: Optimal BU Deployment

10.4.1 Branching Unit Cable Allowances

Additional lengths of operational slack have been inserted into the Scotland – Ireland RPL in Appendix 13.10 at BU locations on each laydown (non-trunk) leg. This is to allow for jointing the BU into the cable. The values included are 1 x WD plus the estimated distance from the cable sheave to the vessel's jointing space. For a typical cable ship, a distance of 100m has been judged to be adequate to cover this distance. A generic allowance of 100m jointing space allowance plus the water depth, to a maximum of 300m total allowance, has therefore been used in the DTS RPLs, which should accommodate most vessels' layouts.

10.5 Repeaters

The Transatlantic Connection cable route designed as part of this study is likely to be repeatered in order to connect to a transatlantic system that passes very far offshore of Scotland.
Modern repeaters are optical amplifiers that use specially doped fibres and lasers inside the repeater to enhance the strength of the signal and this enables cable systems to be extended to transoceanic distances. An example repeater is shown below in Figure 67.
Repeater spacing ultimately depends on the supplier selected and system design specifications. The HMN RPT 1660 R2 repeater shown below has a maximum span distance of around 120km. The optimum spacing for this system may vary. In particular, the repeater spacing is required to be less when close to branching units in order to maintain the required optical power. Repeater spacing is also usually less than the maximum possible in order to allow for a system repair budget over the lifetime of the system. If a repair becomes necessary, system performance will not then be degraded by the additional cable and joints inserted.

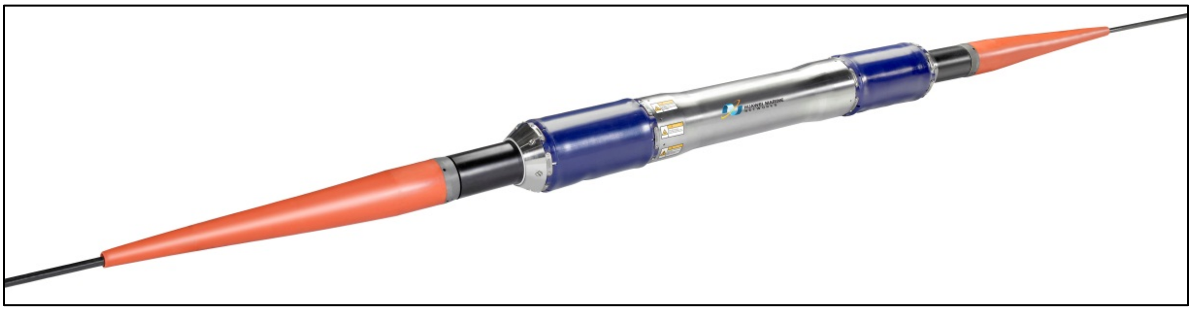

Figure 67: HMN RPT 1660 R2 Repeater

Detailed system engineering by the supplier chosen will consequently be required to determine the exact number and placement of repeaters. Repeaters require power to function which adds to the cost of the shore equipment and cable itself, as well as the cost of the repeaters themselves. This is why they are typically not used where an unrepeatered link is possible.

10.6 Cable Protection Recommendations

10.6.1 General Recommendations

Based on the risk assessment for the SFT cable routes the following recommendations are made to improve cable security:

- A programme of offshore liaison with fishermen active in this area is advised, prior and after the cable is installed. This should make the fishermen aware of the cable routes and the danger to their gear and personal safety from snagging a cable. Such liaison work has been successful in other regions of the world in helping to prevent cable faults.
- Ensure that the cable is clearly marked on navigational charts by the relevant authorities. This will reduce the risk of ships accidentally anchoring over the cable.

- Ensure the cable route survey includes high resolution bathymetry, and ensure the installer has competent slack planning software to be able to plan the installation slack thoroughly and so reduce the risk of suspensions and chafing.
- Install articulated pipe (AP) at the shore ends to 1m WD to protect against damage on the beach. If unavoidable rock outcrops are found in the nearshore, extend the AP over them, especially if this occurs close to the small vessel anchorage offshore of Port William.

10.6.2 Cable Burial

The preferred method of additional cable protection is cable burial, which has proven to be the most successful method for protecting submarine cables from external aggression. The main reasons for selecting cable burial as a primary protection strategy are the risks from fishing activity for an unburied cable in this area, the success of this type of protection and the financial economy of burial versus increased armouring.

Based on the cable fault information found during this study in Section 10.2, the types of fishing activity described in Section 7.2 and the geological constraints in Section 5.3, the recommended target depth of burial is 1m throughout the proposed cable routes, except in the Rockall Trough deeper than 1,000m and in the Beaufort's Dyke munitions dumping zone where the cable can be surface laid. Burial to a metre is considered sufficient to protect from the trawl and dredge fisheries in this area. The efficiency of cable burial as a means of protection is related to the hardness of the seabed. There is a risk of encountering hard seabed and subcropping rock in several areas crossed by the SFT cables. Where harder seabed is encountered and depth of achievable burial potentially reduced, the depth of penetration into the seabed from the various cable damage threats (i.e. an otter trawl board or an anchor) is often also reduced and thus the risk decreased for a cable at any particular depth. Burial should be planned to compensate for any bedforms found during the cable route survey (Section 5.4.1). If burial is found to be impossible in some sections up-armouring or additional protection will need to be considered.

Due to the limitations of the shallow geological information available to this study the probability of achieving the target burial for the entire cable route is uncertain. Other cable protection measures should therefore be reviewed if necessary after the marine route survey and a burial assessment report are completed.

10.6.3 Cable Armouring

Cable armour selection at the desk top study stage of a project is normally determined based upon knowledge of regional risk to the cable combined with the expected geological sediments along the route. The result is a set of design criteria for cable armour transitions.

Where the cable is recommended for burial, the cable types considered need to be suitable for plough burial. This means an armoured cable selection able to cope with passing through a cable plough. The cable types considered were the family of cables detailed in Section 10.3.

The DA armour variant has been chosen for the areas of the SFT cables that lie on the continental shelf, including the entire lengths of the Scotland – Ireland and Scotland – IoM cable route. This reflects the generally high risk from fishing in this region as well as the risks arising from heavy vessel traffic and abrasion on rocky areas. This armour choice assumes that burial will be achieved to the recommended 1m along the entire route. If the marine survey reveals areas of the cable are expected to achieve less burial then up-armouring to a heavier cable would improve the resistance of the system to the increased risks.

The Transatlantic Connection cable enters deeper water to the west in the Rockall Trough which results in a lower level of risk. The cable type transitions to SA on the upper slope where the cable is to be buried. Deeper than 1,000m WD the armour type transitions again to SAL for abrasion resistance on the lower continental slope. At 2,000m the cable transitions to LWP for the remainder of the route to the BU.

10.6.4 Pipeline Crossings

There are five pipelines crossed by the SFT cables (Section 7.7.4). At the pipeline crossings it is recommended that additional protection is provided for the cable. Fishing effort is often concentrated on the pipelines as they act as artificial reefs for fish. This means that additional protection will be required for the cable as it will not be buried at the crossing. The cable and pipeline will also need to be protected from interaction from each other.

Based on GMG’s experience with similar cable systems in the North Sea and Gulf of Mexico as well as ICPC recommendations (ICPC, 2007) a preliminary crossing design has been created. As a general summary, the crossing would involve:

- An end to plough burial 500m from the pipeline to be crossed.
- Placement of an articulated concrete mattress over the pipeline at the crossing point.
- Fitting of 200m high performance polyurethane protection (e.g. Uraduct®), 100m either side of the crossing, to the cable prior to deployment. Where the separation between crossings is less than 100m then the polyurethane protection should be extended and become continuous between crossings.
- Placement of the Uraduct® protected cable on the concrete mattress.
- Burial of the cable and Uraduct® into the seabed by ROV trenching as close to the pipeline as possible (and agreed with the pipeline owner).
- Remediation of any cable freespans using gravel bags.
- Resumption of plough burial 500m from the pipeline.

TDM will be required throughout the operation over the pipeline. Figure 68 shows concrete mattressing operations being carried out from a GMG vessel in the North Sea.

The amount of protective polythene tubing required in total for the system as designed is 1km.

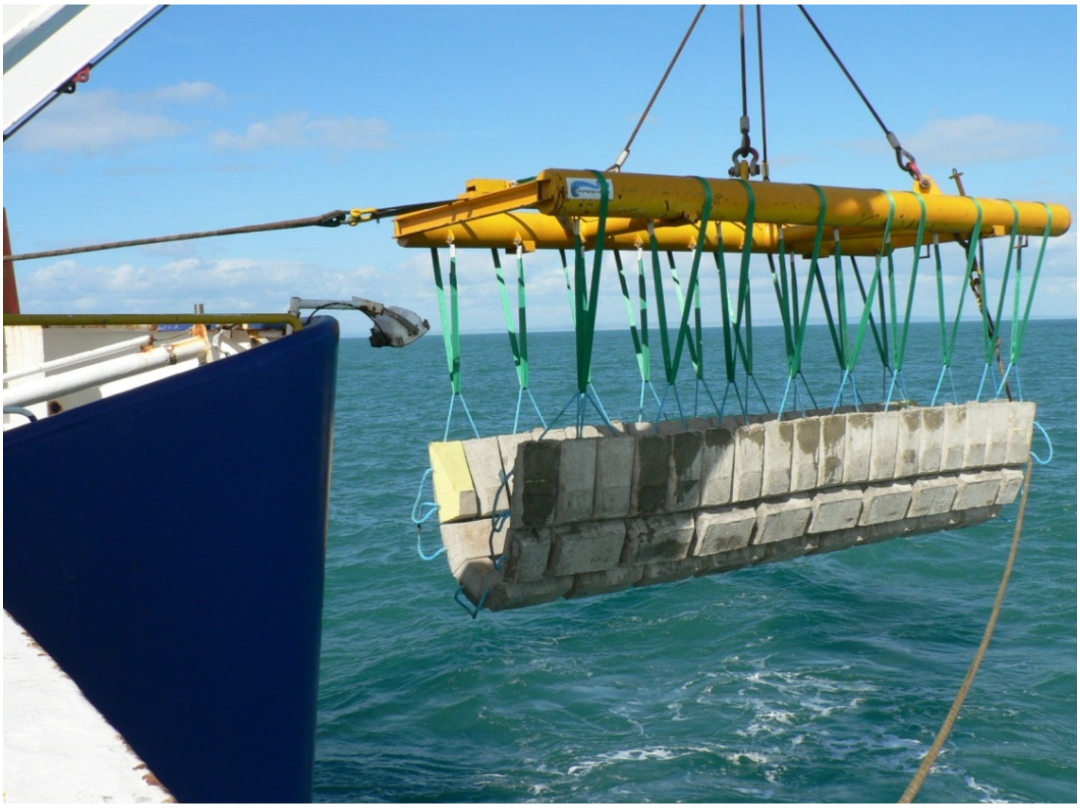

Figure 68: Deployment of a Flexible Concrete Mattress (GMG)

This default plan cannot be fully defined until all details of the pipelines crossed are known (surface laid/buried, anode spacing, diameters and nature of any coverings), at which point final crossing designs can be engineered. The pipeline owner may require a higher or lower level of protection than that proposed in the design above before the completion of a crossing agreement. Many pipeline owners will specify a minimum separation to be achieved.

No rock/gravel dumping is assumed at this point but may be required depending on each detailed crossing design. A general rock dumping design is described below.

10.6.5 Telecoms Cables Crossings

In-service telecoms cables are known to cross the SFT cable routes (Section 7.8.1). If previously unknown in-service cables are discovered during the marine survey, for instance new cables or those of a military nature, the owner should be identified and a crossing design should be developed. A minimum crossing angle of 60° has been adopted in routeing for this study to ensure that cable maintenance operations can be carried out with a minimum of potential problems near to the crossing points. In most cases no additional protection is required as long as the armour types of the cbales match (e.g. SA cable is not laid over LWP cable). For cable crossings where additional protection is required it is recommended to use 100m of Uraduct® high performance polyurethane half shells. These are applied on the vessel before overboarding. The Uraduct® provides physical separation between the two cables and should prevent any risk of mutual abrasion. The crossing point can then be post-lay buried.

10.6.6 Power Cable Crossings

The SFT cable routes will also cross several power cables (Section 7.8.2). These cables are expected to be crossed using a similar design as for a telecoms cable. Separation requirements may be increased for power cables compared to telecoms cables. This can be achieved with polyurethane half shells (e.g. Uraduct®) or concrete mattresses depending on the desired separation.

10.7 Cable Route Commentary

This section details the cable routeing decisions made in the production of the RPLs in the appendices to this report. One of the main constraints on route design is the maximum lay curvature, or rate of turn, chosen. The lay curvature of a route during installation depends on two factors; the installation method and the depth of water. For plough buried cable GMG has limited cable alter courses to 15°. For surface laid and post-lay buried cables the maximum A/C is 25°. In up to 100m of water A/C separation is a minimum of 250m, from 100-1,000m WD it is 300m and beyond 1,000m it is twice the depth of water. A/Cs on the beach may exceed 25° through the use of quadrants to avoid obstacles.

10.7.1 Transatlantic Connection

The SFT Transatlantic Connection route begins at a hypothetical branching unit location on the Havfrue system that runs from New Jersey, USA to Denmark and Norway. The BU is located in the Rockall Trough between the British Isles and the Rockall Bank to the west in a water depth of approximately 2,600m. The route starts at the BU to avoid a final bight in deep water that would use around 5,200m of extra cable.

From the BU position the cable route travels southeast towards the Scottish continental slope. It remains 20km clear of the lower slopes of the Hebrides seamount to the east of the BU in order to avoid the risk from mass wasting events and abrasion. The cable is designated as LWP throughout this section to protect from the low but present abrasion risk in the Rockall Trough. The cable route has been designed to avoid known wrecks and there are few other constraints on cable routeing.

VMS data from 2007-2011 and 2016 shows demersal fishing does not take place down the continental slope near to the cable route. The main risk is from longlines on the upper reaches of the slope. Plough burial has been recommended from 1000m WD, with a transition to single armour just before. From 2,000m WD to 1,000m WD the cable is designated as SAL for protection from abrasion on the slope. These protection measures will also reduce the risk from future expansion of the longline or other fisheries into deeper water over the lifetime of the cable. The cable has been routed to climb the slope as directly as possible rather than in parallel to the contours. This will reduce the risk from mass wasting events as it reduces the cable's cross-section exposed to such events and makes us of its increased axial strength.

There is minimal fishing recorded in VMS data over the outer continental shelf north of Ireland. The biggest influence on the design of the cable route across the majority of the shelf has been the desire to avoid Irish territorial waters. This is expected to reduce the permitting burden of the project significantly and improve the economics of the system by avoiding the requirement to pay a seabed lease in Ireland which can be a significant cost (Section 9.6). The second biggest influence has been the presence of numerous wrecks which have been avoided (Section 7.4).

From around KP295, north of Malin in Ireland, the cable begins turning southeast towards the North Channel south of Kintyre. For the next 100km the primary concern has been to avoid areas of rugged bathymetry and known rocky outcrops as far as possible, and to cross them at the best point where necessary. This is particularly key southwest of Islay where two rocky ridges extend southwest from either side of Laggan Bay out across the cable route. The cable crosses the first of these ridges near to the end of its length and following the marine survey it may be possible to route the cable in such a way as to avoid rock outcrops and maintain plough burial. If not, it is expected that the cable may need to be up-armoured for a relatively short section of around 3km. The second ridge is a more significant obstacle. The cable has been routed through a gap in the ridge that is approximately 500m wide (Figure 69). Depending on the findings of the marine survey, this section may be buried or may need to be surface laid and up-armoured.

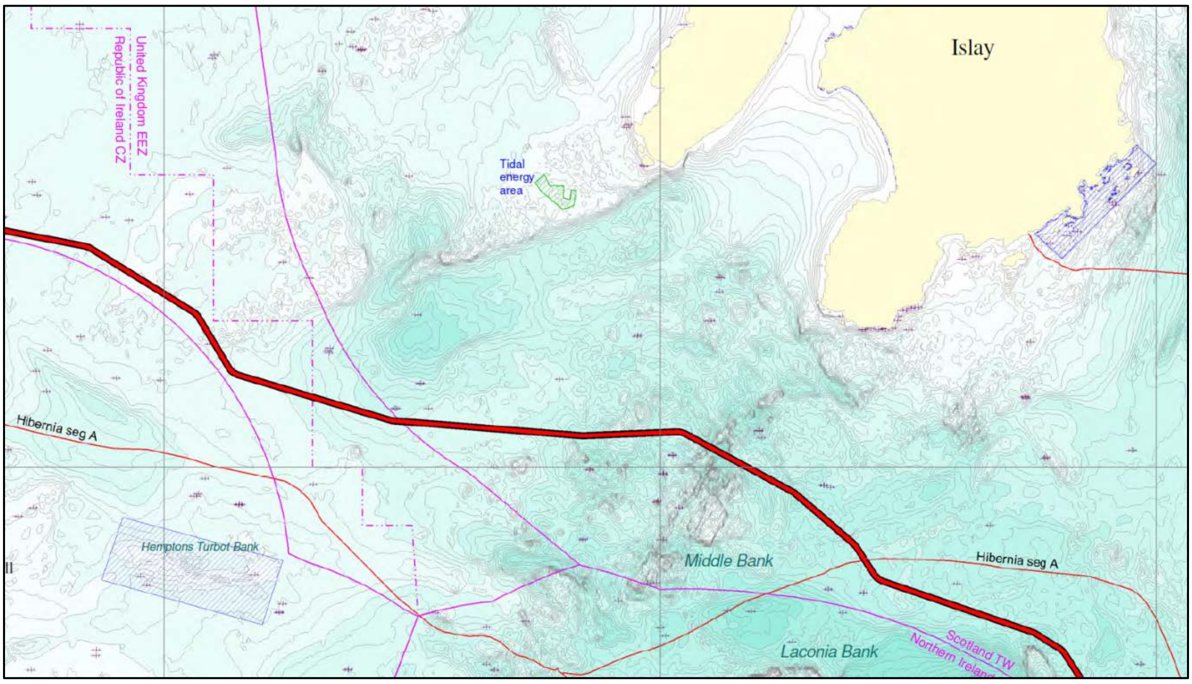

Figure 69: Eastern Rock Ridge (GEBCO, 2014)

Shortly after the second ridge the cable route makes its first crossing of the in-service fibre optic cable Hibernia Segment A. It does so in order to get on the south-western side of the Hibernia cable and avoid the rugged terrain which lies between it and the Kintyre peninsula. This also allows the SFT cable to pass through the dividing section in the centre of the Traffic Separation Scheme between Kintyre and Northern Ireland. This area is relatively light in vessel traffic with a corresponding reduced risk of anchor incidents. The cable route has been designed to pass north of a relatively shallow, rocky area in the centre of the TSS northeast of Rathlin Island.

To the south of the TSS the cable route makes its second crossing of Hibernia Segment A as it turns east to pass south of Kintyre. The cable avoids the shallow, likely rocky area immediately south of the peninsula and instead passes up a wide, relatively flat valley 8km south of Sanda.

From this point to the landing in Irvine the cable route is relatively straight. The biggest change in course is due to the crossings of the Sirius North and LANIS Segment C fibre optic cables south of Arran. The route has been engineered to have a minimum crossing angle of over 60°, in accordance with ICPC guidelines. Wrecks and other obstructions have again had a local effect on cable routeing, with the cable route avoiding them as far as possible, with a minimum of 750m for wrecks. The cable route parallels LANIS Segment C towards the landing point with a minimum separation of around 800m to facilitate maintenance operations except close to crossing points.

The SFT cable crosses LANIS Segment C for a second and final time 6.8km offshore of the LP in Irvine, 6.6km west of the LANIS LP in Troon. The route within Irvine Bay has been constrained by rock pinnacles which have been avoided. To do so the SFT Transatlantic Connection route parallels the SFT Scotland – Ireland route described below at a distance of 200m. This generous separation in

<25m of water will allow both cables to be routed within their combined survey swathe to avoid rocky areas and other obstacles whilst leaving enough separation for potential future maintenance operations to proceed without risk of damage to the other cable.

From around 400m offshore the cable route parallels an outfall pipe at a distance of roughly 40m in <2m of water. The exact route of this pipe should be established by the cable route survey. From meetings during the site visit this outfall is thought to be disused (Appendix 13.2). A large concrete manhole thought to be related to the outfall was located on beach. A beach A/C has been used to avoid crossing the outfall pipe. The cable route then passes up an access road from the beach to an area of grass adjacent to a roundabout and car park where the BMH is sited.

10.7.2 Scotland – Ireland

The SFT Scotland – Ireland cable is designed to be installed from south to north. The direction of lay could potentially be reversed but the route close to the branching unit positions would need to be revised to allow them to be deployed safely and efficiently.

The landing at Portmarnock in Ireland is shared with the Sirius South and Emerald Bridge One fibre optic cables and the SFT cable will be laid between them close to the route of the out of service BT-TE 1 cable. The inshore area close to Portmarnock is very shallow. The 10m WD contour is 2.7km offshore, beyond the practical length of a direct shore end where the cable is floated ashore from the main lay vessel. Instead the inshore section would need to be installed separately as a pre-laid shore end (PLSE). The ultimate length of the PLSE will depend on the findings of the marine survey and the draft of the installation vessel. For this DTS the 13m WD contour has been used as a realistic conservative estimate. This yields a PLSE length of 9.465km, or 9.559km of cable after slack is added.

The end of the PLSE is south of Lambay Island. From here the cable route continues east-northeast, crossing Hibernia Segment C. The cable takes a direct route to the edge of Irish territorial waters, remaining between Sirius South and Emerald Bridge One. At the first opportunity it turns north to cross Sirius South, Hibernia Segment C, the East West Interconnector power cable and the 24” Scotland to Ireland Interconnector 1 gas pipeline. These all run roughly parallel at the chosen crossing location, reducing the amount of cable required to achieve good crossing angles, although the crossings of the power cable and pipeline are only 79° rather than the preferred 90°.

After the crossings the cable turns northeast towards Scotland, making small course changes to avoid wrecks and significant local bathymetry in the form of submarine valleys. It leaves Irish waters and enters the UK EEZ.

The first BU on the system is positioned 32km west of Port Erin on the Isle of Man. It is intended to facilitate a future connection to the island and this location would allow an easy connection to most potential landing points such as Peel, Port Erin, Port Grenaugh or Douglas. The branching unit is outside of Manx territorial waters to avoid paying for a seabed lease for the trunk system.

As it continues northward the cable route also avoids crossing into Northern Irish waters to avoid the potential increased permitting burden. It enters UK territorial waters in the Scottish area, crossing the proposed replacement for the Scot-NI 1 fibre optic cable a few kilometres after. A second branching unit has been engineered into the system 26km east of Ballywalter in Northern Ireland to allow for a future connection to the region close to Belfast. The BU position has been chosen to lie outside of the Beaufort’s Dyke munitions dumping ground to reduce the risk of UXO when recovering the BU tail (Section 7.9.1). It is still recommended that this recovery operation be undertaken using an ROV lift line rather than a grapnel to further minimise the risk.

From the BU the cable will be ROV-buried to the boundary of the Beaufort’s Dyke area. From this point it will be surface laid through the Dyke. This action minimises the risk from UXO to the cable lay and is possible due to the low to non-existent levels of bottom-contact fishing within the Dyke. An analysis of fishing in the area is carried out in Section 7.2.3.2.

Within the Dyke the cable crosses the Hibernia Segment A and Scot-NI 1 fibre optic cables, as well as several out of service cables between Scotland and Northern Ireland. Plough burial of the cable is expected to resume as it exits the Beaufort's Dyke area. This is at the top of a slope, reducing the risk of UXO. It overlaps with an area of more intensive bottom fishing, although this is expected to be mainly or entirely outside of the Beaufort's Dyke dumping ground. The plough down positon should be reviewed following survey. If trawl scars and/or dredge marks are found inside the boundary with no or minimal UXO, the plough down position should be brought inside the area. If both are found, the cable should be up-armoured and potentially ROV-buried. If neither is found, as expected, the RPL should remain as it is.

The seabed north of Beaufort's Dyke is very crowded, with infrastructure between Scotland and Northern Ireland largely passing north of the dumping ground. Over the next 10km the cable crosses the 24" SNIP gas pipeline, the LANIS Segment C and Scot-NI 2 fibre optic cables and the northern and southern cables of the Moyle Interconnector power cable system. Following this the cable turns northeast towards Irvine. It avoids known wrecks and obstacles by a safe distance (Section 7.4) before crossing LANIS Segment C for a second time and passing north of Ailsa Craig. It parallels the route of the Western Link HVDC system at a minimum distance of 750m in 65m WD to allow safe access to either cable in the event of a repair even if the SFT cable is moved closer within the survey swath following the marine survey.

The cable crosses LANIS Segment C for a third and final time in the approach to Irvine as that cable turns east towards its landing in Troon. The route close to shore has been designed to avoid shallow rocky areas and rock pinnacles. It parallels the SFT Transatlantic Connection route described above at a distance of 200m. This generous separation in <25m of water will allow both cables to be routed within their combined survey swathe to avoid rocky areas and other obstacles whilst leaving enough separation for potential future maintenance operations to proceed without risk of damage to the other cable.

The cable lands south of the concrete manhole on the beach thought to be related to a charted outfall pipe (Appendix 13.2). A beach A/C is used to direct the cable up the beach access track to the BMH position in a grassy area adjacent to a roundabout and car park.

10.7.3 Scotland – Isle of Man

The Scotland – Isle of Man cable is designed to be laid north to south due to shallow waters at Port William which could limit the manoeuvrability of the vessel when performing the shore end and deploying the final bight. The necessary tight turn offshore of Peel would also mean that the first plough down point would need to be further offshore to avoid pulling the A/C out of alignment. This would reduce the protection of the cable. When laid towards Peel, the final plough up point can be much closer inshore, increasing the protection of the cable.

The water in Luce Bay offshore of Port William is very shallow. To avoid a PLSE of approximately 4km in length the end of the shore end has been positioned at 10m WD. This allows a 1km direct shore end, at an increased risk of installation delays due to tides or adverse weather conditions making it unsafe for a vessel to approach this far inshore. The shore end section is angled to avoid a small vessel anchorage offshore of the LP in 3m WD but burial will be essential to avoid the risk of small vessel anchors damaging the cable (Section 7.3.3).

From the end of the shore end, the cable route proceeds further offshore before turning south to avoid a marker buoy offshore of Port William. The route then heads almost directly south to reach deeper water (>20m) with a reduced risk of storm-driven sediment movement exposing the cable. This also avoids the reef known as "The Scares" in the mouth of Luce Bay.

Avoiding known wreck locations, the route then turns southwest towards the Isle of Man. The passage through Scottish TW is expected to be uneventful, with few constraints on the cable route taking a direct line. Midway to the Isle of Man the cable route passes through a series of shoals, valleys and pits which it largely avoids. Intensive route engineering may be required in this section following the marine survey to avoid smaller features revealed by more detailed bathymetry.

South of the area of complex bathymetry the cable route travels further southeast before turning to cross the 24" Scotland – Ireland Interconnector 1 and 30" Scotland – Ireland Interconnector 2 gas pipelines at a 90° crossing angle. There is a small A/C between the two pipelines to create this ideal crossing angle. The section between the crossings (2.674km) is ROV buried to avoid pulling the suspended cable tight over the pipelines. Crossing the pipelines at this point avoids a third and fourth crossing of the branch pipelines from the Scotland – Ireland Interconnector 2 trunk to the Isle of Man.

After the crossings the cable route proceeds inshore. The landing at Peel is designed to be to the east of the landing of the LANIS Segment B fibre optic cable, avoiding the necessity of a crossing. This does mean that the SFT cable is forced to approach Peel from the northeast, with a series of A/Cs to bring the cable into alignment. Because inserting A/Cs into a floating shore end is difficult and imprecise the end of the shore end is close inshore at the 10m WD contour, with the attendant risks discussed above for Port William. At this point the SFT route is 100m from LANIS Segment C. This gradually narrows through the 1.26km shore end to 5m at the BMH.

10.8 Summary for Cable Route Engineering

Potential cable routes have been developed for each of the proposed SFT fibre optic links and incorporated into the GMG RPLs and SLDs given in Appendix 13.10. This route has evolved as the result of GMG research combined with customer-supplied data. This process has produced the optimum cable routes achievable with the data available to a desk top study, with maximum mitigation against the perceived risks.

Cable types have been designated along each route based on the expected risk environment at each point. If the cable type is changed before the installation of the system the RPL should be reviewed to ensure that cable security is not compromised. The armour type should be reviewed following the marine survey to ensure that it is appropriate to the conditions found.

Cable burial to a target depth of 1m below the seabed is recommended to 1,000m water depth. The Ireland and Isle of Man connections will be entirely buried. This is based on the types of fishing gear found along the cable routes and the high proportion of historical faults caused by fishing in the area. AP is recommended at the landing points to protect the cable on the beach.

Additional protection may be required at in-service cable and pipeline crossings. Example protection methodologies have been detailed. These methods will provide protection from threats where cable burial is expected to be reduced or non-existent. They will also prevent accidental damage to the cable or crossed infrastructure at the crossing point. These designs are suitable for use a basis for the negotiation of crossing agreements with the owners of the crossed infrastructure.

The dominant influence on the SFT routes has been the selection of recommended LPs based on datacentre location (Section 4.0) and the detailed findings of the site visit report (Appendix 13.2). The route commentary in Section 10.7 discusses the effect of all influences on the cable routes in detail. Other major influences include the rock ridges that cross the Transatlantic Connection route southwest of Islay, the presence of the Beaufort's Dyke munitions dumping ground and crossings of the gas interconnector pipelines between Ireland and Scotland across the Irish Sea.

11.0 OPERATIONAL REVIEW

11.1 Cable Route Survey

11.1.1 Introduction

The main objective of the marine survey is to confirm or update the proposed route in order to ascertain a safe and viable cable route taking into consideration system design, cable deployment, system security and subsequent repair and maintenance operations for the lifetime of the cable. The survey will also allow firm decisions to be made concerning marine installation procedures and the extent of cable armouring and projected burial for the cable route.

Since the installation route cannot be precisely determined prior to the survey, the assessment of the data as it is acquired will determine any route deviations from the initially proposed pre-survey route.

The route should be mapped using a full geophysical spread of equipment including side scan sonar and sub-bottom profiler. It is the recommendation of this study that the SFT Cables should be buried where possible across the entire length of the route, as stated in Section 10.6.2. It is therefore recommended to include burial assessment survey tools such as CPTs in the survey scope. Seabed sampling by means of cores will be essential to build up a complete picture of the cable environment and burial potential.

Recommendations are given below for the cable system survey.

11.1.2 Equipment

The survey equipment on board the survey vessel should include, but not be limited to the following:

- PC based navigation, helmsman display and data logging system.
- DGPS primary and secondary positioning for all phases of the project.
- Multibeam Echo Sounders (shallow and deepwater configurations).
- Side Scan Sonar.
- Sub-Bottom Profiler.
- Magnetometer (for the location of in-service cables and pipelines).
- USBL Tow Fish tracking.
- Gyrocompass.
- Seabed sampling equipment (Gravity Corer, Grab Sampler, etc.).
- CPT rig.
- Single Beam Echo Sounder and SSS for inshore route surveys.
- ROV for pipeline crossing survey.

11.1.3 Navigation

The vessel's position from the DGPS receiver should be interfaced to a navigation computer system to provide track guidance information for the survey crew. Output of the vessel's position to a remote VDU monitor on the bridge provides a display to assist the helmsman in maintaining the selected survey line. The position of each fix, combined with fix number, depth, PDOP and down-line distance should be logged. Two survey gyrocompasses should be provided on board if a DGPS system is not to be used.

11.1.4 Bathymetry

A suitable multibeam system which has minimum swath coverage of approximately 3 x water depth is recommended. Where multiple lines are run, data should be collected to ensure that a minimum 20% data overlap is achieved. Multibeam systems should be calibrated before commencement of survey and periodically checked by patch test during survey acquisition. Sound velocity profiles should be performed regularly using an SV probe and supplemented by XBT (Expendable Bathythermograph) or XSV (Expendable Sound Velocity probe) profiles.

11.1.5 Seabed and Sub-Bottom Characteristics

A high resolution, dual frequency, digital SSS is recommended to map the seabed topography. Side scan sonar range should be adjusted so that over 100% overlapping coverage of the survey corridor is obtained. Systems employed should be able to resolve an object with minimum dimensions of $1m^3$. Sub-bottom profiling should be conducted along all vessel track lines. A suitable “Pinger” or “Boomer” type SBP should be used, such as a hull mounted 4 x 4 pinger SBP, towed pinger or combined side scan sonar/sub-bottom profiler. Approximately 5m of penetration should be obtained in medium dense sand and 15m in soft to firm clay. Heave compensation should be employed to reduce the effects of vessel movement and optimise the quality of the sub-bottom data. Both the side scan sonar and sub-bottom profiling data should be recorded with a digital acquisition and processing system.

11.1.6 Magnetometer

It is recommended that the survey equipment includes a Magnetometer to locate in-service cables or pipelines that cannot be identified by side scan sonar or sub-bottom profiling. Crossings should be located by magnetometer. The magnetometer may also be used to determine the difference between seabed scars and unknown cables (of classified or military origin), which are difficult to distinguish by side scan sonar alone.

A magnetometer is not generally required for locating out of service cables, since results are likely to be inconclusive when using database positions.

11.1.7 Tow Fish Positioning

In water depths of greater than 30m a USBL acoustic positioning system is recommended for tow fish positioning and layback calculation.

11.1.8 ROV Crossing Survey

To aid in the design of pipeline crossing protection (Section 10.6.4) visual inspection by an ROV is suggested to be included in the cable route survey. This will enable the survey to determine the exact elevation of the pipeline at the crossing point, the presence or absence of scour pits and identify any other features of relevance, such as sacrificial anodes or snagged fishing gear.

11.1.9 Seabed Sampling

Seabed sampling using a 3m gravity core and Van Veen or Shipek type grab sampler should be used for direct sediment sample acquisition. Standard sampling procedure is to deploy the gravity corer and if it fails to obtain an adequate sample (approximately 1m) after two attempts, then the grab sampler is deployed.

A nominal sample spacing of 10km is suggested to ground truth the SSS and SBP data. Sample positions should be adjusted by the onboard geophysicist to determine the composition of areas of variable sediment; allowing the route to be engineered away from hard patches of seabed where possible. Conversely, where the along-track seabed soil profile is consistent, the frequency of sampling may be reduced to place spare samples where they are needed.

11.1.10 Cone Penetration Tests (CPTs)

The purpose of CPTs is determination of the soil type and mechanical parameters in-situ on the seabed enabling accurate burial predictions. The horizontal accuracy of the test should be better than ± 10m to be useful for this task.

In the event that full penetration is not achieved standard procedure is to select an alternate site in close proximity to the selected site to re-test. Two re-tests should be performed before evidence of impenetrable soils is assumed.

The standard interval between CPT test sites is 4km although this should be adjusted in a similar way to the sampling interval above to build up as complete a picture as possible of the different seabed units.

11.1.11 Deep Water Survey

In deep water beyond the limit of burial in the Rockall Trough geotechnical sampling, SSS, SBP and magnetometer data are not required. The survey vessel should continue to collect multibeam data to enable cable routeing around undersea obstacles.

11.1.12 Charting and Reporting

It is recommended that a sample 'North-Up' Chart and a sample 'Alignment Chart' should be produced by the contractor and agreed by the customer prior to commencement of the marine survey. This ensures that charting styles and legends are consistent and in a format accepted by the client.

11.1.12.1 North-Up Charts

As a minimum, the following should be presented on all North Up charts:

- Mercator grid ticks, at spacing appropriate to the scale.
- Latitude and longitude graticule lines, with divisions appropriate to the chart scale.
- The angle and direction of the seabed slopes where appropriate.
- Survey limits.
- Proposed route including alter courses.
- Kilometre Points.
- A full geological interpretation of the SSS.
- All existing and proposed pipelines, cables and all other manmade features.
- All wrecks will be indicated on the charts, with dimensions.
- Location and sample numbers.

11.1.12.2 Alignment Sheets

The arrangement for the panels on alignment sheets should be as follows:

- Panel One: Bathymetry, RPL route with KP markers.
- Panel Two: Seabed Features, Geomorphology, RPL route with KP markers.
- Panel Three: Shallow Geological Profile. A vertical (cross-section) profile of the seabed with a sub-bottom geological interpretation plotted beneath, including slope gradients and core sample. KP Markers.
- Panel Four: Route Engineering Data.

11.1.12.3 Chart Scales

It is recommended that the chart scales and layout in the below table be adopted.

SURVEY TYPE	DEPTH RANGE	HORIZONTAL SCALE (VERTICAL)	TYPE	CONTOUR INTERVAL (INDEX)	GRATICULE INTERVAL
Landing Site	To Low Water Mark	1:1000 (20)	North-Up	1m (5m)	0.10’
Inshore	0m – 20m	1 : 5000 (200)	Alignment	1m (5m)	0.25’
		1 : 5000	North-Up	1m (5m)	
Shallow Water	20m – 300m	1 : 10000 (200)	Alignment	1m (5m)	0.50’
		1 : 10000	North-Up	1m (5m)	
	300m – Limit of Burial	1 : 25000 (500)	Alignment	5m (25m)	1.00’

		1 : 25000	North-Up	5m (25m)	
Deep Water	>Limit of Burial	1 : 100000	North-Up	10m (100m)	5.00'
	>Limit of Burial In areas of complex topography	1 : 50000	North-Up	10m (100m)	2.50'

Table 39: Chart Layout Requirements

11.1.13 Special Considerations for Survey

LOCATION	ROUTE SURVEY ISSUE	SURVEY RECOMMENDATION
Irish Sea	Lithified Sediment	Lithified sediment may be present at or near the seabed. This should be watched for in SBP and geotechnical data and the extent and depth shown on charts if possible.
Shallow Water	Rock Outcrop	Outcrops should be identified. Route development may be required to find a viable cable path around outcrops.
Several	Cable Crossing	The cable should be identified with SSS and magnetometer data and clearly plotted on charts.
Several	Pipeline Crossing	The pipeline should be identified with SSS and magnetometer data and clearly plotted on charts.
Near to Platforms	Pipeline Proximity	The pipeline should be identified with SSS and magnetometer data and clearly plotted on charts.
BU Locations	Branching Unit	Conduct a 1km by 1km box survey to identify a suitable site for BU placement.

Table 40: Special Considerations for Survey

11.2 Installation Recommendations

Marine operational implications covered in this section will also apply to the marine survey (Section 8.8). Table 41 provides an overview of the type of parameters likely to affect marine operations and the recommended window for work. Conditions will vary each year and daily meteorological will be essential during operations. Survey and installation operations are recommended between April and September on the basis that these are statistically the months with the best weather and therefore have the greatest chance of operations proceeding to schedule (Section 6.0).

A PLSE is expected at Portmarnock. There is therefore some flexibility as to whether the shore ends are installed before or after the main lay operation. It is the recommendation of this DTS that unless there are overriding considerations, the PLSE sections should be installed before the main lay. This will avoid the need for a jointing space on board the PLSE vessel and remove a potential cable bight due to jointing offshore of the Portmarnock LP. A buffer between the two operations will also reduce the risk of a delay to the shore end causing a delay to the main installation operations. The RPL in Appendix 13.10 has been designed based on the assumption that the shore ends will be in place first.

Careful planning will be required to best utilise the available working periods and clear procedures must be in place for mitigating any slippage from schedule. A week's delay may result in having to wait months to complete work if it occurs near to the end of the project.

11.2.1 Slack

When laying submarine cables, there are three types of slack to be aware of:

- Bottom slack is the slack intended to remain in the cable after installation.
- Infill slack is the slack added to the cable to compensate for slopes on the seabed.
- Area slack is the total of the bottom slack and infill slack values.

The bottom slack values used by GMG in this study are 0.15% for ploughed cable, 0.8% for post-lay buried cable, 1% for surface laid armoured cable and 3% for surface laid unarmoured cable. It is changes in the bottom slack which are indicated in the RPLs in Appendix 13.10. The infill slack has been calculated using MakaiPlan™, providing an indication of the amount of extra cable required using bathymetry of the area taken from UKHO charts and GEBCO_2014 data. The resultant area slack is the value which is included in the slack column of the RPL. It should be ensured that the cable installer uses competent slack planning software such as MakaiLay™ when installing the cable to avoid problems such as loops or suspensions occurring.

11.3 Maintenance Recommendations

Diligent planning in the form of a comprehensive DTS and survey minimise the risk of damage to the cable. However, it is recommended that a maintenance contingency should be put in place as the potential for cable faults can never be totally avoided.

The submarine cable industry is around 160 years old, and is made up of independent systems, operated and organised by individual cable owners globally. There are on average around 200 cable faults each year worldwide. Due to the vital role that submarine cables play in international communications and connectivity, well established maintenance agreements have evolved to ensure that in the event of a cable fault, a repair can be conducted safely and quickly to restore system traffic and keep the networks operational.

Close co-operation between cable owners has facilitated several maintenance zones, whereby the cable owners pay a standing charge to have dedicated cableships 'on call' 24 hours a days, 365 days a year, and are available to sail within 24 hours of notification of a fault. These agreements can significantly reduce the cost and time of each repair. Cable faults can be suffered at any time for any number of reasons, and it is vital to ensure that any risk is minimised by having an appropriate maintenance solution in place.

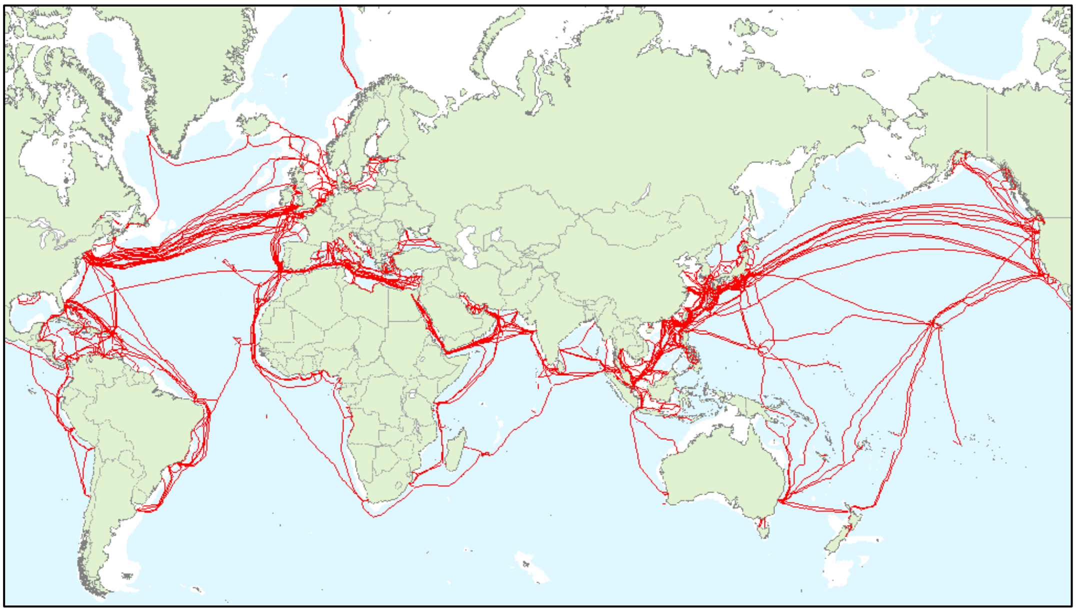

Figure 70: Submarine Cables of the World

Figure 71: Ships Anchor caught up in cable

There are five “zone” agreements; contracts between consortiums of cable owners and cable-ship owners. These are:

- The Atlantic Cable Maintenance Agreement (ACMA)
- The Mediterranean Cable Maintenance Agreement (MECMA)
- The North American Zone (NAZ)
- The Yokohama Zone Agreement (YOKOHAMA)
- The South East Asia Indian Ocean Cable Maintenance Agreement (SEAIOCMA)

The proposed Transatlantic Connection, Scotland Ireland and Scotland Isle of Man cable systems sit within the ACMA zone. There are also private maintenance agreements available through individual operators.

The majority (>98%) of communications worldwide are carried by cable, not by satellite as is a popular misconception. It is therefore essential that cable owners have a maintenance solution in place for provision of specialised marine maintenance and repair services that can mobilise on a 24 hour notice basis. For the period a system is not operational, services can be affected or even cut off completely. The services of a cable ship are required to reinstate submarine cables as soon as possible.

Figure 72: Cable fault with Cargo Lashing chain on cable

Cable damage and faults most commonly occur in shallow water of less than 200m and statistically are most commonly caused by fishing gear and anchors. However, cables are designed with additional armour and burial (where geologically possible) in depths less than 1500m to afford extra protection in this higher risk area. Faults and cable damage are not predictable, hence the requirement of the cable owner to contract for emergency response to be able to react within 24 hours, 365 days per year. This response, depending upon the event that has occurred and number of faults that may have been caused, can involve numerous cableships from across the world in order to restore normal service in the most efficient time possible.

Figure 73: Cable fault caused by fishing gear entanglement

Cableships are specialised and work across international boundaries. In recognition of this, most nations have relaxed restrictions for cable vessels allowing uninterrupted access to their territorial waters in order to ensure that the fibre optic network can be restored in the shortest possible time following unavoidable cable faults.

11.3.1 Repair Operations

In the event that a cableship is called out, first, it will have to mobilise, to ensure that everything is ready that will be needed for the repair operation. Jointing kits which are owned by the cable owner and kept in the depot will need to be loaded on board; these are specific to the cable type, and allow the cable to be spliced back together. Spare sections of cable must be loaded to allow for a new section to be jointed to the existing cable and the damaged section to be removed. The vessel will attend the repair site, recover the cable using a Remotely Operated Vehicle (ROV) or grappling tool, insert the new section and return the repaired cable to the seabed. A typical shallow operation may take around five to seven days to complete depending upon the operational or weather conditions experienced. This can increase to 10 to 14 days for a deep water repair; however the time taken can also vary depending on many other factors such as complexity of repair, water depth and currents, and many other influences.

Figure 74: A cableship laying a final bight

11.3.2 ACMA

The Atlantic Cable Maintenance Agreement (ACMA) provides a 'Zone Agreement' for submarine cable maintenance spanning an area in the Atlantic, North Sea and south-eastern Pacific.

The agreement provides for repair and reinstatement of submarine cables that carry international telecommunications traffic in the event of cable damage by ship anchors, fishing, tsunami, earthquake or any other factors that can cause a cable fault. Three vessels: the CS Wave Sentinel, the CS Sovereign and the CS Pierre de Fermat - are currently providing maintenance services in the agreement. Depot storage facilities for operational spares are available at the Portland, Brest, Bermuda and Curacao base ports. These vessels are on standby ready to sail within 24 hours in the event of a disruption to telecommunications traffic (subject to the loading of operational spares). A Maintenance Authority (MA) requiring an operation will notify the Contractor of the service requested. There are dedicated 'on call' personnel to ensure that the repair is dealt with 24/7. An ACMA ship will be selected for the repair and loaded with the necessary spares in order to be ready to sail at the request of the MA. When dealing with a submarine cable repair, time is of essence.

ACMA is a non-profit cooperative subsea maintenance agreement consisting of 60+ members and has been in existence for 45+ years providing maintenance solutions throughout that period to ensure subsea fibre network integrity.

With no pressure to show a profit on such activities, ACMA is a genuinely cooperative organisation, concentrating solely on the interests of its members who own telecommunications cables, power cables and oil and gas cables throughout the region.

For more information please visit www.acmarepair.com

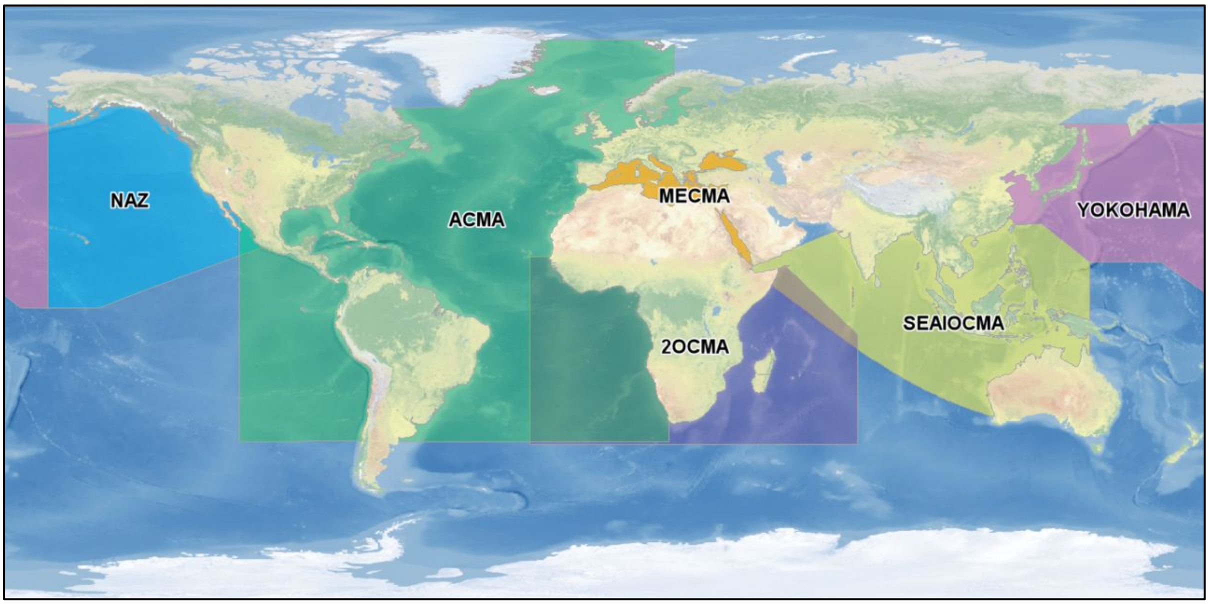

Figure 75: Cable Maintenance Zones

11.4 Marine Operations Summary

OPERATIONAL PHASE	HAZARD	MITIGATION	RISK LEVEL
Survey	The survey specification is too generic and does not address the specific requirements of the project.	Reference Section 11.1.13 when designing the survey scope.	Low
	Poor weather prolongs the survey and affects survey quality.	Plan the survey between the beginning of April and the end of September to take advantage of better weather periods.	Low
Installation	Poor weather prolongs the installation and affects the quality of the installation and therefore security of the cable.	Plan operations between the beginning of April and the end of September to take advantage of better weather periods	Low
	PLSEs are delayed, holding up the main installation.	Install PLSEs before main lay operations.	Medium
Maintenance	Soon after the system comes into service a fault occurs and the system does not have a maintenance solution, causing an extended outage.	Provide for maintenance of the SFT cables by joining a cable maintenance zone agreement such as ACMA or negotiating a private agreement with a cableship operator.	Low

Table 41: Marine Operations Summary

12.0 CONCLUSIONS AND RECOMMENDATIONS

12.1 Conclusions

This report presents the potential risks to the SFT cables along their routes and provides a summary of the perceived issues in each section. The area of interest is a busy one, with many other sea users, presenting challenges to cable route engineering. Traditionally the key elements affecting routeing are geology of the seabed, bottom fishing activity and other hazards such as military ranges, oil platforms and shipping and all of these have been assessed.

Geology is the primary factor affecting the capability to achieve good burial, which is one of the key methods of risk mitigation. Routeing around subcropping rock or known boulders optimizes cable security and is employed where the route is unconstrained by other elements. A risk remains in the nearshore near to each cable landing point. Similarly zones of intense bottom fishing are avoided where possible.

Ideal routes can be extremely difficult to achieve, for example the Transatlantic Connection cable crosses known rocky ridges despite the abrasion risk due to a lack of other options north of Ireland. In these cases the route has been optimized as far as possible to improve viability and security. These routeing decisions are discussed it the cable route commentary in the report.

Normally other hazards such as military ranges, dumping grounds and major shipping routes would be avoided if possible. The Scotland – Ireland route is constrained by the narrow channel and existing infrastructure and is forced to pass through the Beaufort’s Dyke munitions dumping ground. The cable will need to be surface laid in this section but the data analysed suggests that bottom-contact fishing will not be a risk in this location due to the risk to fishermen themselves.

GMG have developed RPLs and SLDs that comprise the compound knowledge gained from customer supplied data and GMG research. The routes have been designed to improve cable security and prevent loss of service. If the customer chooses to implement these routes then the optimum cable route will be achieved, with maximum mitigation against the perceived risks.

12.2 Recommendations

The key recommendations of this report are:

› Bury all cable in water depths shallower than 1,000m to a target burial depth of 1m below the seabed except in the Beaufort’s Dyke munitions dumping ground through which the cable should be surface laid.

› Negotiate crossing agreements for telecoms cable, pipeline and power cable crossings. Apply additional cable protection as required, such as mattresses and/or a polyurethane protection system such as Uraduct®.

› Review the cable route and armour levels during and following the marine survey to optimise security, with particular attention to the expected achievable depth of burial of the cable in locations with subcropping rock or hard clays.

› Ensure any areas of sandwaves and pockmarks along the route are captured during the marine survey and compensated for by route engineering, deeper burial or increased armouring.

› Undertake a marine offshore liaison program with fishing groups before, during and after installation to reduce the chances of damage to the cable.

- Perform marine survey and main cable lay during the annual good weather window from April to September.
- The PLSE at Portmarnock should be installed prior to the main lay.
- Make sure that the installed cable is marked on navigation charts.
- Begin application for permits and negotiate crossing agreements with cable and pipeline owners with plenty of time to spare.

The websites and charts used in this DTS are suitable for planning purposes but for operational issues more detailed data intended for navigation purposes should be acquired.

13.0 APPENDICES

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13.2 Site Visit Report

13.3 CES Heads of Terms

13.4 Marine Scotland Meeting Minutes

13.5 Crown Estate Decommissioning Guidelines

13.6 Foreshore License Consultees List

13.7 IoM Application for Authorisation

13.8 Master Licence Telecommunications Cables

13.9 Master Option Telecommunication Cables

13.10 RPLs and SLDs

13.11 Charts

Charts have been generated to the required scale for the entire system and are included here as an Appendix. The below table provides an overview of all the charts available for each segment of the route.

CHART	DESCRIPTION	REVISION
5382-1	System Overview	0
5382-2	Bathymetry Chart 1 of 3	0
5382-3	Bathymetry Chart 2 of 3	0
5382-4	Bathymetry Chart 3 of 3	0
5382-5	Admiralty Chart Overview 1 of 3	0
5382-6	Admiralty Chart Overview 2 of 3	0
5382-7	Admiralty Chart Overview 3 of 3	0
5382-8	Admiralty Chart – Irvine	0
5382-9	Admiralty Chart – Scotland to Isle of Man	0
5382-10	Admiralty Chart – Dublin	0

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