Moyle Interconnector Ltd

Replacement Metallic Return Conductors - Marine Environmental Report

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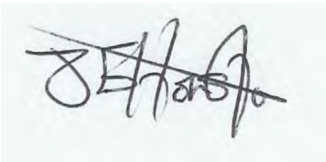	
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A.1: Specialist Reports Consultation Response Table

	Comments	Response
1	Benthic Ecology Environmental Assessment (AFBINI)	
	Marine Scotland Science (Benthic Ecology)	
1.1	This is a well written and well produced report covering most aspects of benthic work required for the cable project. They have incorporated SNH's suggestions to their and my satisfaction. I have no further comments to make at this time.	Noted with thanks
	SNH	
1.2	I am content that they have incorporated my previous comments, including consideration of PMFs in this report.	Noted with thanks
	DoE Marine Division	
1.3	2.3.2 -3 Issues identified about speed of tow of camera system should be addresses by contractor in future.	The Benthic Ecology Environmental Assessment (AFBINI) is based on a review of existing information for the cable corridors. The main purpose for this work, undertaken on the advice of DoE Marine Division, was to confirm if sufficient data was available to avoid the need for commissioning additional environmental/habitat survey works. The AFBI review has allowed a comprehensive biotope map of the seabed to be produced of the100m corridors, within which the replacement cables will be installed. The main purpose for consultation on the AFBI benthic report, ahead of incorporation into the non-statutory environmental report, was to obtain a view from DoE Marine Division and Marine Scotland Science as to whether additional pre-installation habitat/environmental surveys would be required as a condition on the marine licence.
1.4	Assessment is for the expected route – is this now the designated route, if deviations have been identified has additional survey been done?	As above the purpose of the AFBI Benthic Ecology Environmental Assessment is to inform the requirement for additional survey works in consultation with DoE Marine Division and Marine Scotland Science.
1.5	2.3.2 -4 limitations of acoustic techniques identified but not fully resolved	As above the purpose of the AFBI Benthic Ecology Environmental Assessment is to inform the requirement for additional survey works in consultation with DoE Marine Division and Marine Scotland Science.
1.6	3.1 general comment would be useful to apportion biotopes %ages in tables 5 & 6 rather than just in maps would allow easier assessment of %age sensitivity	Noted with thanks. See ER Section 9.1 Table 9.5.
1.7	Recommendation that infaunal sampling be undertaken – was this done? Report unable to assess infaunal communities as no grab data – what %age of track does this equate to?	As above the purpose of the AFBI Benthic Ecology Environmental Assessment is to inform the requirement for additional survey works in consultation with DoE Marine Division and Marine Scotland Science.
1.8	3.1.2 Sublittoral sands – identifies grabs required Sublittoral mixed seds – identifies grabs required	As above the purpose of the AFBI Benthic Ecology Environmental Assessment is to inform the requirement for additional survey works in consultation with DoE Marine

		Division and Marine Scotland Science.
1.9	Nomenclature, old names used e.g. Pomatoceros used not Spirobranchus	Noted but no change made.
1.10	5.2 Any take up of recommendations?	As above the purpose of the AFBI Benthic Ecology Environmental Assessment is to inform the requirement for additional survey works in consultation with DoE Marine Division and Marine Scotland Science.
1.11	6.1.3 No infaunal data yet impact deemed not significant (probably correct, but some taxa (priority) may be more sensitive/important than generic sediment habitat rule of thumb applied) 6.1.4 As above	As above the purpose of the AFBI Benthic Ecology Environmental Assessment is to inform the requirement for additional survey works in consultation with DoE Marine Division and Marine Scotland Science.
1.12	6.2.1 No consideration of potential for NNIS to extend range by "Island hopping" on introduce hard substratum	Noted. Please see Environmental Report Section 9.1 Benthic and Intertidal Ecology.
1.13	7 Reported increase in diversity likely to be a product of effort/resolution in divers vs. ROV/towed camera systems	Noted with thanks
1.14	No shallow camera data – could be done	As above the purpose of the AFBI Benthic Ecology Environmental Assessment is to inform the requirement for additional survey works in consultation with DoE Marine Division and Marine Scotland Science.
	DoE Marine Conservation and Reporting	
1.16	Once the final route has been decided can the applicant please provide information on the proportion of the route which will be buried and the proportion where rock or mattress berms will be used. Please also provide information on the quantities of material involved; for example, how wide is the berm and what height?	Please see Environmental Report Section 6.4.6 and Figure 6-14 in Section 6 Project Description. Final calculations on rock protection requirements will be made following the pre-installation surveys.
1.17	6.2.2 Electromagnetic fields / Induced Electric Fields – Please confirm that electric field anomaly will occur at 3m radius of the cable line if it is buried to a depth of 1m. We calculate that this will indeed be the case vertically from the cable but horizontally along the seabed we believe that it will actually only be slightly reduced to 3.87m. See enclosed diagram (EMF 4m radius). This is assuming that the electromagnetic field is the same in water and in the seabed.	Whilst the diagram and distance calculations are correct, we would direct you to the information provided in the technical report 'Assessment of EMF Effects on Sub-tidal Marine Ecology (CMACS) which provides more information on distance of EMF effect from the cables. Such precision may not be necessary and it is important to remember that the magnetic and electric field intensities used within the CMAC study are estimates based upon calculations that use a number of assumptions. The distances inferred are therefore approximations. Furthermore, cable burial depth is also likely to be variable (i.e. to approximately 1m but possibly up to 2m). CMACS have been careful in reflecting this in their report which has informed the AFBI text on EMF effect.
2	Fishing Activity Report (AFBINI)	
	Marine Scotland (Science)	
2.1	The intention is to provide a baseline characterisation of the fisheries along Moyle interconnector cable route but not to identify the potential impacts of the developments on fisheries. By default, this limits the capacity of statutory consultees to comment and assess impact identification and mitigation methods	The Fishing Activity Report provides a baseline description of fisheries along the Moyle Interconnector cable route. Potential impacts and mitigation measures are outlined in Section 10.2 - Commercial Fisheries of the Non-Statutory Environmental Report.

2.2	There is a simple reference to target burial depth (1m) and proposed additional protection (armour or mattressing). In addition to this simple statement, a map should be provided with annotated cable sections with both expected burial depths and proposed protection method overlaid with fishing activity in order to facilitate discussions with the fishing industry. This map should be also included in this report.	Predicted rock protection locations along the proposed cable routes are outlined in Environmental Report Section 6.4.6 and Figure 6-14 in Section 6 Project Description. Predicted rock protection locations are now also included in the Figures provided in the final version of the Fishing Activity Report (AFBINI). Final rock protection locations will be informed by the pre-installation geophysical and geotechnical surveys to be undertaken in Q1/Q2 2015. The preferred method for installation is burial of the cable to 1.5m and requirements for rock protection will be minimised where possible. Further consultation will be undertaken with the Fishermen's Organisations and their representatives as part of Fisheries Liaison undertaken as part of the survey works and on the requirements for rock protection along the route.
2.3	There were very long general descriptions of the commercial species biology and characteristics of the fishing methods. Both could be omitted to reduce the length of the report to the minimum possible.	Descriptions of commercial species biology in the final version of the Fishing Activity Report (AFBINI) have been shortened. The description of the fishing methods has however been retained to inform those who may not have a full understanding of the nature of the fishing activity described.
2.4	Most of the quantified information provided (i.e. landings information) is at national level (e.g. total annual Scottish landings of crabs instead of the landings coming from activity along the cable). These data failed to answer the question of the importance of fishing activities along the cable. Sometimes, landings were provided on a port level. Whilst providing landings from the ports within the area of interest partially expresses the level of activity in the surrounding area, it still fails to illustrate the number of vessels and/or trips overlapping with the cable. ICES stat rectangles was another spatial method used to express fishing activity in the study area. However, the area of the ICES rectangles is vast compared to the footprint of the development.	Whilst we have started at national level to show the importance of each fishery, we have tried to narrow down as close as possible to the cable route with the best available information. However, exact spatial information on where vessels fish is not available unless they have a VMS onboard (on necessary for vessels >12m in length) or some other form of monitoring system such as Succorfish. The only other way of getting such specific information is by asking each fishermen how many trips they carry out in a year across the cable route, when these trips were, landings from these specific trips etc. Therefore the information provided is to the smallest spatial scale available. In 2013 AFBI produced a report for DARD on a strategy for NI inshore fisheries. One of the recommendations in this was that to address the lack of spatial information a form of inshore monitoring system should be placed on all fishing vessels. Whilst this has gone to consultation there has not been any formal response from DARD to date. Please also see additional analysis on fishing activity provided in Section 5 of the Shipping and Navigation Report.
2.5	Author's effort to use ScotMap is worth noting. However, there are references to fishing effort layers derived from ScotMap. ScotMap project has not produced effort maps yet. Please clarify if the author is referring to maps showing the distribution of the numbers of vessels which are a proxy to effort? E.g. temporal intensity and vessel size (engine horsepower) are missing from this	Each figure which has been taken form Scotmap is labelled as "Scotmap data showing the effort (number of vessels) ...". The fact that number of vessels has been used as a proxy for effort is now included in the report text also. Again, without a form of monitoring system any information such as Scotmap can just be used to

	map. The numbers of vessels analysis provides information on the spatial extent of fishing as reported during interviews and a representation of fishing intensity i.e. where most boats fish. It is not necessarily a good indicator of fishing effort, particularly for the combined (all interview) data set, or for fisheries where activity varies seasonally.	provide a guideline of where fishing activity occurs.
2.6	Most of the maps provided in the second half of the report were referring to "landings" without specifying the fishery they are referring to.	This has been amended so that now the fishery for which the figure represents is highlighted e.g. "Figure 7 2012 landings by pots ... "
2.7	Please clarify if gridded layers of VMS data produced only for N. Ireland refer to all VMS points or speed-filtered VMS.	This has been modified to include the following statement "Data were provided by DARD for years 2007 to 2011 for all scallop fishery vessels. All data were combined and sorted in Microsoft Access. Erroneous data were filtered and removed. No speed restrictions were imposed on the data to filter specifically for fishing activity. Density analyses were undertaken in ESRI ArcGIS software and fishing intensities for the scallop fishery were derived (Source: DARD)."
2.8	It is inconsistent to provide landings for Scottish port as a table and landings for N. Irish ports as a map with pie-charts. A single method should be employed to allow easier comparison between the two.	Figures for first sale value of pots for both Scotland and Northern Ireland have now been shown as a single figure with pie charts (Figure 7). Whilst consideration was initially given to displaying both in a table format, the author was aware that actual landings values by port could be related back to individual fishermen and could cause problems. The Fishing Activity Report has now been updated to include a paragraph explaining how any values does not include the value of v-notching through which NI fishermen receive a grant of £6 per lobster v-notched and released.
2.9	Consideration should be given to the relevance of including maps of fishing activities that do not have an overlap with the proposed cable work.	There are 3 figures which examine fisheries not overlapping the cable route. Whilst we have discussed removing these figures with Intertek, it was decided that they should be left in. Removing these figures could draw further questions from the fishing industry.
2.10	The SFF and Marine Scotland Compliance could also provide relevant fishery stakeholders	AFBI contacted the South West Inshore Fisheries group who responded with suggestions of groups to be consulted. The Ayr Fishery Office was also contacted but have not responded to date. Also a letter provided to Intertek by the Scottish Fishermen's Federation which contained possible consultation groups was passed to AFBI and these details are now included in the report. MIL/Intertek met with SFF/CFA and this meeting is recorded in Section X of the Non-Statutory Environmental Report.
	DoE Marine Division Nature Conservation	
2.11	Conclusions reflect own concerns on how useful it actually is given limitations with availability of site specific dat. Many of the plots have been produced by interpolation mapping data which can	MIL and the appointed Contractor will continue to engage with the fishing industry. A project Fisheries Liaison Officer will be appointed.

	give a false impression on the density of data. That said it appears generally that fishing in the area of the license application is relatively low and it will be up to Moyle to negotiate locally through the Pos.	
	NIFPO (Dick James)	
2.12	On page 23 of the report states that 8 vessels North of Belfast Lough are identified as fishing the area & it is assumed that vessels based in ports South of Belfast Lough would be unlikely to fish the area. This is not so. On previous cases of sub tidal works in the area and new proposals (Salt Caves off Island Magee) 3-4 vessels from South of Belfast Lough were identified as active in the area; they are: Spindrift – Warren Holmes/ Paul Leeman Mariona – Eric Brown Swift Sure – Wm Angus	The NI pot fishing section has been amended to include the value of landings into Bangor, Groomsport and Donaghadee, the area where these fishermen land catch. The author has discussed with a fisherman from Ballywalter, the next port down, and he does not fish further north than Donaghadee so outwith the proposed cable route area.
2.13	Also Scallop fishing is the most likely to inter-react with the operation. This is mainly activity close to shore and it is mainly under 15 metre boats involved – therefore no VMS or AIS records. This fishery is also understated in the shipping report as there is a close season 1st June to 31st October when no activity takes place and a curfew from 20-00hrs to 06-00hrs is in place and a ban on weekend operations. Outside of this activity can be intensive.	In response to this the author has included a figure from Yates (2012) whereby fishermen were asked to map where they fish along the NI coastline (similar to Scotmap in Scotland). This will provide some information on scallop fishing by the <15m fleet.
2.14	In general there is no risk analysis done on rock dumping or monitoring exposed cable. This is the most likely to interfere with both static and mobile gear fisheries. There appears no mention of the need and sensibility for guard/chase vessels or liaison officers for the fisheries sectors. This would apply to both sides of the channel as well as the central portion.	The Fishing Activity Report provides a baseline description of fisheries along the Moyle Interconnector cable route. Potential impacts and mitigation measures are outlined in Environmental Report Section 10.2 - Commercial Fisheries.
3	Assessment of EMF Effects on Sub-tidal Marine Ecology (CMACS)	
	Marine Scotland (Diadromous fish expert)	
3.1	This report is also generally well prepared, at least in relation to diadromous fish. I again have a few comments:	Noted with thanks
3.2	As in my comments on Report No. 7, I will mention that the relevant new information on magnetic navigation at sea in salmonids.	Reference to these documents has been added to Section 5.33, in which demonstration of magnetic sense in teleosts is discussed.
3.3	Page 17. I would question that salmon and sea trout are only medium importance receptors. They are both of high conservation and fisheries value and relatively large numbers of both would be expected in the Project Area.	The importance of teleost fish (in general) has been updated to ‘medium to high’ accordingly.
3.4	Page 19. I would agree that salmon and sea trout are likely to be predominantly close to the surface. However both are likely also to spend a significant amount of time in deeper dives and may spend time close to the sea bed in deeper water. Consideration should be given to whether this will affect the assessment.	The reference suggested (Godfrey *et al*., 2014) confirms that in the UK, returning salmon are predominantly surface-dwelling. However, it also suggests that many regularly pass through the water column, although predominantly briefly, but that some spend time at depth. The potential therefore exists for some salmonids to encounter EMF generated by the Interconnector if venturing near the seabed. Given the rapid attenuation of EMF, however, any effects are expected to be very localised. The report has been updated to reflect this.

3.5	The proposed mitigation measures (cable burial / protection) are helpful.	Noted with thanks
3.6	I note (page 28, 7.2 Monitoring and future research), the suggestion to help address uncertainty with respect to the Moyle Interconnector of - Measurements of actual magnetic and electric fields in situ - Monitoring movement of diadromous fish species within the area, and specifically across the Interconnector before and after reconfiguration of the Interconnector to determine whether migration is affected. - Photographic or video transects along the operational, reconfigured Interconnector to investigate whether fish appear to be attracted to, repelled by, or indifferent to sub-sea cable EMF, although salmonids are not given as potential target species for such work.	The requirement for implementation of any monitoring recommendations will be discussed with Marine Scotland and DoE Marine Division and their advisors. Tagging studies might be possible to monitor movement of diadromous fish species through the area, as suggested above (albeit a very challenging undertaking). Salmonids would probably not, however, be good test subjects for baited camera traps or video transects, which are better suited to elasmobranchs and macro-invertebrates. We have updated the text in this section slightly for clarity.
3.7	MS would welcome further discussion of the potential to carry out the above studies.	See above. CMACS would be happy aid discussion
	Marine Scotland Science (Benthic Ecology)	
3.8	No comment at present	Noted with thanks
	Marine Scotland Science (Marine Mammals)	
3.9	No comment	Noted with thanks
	SNH	
3.10	The report provides comprehensive reviews of predicted electromagnetic field generation, the possible receptors, and potential impacts. I am content with their approach and with the conclusions they have reached in both cases. I therefore have no further comments on either of these issues.	Noted with thanks
4	Assessment of the likely effects of noise during installation of new low voltage returns on sub tidal marine ecology (CMACS)	
	Marine Scotland (Diadromous fish expert)	
4.1	I am generally satisfied with the diadromous fish aspects of this report. I would note that the capability of small fish to take avoiding action may be very limited.	The text has been altered accordingly.
	Marine Scotland Science (Marine Mammals)	
4.2	MSS welcome the information provided in the noise assessment report. The scope of the document is sufficient for this purpose.	
4.3	The noise assessment indicates that there is the potential for disturbance to cetacean species, but that this disturbance is unlikely to be significant to the species concerned or to have long term consequences. It is noted that a cable burial assessment will be submitted with the Marine Licence application. The applicant should be aware that a licence to disturb marine EPS might be required. The need for this will be informed by provision of further details of cable installation methods and protection requirements. Advice on EPS licensing within 12 nautical miles of Scotland is available at http://www.scotland.gov.uk/Resource/0044/00446679.pdf. If an EPS licence is required, MSS would advise the applicant to consider applying for a licence at least two months in advance of	Impacts to EPS are assessed in Environmental Report Section 9.4 Marine Mammals and Reptiles in the Habitats Regulation Appraisal Screening for Appropriate Assessment (see ER Volume 2: Technical Appendix Section A.2). We would seek guidance from MS-LOT and DoE Marine Licensing and their advisors based on the information provided in the Marine Licence Application as to whether an EPS licence is required.

	the start of works	
	SNH	
4.4	This is generally a good review of potential noise sources and possible impacts. I would agree with their conclusion that the risk of injury is minimal, but that there is a small risk of disturbance close to the cable-laying activity. The applicant will need to consider requirement for an EPS licence.	Impacts to EPS are assessed in Section 9.4 Marine Mammals and Reptiles in the Habitats Regulation Appraisal Screening for Appropriate Assessment (see ER Volume 2: Technical Appendix Section A.2). We would seek guidance from MS-LOT and DoE Marine Licensing and their advisors, based on the information provided in the Marine Licence Application as to whether an EPS licence is required.
	DoE Marine Conservation and Reporting	
4.5	Within this report it makes reference to the impact of support vessels and their use of DP, however this is largely related to noise. The use of DP also poses a risk of corkscrew injury to seals. This injury has resulted in several seal deaths and current expert thinking suggests that these may be caused by the use of ducted propellers in certain circumstances such as during the slow manoeuvring of vessels. If the support vessels have ducted propellers and azimuth thrusters then appropriated mitigation will be required. I have attached guidance which is currently being used by the SNCBs. Depending on the level of risk of injury a series of possible recommendations are made.	Thank you for providing this information. The risk to disturbance to seals at haulouts and the potential for spiral injuries to seals from vessels using dynamic positioning is addressed in Section 9.4 Marine Mammals and Reptiles in the Habitats Regulation Appraisal Screening for Appropriate Assessment (see ER Volume 2: Technical Appendix Section A.2).
5	Assessment of the likely effects of heat during operation of new low voltage returns on sub tidal marine ecology (CMACS)	
	Marine Scotland Science (Benthic Ecology)	
5.1	No comment at present	Noted with thanks
	SNH	
5.2	The report provides comprehensive reviews of predicted heat generation, the possible receptors, and potential impacts. I am content with their approach and with the conclusions they have reached in both cases. I therefore have no further comments on either of these issues.	Noted with thanks
6	Review of occurrence, distribution and abundance of marine mammal species in relation to the Project Area (CMACS)	
	Marine Scotland Science (Marine Mammals)	
6.1	MSS welcome the information provided in the marine mammals background report. The scope of the document is sufficient for this purpose.	Noted with thanks
6.2	The information provided has not considered the risk of disturbance to seals at haulouts. The Scottish Government has recently introduced legislation to protect seals from disturbance while they are hauled out, at a large suite of sites around the coast. More information is available on this from the Marine Scotland website - http://www.scotland.gov.uk/Topics/marine/marine-environment/species/19887/20814/haulouts. The applicant should ensure that any activities that may take place in the vicinity of any of these protected sites are not likely to disturb animals.	Thank you for providing this information. The risk to disturbance to seals at haulouts is addressed in Section 9.4 Marine Mammals and Reptiles in the Habitats Regulation Appraisal Screening for Appropriate Assessment (see ER Volume 2: Technical Appendix Section A.2).
6.3	MSS would also suggest, given the occurrence of spiral lacerations to seals, that any vessel involved in the work which has ducted propellers, does not use areas near seal haulouts for sheltering during standby periods if at all possible. If this is necessary, then the vessel should	Thank you for providing this information. The potential for spiral injuries to seals from vessels using dynamic positioning is addressed in Section 9.4 Marine Mammals and Reptiles in the Habitats Regulation Appraisal Screening for

	anchor, rather than using dynamic positioning to hold station. The latest research into the spiral lacerations to seals issue is available from the SMRU website - http://www.smru.st-and.ac.uk/documents/1282.pdf	Appropriate Assessment (see ER Volume 2: Technical Appendix Section A.2).
	SNH	
6.4	No comment	Noted with thanks
	DoE Marine Licensing	
6.5	You can get the data mentioned below from Irish Whale and Dolphin Group. It is uploaded online monthly from DOE counts and should be available to download. If not, get back to me, and I will see what I can get from our data files. http://www.iwdg.ie/index.php?option=com_k2&view=item&id=2269:search-sightings	Noted with thanks
	DoE Marine Conservation and Reporting	
6.6	Section 1.2 the Wildlife Order should be referenced to as follows – The Wildlife (Northern Ireland) Order 1985 (as amended)	The text has been altered accordingly.
6.7	The mammal report uses SCANS II data for reference with regard to cetacean abundance, including Harbour Porpoise. There are some local records available for Black Head (Whitehead) and Portmuck from the Northern Ireland Cetacean Monitoring Programme. Counting sessions from land-based observation points of 100 minutes duration take place each month through the year. Counts from these two points are among the best recorded along the Northern Ireland coastline and include a high count of 32 Harbour Porpoise at Portmuck on 01 September 2014.	Mention of these records has been added to the report and the website referenced.
7	Review of occurrence and migration routes of diadromous fish species in relation to the Project Area (CMACS)	
	Marine Scotland (Diadromous fish expert)	
7.1	This report is well prepared. Although there are some errors and omissions, none greatly affect the risk assessment. For example:	Noted with thanks
7.2	Page 6. The life span of Atlantic salmon in the UK is generally 3-6 years, rather than 7-10.	There is some discrepancy between Marine Scotland and AFBI here. Furthermore, one can find evidence of salmon being rather longer lived than even ten years; together of course with the possibility of precocious parr. We have revised the text so that it is more general, and hopefully less controversial.
7.3	Pages 7, 10. There is now relevant new information on magnetic navigation at sea in salmonids, albeit not UK species (Putman *et al* (2013) Evidence for geomagnetic imprinting as a homing mechanism in Pacific salmon. Current Biology 23 (4), 312-316; Putman *et al* (2014). An inherited magnetic map guides ocean navigation in juvenile Pacific salmon. Current Biology 24 (4), 446-450)	Reference to these documents has been added to the report
7.4	Page 8. Information on salmon and sea trout catches has been published on the Ayrshire rivers for all years 1952-2013, ie it includes the years since 2008	The text has been amended accordingly
7.5	The summary table in relation to the report objectives (Table 1) is very helpful. Again, I have a few comments:	
7.6	Salmon. Both past tagging results reported in Malcolm *et al* (2010) and recent satellite tagging	The text and Table 1 have been amended accordingly

	work in the north of Scotland (Godfrey *et al* (2014) Depth use and migratory behaviour of homing Atlantic salmon (*Salmo salar*) in Scottish coastal waters. ICES Journal of Marine Science doi: 10.1093/icesjms/fsu118 indicate that returning salmon may show exploratory behaviour prior to their return to their natal river. It is therefore likely that some adult salmon returning to rivers north of the Project Area will also cross the Project Area.	
7.7	There is some published material on the swimming depth of salmon kelts, they are again predominantly in surface waters	The text has been altered to reflect this and referenced
7.8	Information presented in Godfrey *et al* (2014) now makes it less likely that returning adult salmon will be tied tightly to close to coast waters.	The text has been altered and Table 1 updated to reflect this
	AFBINI	
7.9	Lower end of grilse lifestyle is 4 years	See response to Marine Scotland comment on age ranges, above
7.10	Recent data from studied of salmon at sea suggest that fish from one river may stay together at sea	We cannot find reference to this - it would be helpful to know the citation but a single study (of fish at sea) would not necessarily relate to all fish from all rivers or even apply to coastal waters necessarily and so the current text is still considered reasonable since.
7.11	Northern Ireland Rivers being smaller tend to have later, summer-Autumn – runs, dependent on uplift in river levels after rain	Text altered accordingly
7.12	Note AFBI have recent records of sea lamprey from The Lagan and Shimna Rivers	We have been unable to find reference to this data online, but have updated the text altered accordingly and used pers. com.
7.13	There is risk in this assumption as the data on the species is not strong enough to support such a categorical statement. Maitland lists them as inhabiting coastal waters	As already stated, as a conservative measure, we have considered the species further in the report. Clarification to the initial statement, however, has been added.
7.14	Note AFBI. Annually Salmonid Electrofishing surveys routinely record eel on the northern Ireland rivers and streams from the Glens of Antrim to County Down coasts, 2014 data showed a very significant recruitment of glass eel/elver to this coast	This information has been added to the report using pers. comm.
7.15	Recent results of the EELIAD project (there is a "Nature" publication) Show that silver eels once at sea and heading for their spawingin grounds migrate at considerable depths (200-600m) with a very Pronounced diurnal vertical movement pattern	We believe this refers to a publication in Science (Aarestrup et al 2009). The text has been updated accordingly.
7.16	This omits to record the possible noted southerly residual current along the North-east Antrim coast which could take eel as far as Belfast Lough. These current splits and Timing of arrival of glass eel suggests tentatively that south of Belfast lough glass eel travel north through the Irish sea, and that North of this the immigration to irish coast is from the North	Text has been altered accordingly using pers. comm.
7.17	See earlier comment re EELIAD. It appears that silver eel move to the continental shelf and then adopt a deep migration patters	The text has been updated accordingly. The study involved eels released from the west coast of Ireland. But the direction of passage of eels from east of Ireland is, however, unknown.
7.18	Papers by Durif and Westin shold be cited here: Westin on deflection of migrating silvers by undersea cables and Durif on the magnetic compass behaviour in eel	Reference to the Durif paper has been added to this and the EMF report, the latter of which, where the Westerberg paper (which we believe was intended rather than Westin) is already discussed.
8	Marine Archaeology Desk Based Assessment (Headland Archaeology)	

	Historic Scotland	
8.1	I am content with the DBA. I just wanted to clarify timings. We will want to see and agree the WSI, given that the survey work and any fall out from that will be post determination. Are you aware of their timetable for producing the WSI in relation to the marine licence application?	Please see supporting Marine Archaeology Written Scheme of Investigation (WSI) and Protocol for Archaeological Discoveries (PAD) in ER Volume 2: Technical Appendix Section A.3.
	DoE Marine Division Archaeology	
8.2	The marine archaeology desk-based assessment and preliminary analysis of existing geophysical survey data undertaken by Headland Archaeology (UK) Ltd. has provided sufficient information to enable the award of a conditional marine license. It is understood that this initial analysis is not intended to circumvent full pre-installation geophysical and geotechnical surveys which will in turn be subject to full archaeological analysis before any intrusive works are undertaken. It is accepted that the potential for identifying further sites once the full pre-installation geophysical surveys have been conducted and analysed must be high but that the impact on heritage assets from the proposed installation are manageable through the implementation of standard mitigation measures. Therefore, the conditions placed on the License with regard to archaeological considerations must specify that Moyle Interconnector Ltd. will:	Noted with thanks
8.3	Produce a project-specific archaeological Written Scheme of Investigation (WSI) to be prepared and submitted detailing a staged programme of works that will be undertaken to identify and protect the marine cultural heritage resource.	Please see supporting Marine Archaeology Written Scheme of Investigation (WSI) and Protocol for Archaeological Discoveries (PAD) in ER Volume 2: Technical Appendix Section A.3.
8.4	Conduct full pre-installation geophysical and geotechnical surveys which will then be subject to full archaeological analysis prior to any intrusive works being undertaken in association with the project.	Noted. Please see Environmental Report Section 6.3.1 in Section 6 Project Description for information on pre-installation geophysical and geotechnical surveys.
9	Shipping and Navigation Risk Assessment (Anatec)	
	RYA Scotland	
9.1	RYA Scotland has no additional points to make as we do not see this proposal as being a hazard to recreational craft.	Noted with thanks
	MCA	
9.2	The Anatec report is as expected and we have no comments to make at this stage.	Noted with thanks
	DoE Marine Licensing	
9.3	MCA and CIL had no comments to make with the document other than UKHO must be advised of the cable laying to update the appropriate marine charts	Noted with thanks
	DARD Fisheries	
9.4	'Moyle – Shipping and Navigation Assessment'. This report includes a section on fishing, and there are a couple of points I have regarding this:	Noted with thanks
9.5	- the sightings data is from 2005 – 2009 & the VMS data is from 2009. This data is now fairly old and may not represent the current fishing activity within the area. The main NI fleet to fish in and around this area are the potters & scallop vessels.	The VMS data for this area is no longer available in the form of individual vessel positions but now comes in the form of a density grid, as presented in Section 5.4.2 for 2012. The 2009 data is the most recent VMS data available in the form of individual vessel positions. The VMS data only covers vessels above 15m in length.

	- although the AIS data is more recent, this mostly only includes vessels >18m & therefore would miss out on the majority of our vessels utilising the area of the cables (majority of larger NI vessels fish further south or north)	In comparison the AIS data used in the report covers all vessels over 18m in length and also includes a number of fishing vessels below this length, which choose to carry AIS voluntarily. This is likely to be the case for vessels between 15m and 18m in particular, as they prepared for the change in legislation that required all fishing vessels over 15m to carry AIS data by May 2014. Sightings data later than 2009 is not considered to be as reliable as the older sightings data, since the number of overflight patrols has vastly decreased in recent years. In addition they no longer provide a record of the number of patrols per ICES rectangle in a given year, making it difficult to compare the data as this number varies across different rectangles. The sightings data is mainly used to validate the findings of the AIS data. The AIS data therefore gives the best recent data set for fishing vessels. Although it is not guaranteed to cover all fishing vessels, the smaller ones are unlikely to present a significant risk to subsea cables.
10	Intertidal Survey Reports (RPS)	
	Marine Scotland Science (Benthic Ecology)	
10.1	No comment at this time	Noted with thanks
	SNH	
10.2	The methodology used for the intertidal surveys was appropriate and the presentation of the biotope map is useful. Although one PMF habitat was identified (IR.MIR.KR.LhypT), this is not in the direct path of the cable route and is not likely to be negatively affected by the proposed work.	Noted with thanks
	DoE Marine Division	
10.3	There were no comments from the team responsible for the intertidal aspects, however they did query if the terrestrial impacts of the project will be dealt with as part of the planning process? The area is part of the Gobbins ASSI, which includes both earth science and biological features (i.e. maritime cliff and slope).	Noted with thanks. Onshore planning requirements are subject to a separate process.
11	Compass Deviation Risk Assessment (Intertek)	
	NLB	
11.1	We would advise that having examined the report, we are content that there is little risk to the mariner, particularly with regard to the location of the cable route through Scottish waters. We would however require that the United Kingdom Hydrographic Office is contacted regarding the possible inclusion of a chart note on those Admiralty Charts through which the cable route passes, referring to the potential for temporary compass deviation as a result of proximity to the cable.	Noted with thanks
	Maritime and Coastguard Agency (Rakesh Pandit)	
11.2	I would agree with Harry (CIL) – a physical mark should be unnecessary for any localised	Noted with thanks and for clarification on correct terminology.

	changes to the existing magnetic Variation* which is depicted on the nautical charts along with any secular rate of change if/as applicable. Depending on the actual magnetic effect a suitable note, as part of chart update(s) via Notice to Mariners, stating localised magnetic anomalies can be considered for the nautical charts for the area. Hydrographic Offices do it all the time as, indeed, one may observe on many charts produced by UKHO. *Although being referred to as magnetic Deviation within our correspondence here, puritanically speaking it's really the Variation that's being considered. Deviation, within this context, by definition and by operational shipboard understanding, is the magnetic effect on the ship's compass by the ship itself or the 'internal effect' whilst the Variation is the 'external' one. Similar with the shipboard Table of Residual Deviations or the Deviation Card – which is only to record the shipboard magnetic effects (permanent/hard iron and induced/soft iron) after the compass has been 'adjusted'. Whilst on Variation it's worth noting that within the American nautical lexicon it's referred to as 'Magnetic Declination'.	
	Maritime and Coastguard Agency (David Carlisle)	
11.3	I have now viewed the report however I (and colleagues in the Navigation Safety Branch) feel that the risk posed to small vessel's in close proximity to the Muck Island "deviation spike" whilst coming into the ALARP section of the risk matrix, is still tangible. We would like to see the following additional safety measures (which have all been previously discussed) considered :- 1. A post installation survey which should also be forwarded to UKHO who will then decide charting/publication requirements e.g. Appropriate chart and pilot book notations (including RYA cruising guides, Imray etc). 2. Consideration be given to the deployment of a cardinal or special mark to the east of the affected area off Northern Ireland. CIL can advise and may consider this unnecessary. 3. Any additional safety measures the MMO in Scotland require on their side of the interconnector be considered.	Noted with thanks. Please see proposed mitigation in Environmental Report Section 10.1 Shipping & Navigation and Section 12 Schedule of Mitigation.
	Commissioner of Irish Lights (CIL)	
11.4	From the information provided CIL would consider a physical mark unnecessary and believe that notations on the navigation charts and pilot books would be sufficient warning to the mariner. However tests should be carried out after the cables have been laid and if the deviation spike is significant and consistent then the option of deploying a special mark should be reconsidered.	Noted with thanks. Please see proposed mitigation in Environmental Report Section 10.1 Shipping & Navigation and Section 12 Schedule of Mitigation.
	DARD Fisheries	
11.5	I have had a look at the Moyle Interconnector Deviation Risk Assessment, and can confirm DARD Fisheries have no further comments to make regarding this report.	Noted with thanks

A.2.1 – Benthic Ecology Environmental Assessment

Benthic Ecology Environmental Assessment for proposed Moyle Interconnector cables

Prepared by AFBI Fisheries and Aquatic Ecosystems Branch for Intertek Ltd.

August 2014

Version 3
Lead author: Annika Clements
Reviewed by: Adele Boyd

www.afbini.gov.uk

1. INTRODUCTION

This report describes the subtidal benthic communities, defined as the species living in and on the seabed, found in the region of the proposed cable routes, and the physical environment in which they exist. This report also addresses the sensitivity of these benthic communities to impacts from marine cable installation and operations, which are described in terms of the resultant effects of these activities on sediment suspension and deposition, abrasion and burial, and how the identified benthic species could be affected by such conditions.

2. METHODS

2.1 Scope

This report considers the 100m corridor south of each existing cable, in a regional context (i.e. environmental conditions at a regional scale).

2.2 Assessment Guidelines

In accordance with published criteria for the assessment of the significance of effects (Institute of Ecology and Environmental Management (IEEM), August 2010), the following must be established to assess the overall significance of an effect:

1. The likelihood of a potential effect occurring based on a scale of likely, possible or unlikely;
2. The sensitivity and/or importance of the receiving environment or receptor; and
3. The magnitude of the potential effect occurring; the potential change to the existing baseline conditions as a result of the development

To assess species and habitat sensitivity, methods used and published by the Marine Life Information Network for Britain and Ireland (MarLIN) have been used, with specific use of the Biology and Sensitivity Key Information Reviews as published on the MarLIN website (www.marlin.ac.uk)

2.2.1 Sensitivity or Importance of Receptor

The criteria detailed in Table 1 have been applied to assessment of benthic species and habitat sensitivity.

Sensitivity	Description
Very High	Rare or very restricted in distribution/in decline or has been in decline/high proportion of the world extent
High	High environmental value, quality or rarity on a regional scale/keystone in a biotope by providing a habitat for other species
Medium	Species or biotopes of local importance but not recognised as rare/protected or nationally important examples/species whose loss or depletion would cause disruption of the local food web
Low	Common species or biotopes which are well represented at a site scale and tolerant of change
Negligible	Common species or biotopes which are well represented locally and resistant to change

Table 1. Sensitivity criteria

2.2.2 Magnitude of effect

The magnitude of any potential effect takes into account the scale of the predicted change relative to baseline conditions, and considers the duration of the effect. Criteria for describing the magnitude of an effect are detailed in Table 2.

Magnitude	Description
High	Keystone/dominant species throughout the wider biotope or habitat are likely to be killed/destroyed by the factor under consideration. Only partial recovery is likely within ten years and full recovery is likely to take up to 25 years.
Medium	The population(s) of keystone/dominant species in the wider biotope may be reduced/degraded by the factor under consideration, the habitat may be partially destroyed or the viability of a species population, diversity and function of a community may be reduced. Only partial recovery is likely within five years and recovery may take up to ten years.
Low	Keystone/dominant species in the wider biotope considered are unlikely to be damaged. However, the viability of a species population or diversity/functionality of the immediate biotope community will be reduced. Full recovery is expected within a few weeks or at most six months.
Negligible	The factor does not have a detectable effect on structure and functioning of the wider biotope or the survival or viability of keystone/important species. Recovery immediate or within a few days.

Table 2. Magnitude criteria.

2.2.3 Significance of effects

Expert judgement is used to undertake a qualitative appraisal of the significance of effects, and is based upon a combination of the sensitivity and importance of the receptor (species or biotope) and the magnitude of a potential effect. The categories “Major”, “Moderate”, and “Minor” describe the significance of the effect, while “None” denotes “No significant effect”.

A matrix describing the categories of magnitude effect and sensitivity of receptors that is used to assess the significant of effects is provided in Table 3.

Magnitude of effect	**Sensitivity of receptors**				
	Very High	**High**	**Medium**	**Low**	**Negligible**
High	Major	Major	Moderate	Moderate	Minor
Medium	Major	Moderate	Moderate	Minor	None

Low	Moderate	Moderate	Minor	None	None
Negligible	Minor	Minor	None	None	None

Table 3. Assessing the significance of effects

The assessment results are presented as residual effects; namely the effects remaining after the consideration of proposed mitigation measures Residual effects identified as "Minor" or "None" are considered Not Significant; residual effects identified as "Major" or "Moderate" are considered to be Significant.

2.3 Approach to the appraisal

AFBI was commissioned by Intertek and Mutual Energy to assess the quality of existing cable survey data (multibeam sonar, sidescan sonar and ROV underwater video footage) for use in habitat assessment, and to produce a habitat map (EUNIS biotopes) for the 100m corridor south of the two existing cables. The existing survey data for the route met an adequate standard for habitat discrimination, including assessment of Annex I habitats (according to the Habitats Directive 92/43/EEC).

In addition to the Mutual Energy data, underwater video footage from video tows undertaken by Marine Scotland for *Nephrops norvegicus* burrow counting near the cable route were reviewed. Seasearch dive data was also extracted for the area near the Islandmagee end of the cables to provide context on the shallow sublittoral areas (biotope and species records reviewed).

2.3.1. Datasets used in habitat mapping

The following datasets were utilised courtesy of Mutual Energy:

1. Multibeam sonar bathymetry (XYZ data) collected in 2012 along the cable route, at $0.5m^2$ horizontal resolution.
    a. The XYZ data was gridded by AFBI in ArcGIS, and the dataset split into tiles to facilitate use in GIS due to the very large file sizes).
    b. Slope angle was derived from the bathymetry layers by AFBI.
2. Sidescan sonar data collected in (a) 2008 and (b) 2012 along the cable route. The sidescan sonar data was provided as raw XTF files, and also as georeferenced mosaic images with applied positional corrections for use within ArcGIS.
3. Derived point features datasets from the 2012 sidescan sonar survey: These identified debris, boulders, rock dumps, cable exposures and trawl scars.
4. 2012 underwater video (collected by ROV) as part of the General Visual Inspection (GVI) of the known cable route. The track of the ROV was available in ArcGIS as a point shapefile. The date and time stamp then allowed cross-referencing with the video library. The centre view camera was used for habitat interpretation.
5. Derived point features dataset from the 2012 GVI of the cable routes, identifying cable exposure, cable intervention (rockdumps), boulders, seabed debris (ammunition, rope, wire etc.)

The following supplementary datasets were used for habitat mapping:

1. Royal Navy multibeam sonar data off the east Antrim coast (bathymetry)
2. UK Seamap (JNCC) data products (EUNIS Level 4 map)
3. AFBI nearshore habitat mapping data (2004)

2.3.2. Habitat interpretation

All datasets were presented within ArcGIS 10.1 and habitat interpretation was completed as follows:

1. The sidescan sonar georeferenced mosaics (both 2008 and 2012 sets) and multibeam bathymetry/slope datasets were used to derive "ground types", which were manually digitised within ArcGIS. Emphasis was placed upon the 2012 sidescan sonar dataset, as much of the seabed consists of mobile bedforms and therefore the more recent dataset gives a more accurate assessment of recent conditions. The sidescan and multibeam datasets did not always extend the full 100m south of the existing cable routes, and therefore a degree of interpolation of ground-types was required to generate a full coverage map for this area of interest.
2. Following initial digitising of ground-types the full extent of the area of interest was reviewed for internal consistency in ground-type assignment, and amendments made as necessary.
3. The "ground types" were subsequently ground-truthed using the GVI point dataset and by selecting a random sample of video records from each ground-type at varying positions along the cable route. Video footage from the centre camera was reviewed with notes taken on the substratum, substratum features and characterising species. Field of view was not constant and therefore records are qualitative rather than quantitative. A minimum of two minutes of video footage was reviewed at a total of 84 randomly chosen locations along the cable routes, which enabled an assessment of habitat and biotope(s) to be made for that area. Where visibility was poor, additional footage was reviewed. The timestamp on the footage allowed the position to be determined through the ArcGIS video track shapefile. Footage quality varied considerably, andthe speed was often outwith the range required for focussing on smaller species. However the footage is deemed adequate for discrimination of habitats at EUNIS level 4. It must be noted that the video was collected along the expected cable route only, and therefore the physical ground-type interpretation to 100m south of the cable routes is based on the sidescan and multibeam datasets only, with biotopes interpolated to cover this area based upon their relationship with ground-types.
4. As a result of the video footage review, biotopes/habitats (EUNIS level 4 or higher) were assigned to ground-types, and mapped accordingly in ArcGIS. In many cases the ground-types, which represent broad scale homogeneous/consistent acoustic patterns, actually contained more than one biotope. However, the acoustic data did no permit discrimination of these to allow accurate mapping of individual biotopes. This is particularly the case for many of the megarippled bedforms where the crests and troughs consist of different biotopes. These areas are also mobile, and therefore trough/crest positions are likely to change over relatively short time periods (between surveys). Therefore within ArcGIS each section of the area of interest originally assigned as one ground-type may be shown as a mosaic of habitats.

3. EXISTING CONDITIONS

The North Channel is a constricted sea basin and as such tidal currents are notable: depth-average values exceed 1 ms^{-1} at spring tides. Within the Channel, higher values in excess of 2 ms^{-1} can be found near headlands and outcrops such as the Maidens and localised near shore areas adjacent to Islandmagee. The prevailing wind direction throughout the Irish Sea is south-westerly (Wilding *et al.,* 2007) and it is therefore moderately sheltered from wave action. Moderate to strong tidal currents result in mobile sedimentary bedforms which are a prevailing feature of the seabed, and result in a dominance of coarse substratum throughout the central and western section of the cable routes. Tidal mixing of Atlantic water with Irish Sea water is important in this area; thermal stratification has not been observed in this region.

Sediments include mobile cobbles and small boulders, with coarse sands and gravels (of glacial and local origins) in the western and central section of the North Channel, with finer sediment patches characterised by fine sand, muddy sand and sandy mud where local tidal currents are diminished allowing deposition of finer grained sediments on the eastern side (see Figure 1 below, taken from UK SeaMap (2010) and BGS data). A small area of outcropping bedrock is found adjacent to landfall on the Scottish side of the cable route (McBreen *et al.,* 2011).

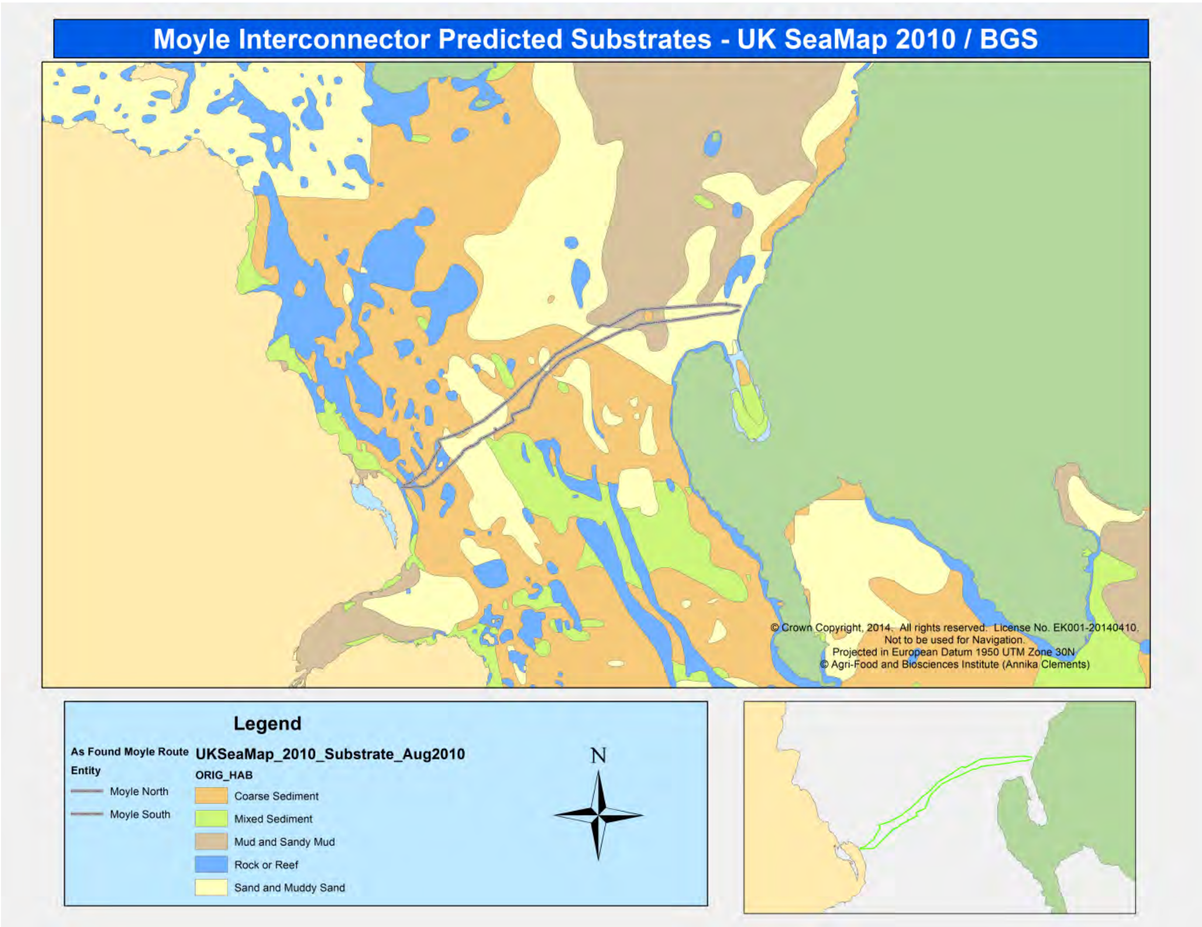


Figure 1. Predicted substrates based on British Geological Survey (BGS) data and JNCC modelling for the UK SeaMap (2010) project.

At a landscape level, the whole of the North Channel is considered as either a moderate or high energy environment with respect to benthic habitat classification (McBreen *et al.,* 2011).

As part of ongoing monitoring for a gas pipeline, AES Ltd. collected tidal current data from a range of sites across the North Channel from 2002-2003 (for 12 months). These confirm that midwater current speeds often exceed 1ms^{-1}, with notably strong currents close to land at Islandmagee (see Figure 2 and Table 4 below).

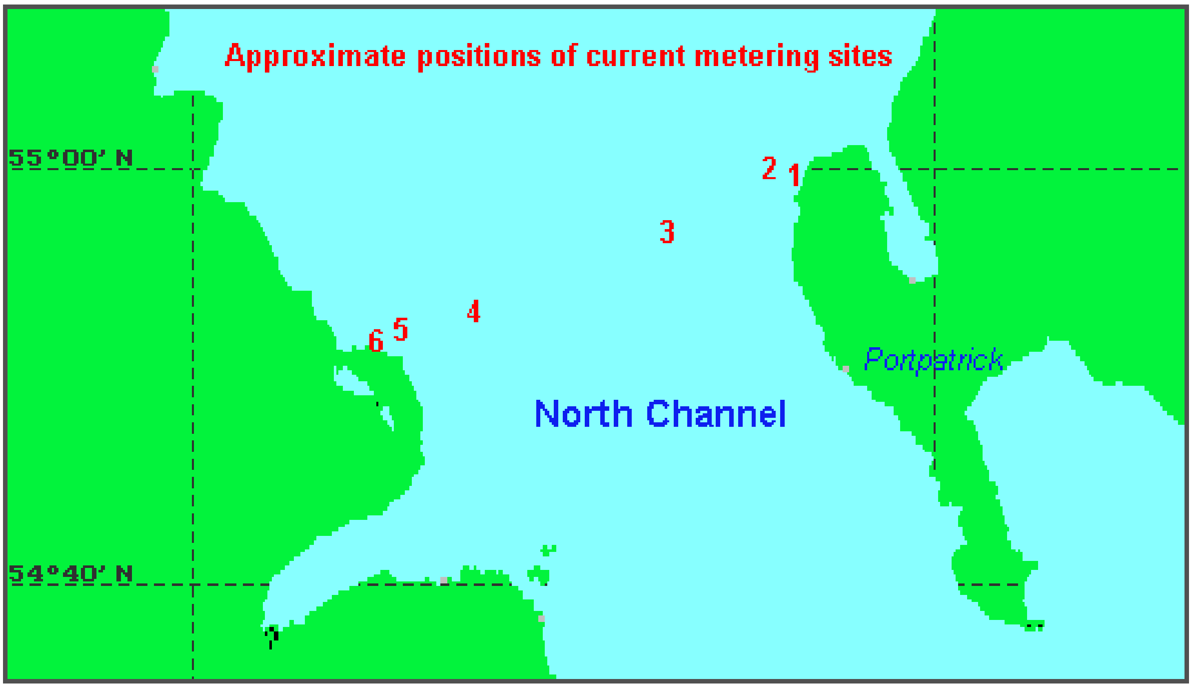


Figure 2. Positions of current meters across the North Channel

Site*:	1	2	4	5	6
Maximum annual average current (ms^{-1}):	0.947	1.291	1.152	1.065	1.435

* Note that data for Site 3 are not currently available

Table 4. Results from current meters in the North Channel

3.1 Benthic Ecology

3.1.1 Habitats: Identified Biotopes

A total of five biotope complexes at level 4 were identified. Within these an additional five level 5 biotopes could be distinguished, and within those a further two sub-biotopes were identified. Table 5 below details the biotopes identified within the habitat map (shown in Figures 3a – 3b):

Level 4 Biotope complex	EUNIS Code	Full title
CR.MCR.EcCr	A4.21	Echinoderms and crustose communities on moderate energy circalittoral rock
SS.SCS.CCS	A5.14	Circalittoral coarse sediment

SS.SMU.CFiMu*[1]	A5.34	Circalittoral fine mud
SS.SMx.CMx	A5.44	Circalittoral mixed sediment
SS.SSa.CFiSa*[2]	A5.25	Circalittoral fine sand

Level 5 Biotope	**EUNIS Code**	**Full title**
CR.MCR.EcCr.UrtScr	A4.213	*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock
SS.SCS.CCS.PomB	A5.141	*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
SS.SMU.CFiMu.MegMax	A5.362	Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud
SS.SMx.CMx.FluHyd*[3]	A5.444	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment
SS.SMx.CMx.OphMx	A5.445	*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment

Level 6 sub-biotope	**EUNIS Code**	**Full title**
CR.MCR.EcCr.FaAlCr.Bri	A4.2144	Brittlestars on faunal and algal encrusted exposed to moderately wave-exposed circalittoral rock
CR.MCR.EcCr.FaAlCr.Pom	A4.2142	Faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately wave-exposed circalittoral rock

*__May also include:__

Level 4 Biotope	**EUNIS Code**	**Full title**
[1]SS.SMu.CSaMu	A5.35	Circalittoral sandy mud
[2]SS.SSa.CMuSa	A5.26	Circalittoral muddy sand
Level 6 sub-biotope	**EUNIS Code**	**Full title**
[3]CR.HCR.XFa.FluCoAs.X	A4.1343	*Flustra foliacea* and colonial ascidians on tide-swept exposed circalittoral mixed substrata

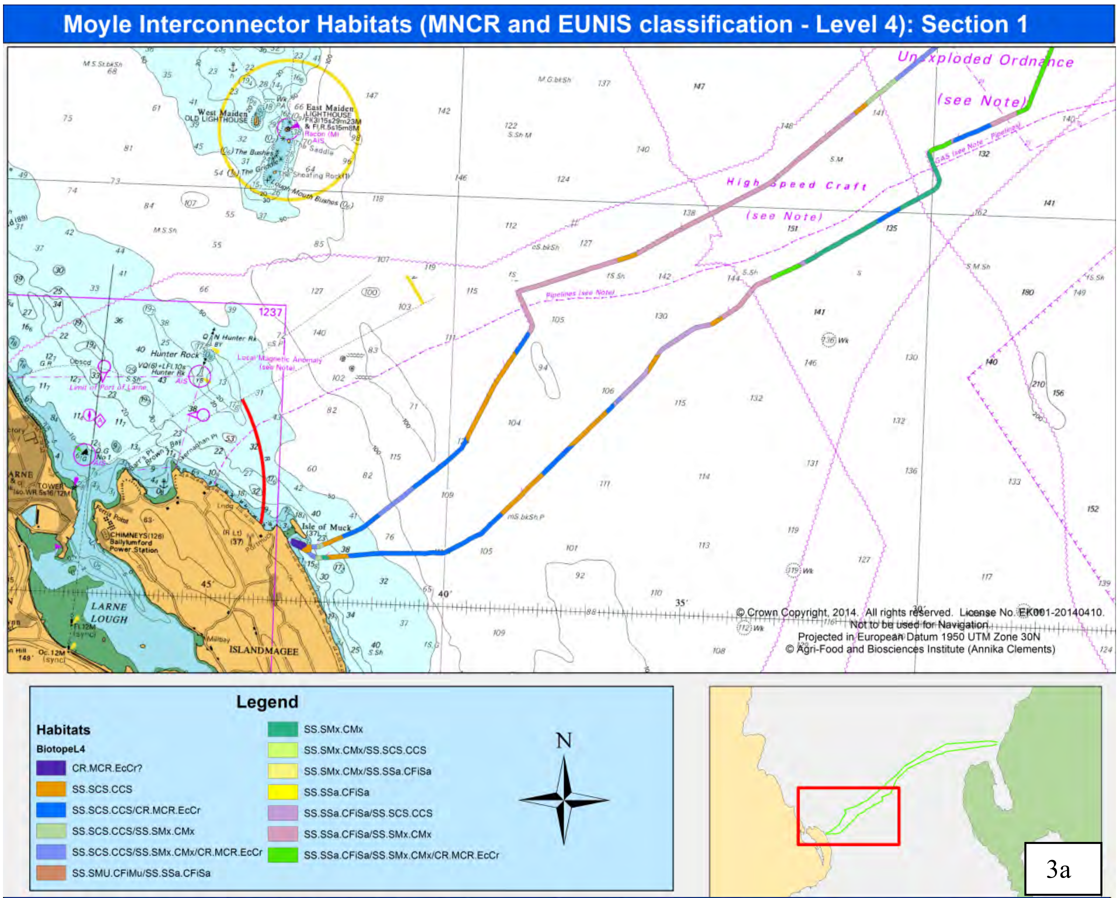
Table 5. Biotope complexes, biotopes and sub-biotopes identified from video review

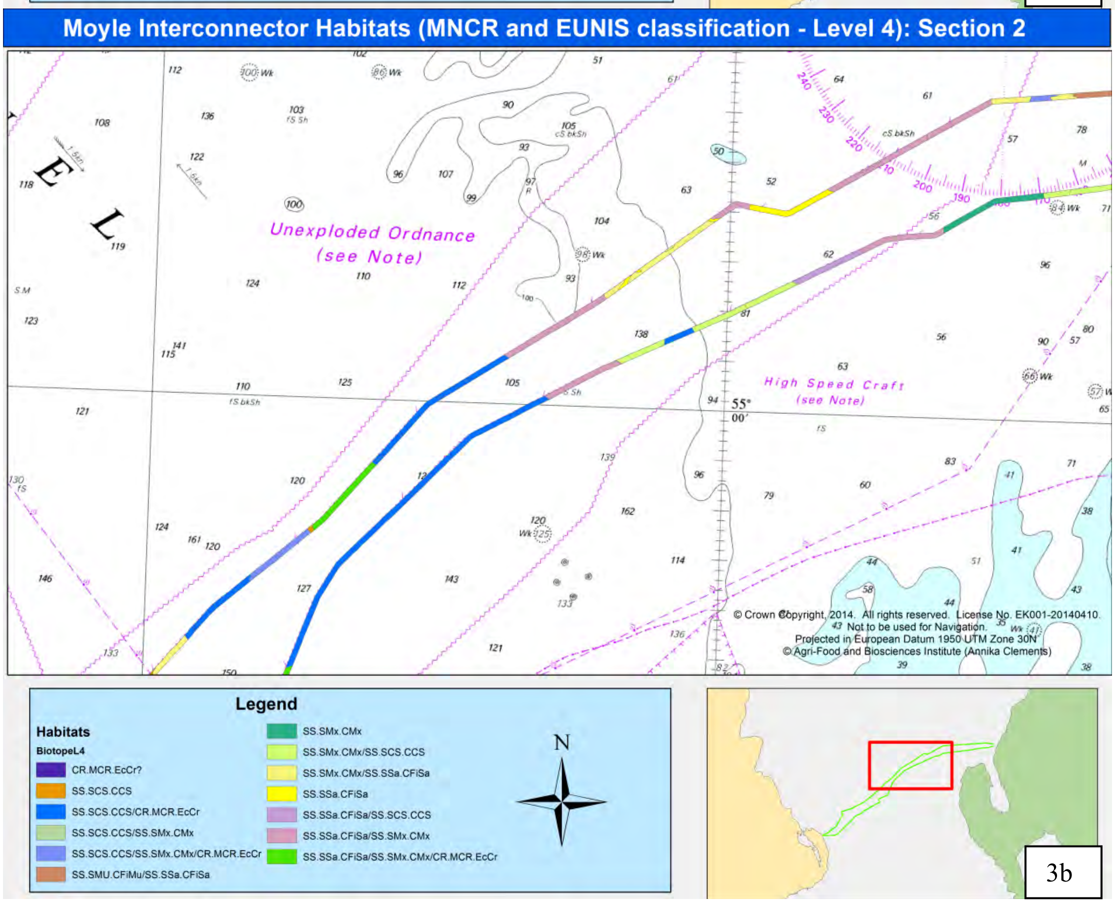
It should be noted that the route is dominated by sediment habitats. To achieve accurate biotope classification to higher levels (Level 5+) and full characterising species lists, infaunal sampling should be undertaken.

The characterising conspicuous species noted for each biotope complex/biotope mosaic are shown in table 6 below:

Level 4 Biotope (mosaic)	**Level 5 or 6 biotopes contained therein**	**Dominant substratum**	**Dominant conspicious species**
SS.SCS.CCS	SS.SCS.CCS.PomB	Cobbles	*Echinus esculentus, Asterias rubens, Crossaster papposus, Pomatoceros triqueter*
SS.SCS.CCS/CR.MCR.EcCr	CR.MCR.EcCr.FaAlCr.Pom/CR.MCR.EcCr.FaAlCr.Bri	Cobbles	*Echinus esculentus, Asterias rubens, Crossaster papposus, Pomatoceros triqueter, Ophiothrix fragilis, Ophiocomina nigra, Flustra foliacea, Munida rugosa*
SS.SCS.CCS/CR.MCR.EcCr	CR.MCR.EcCr.UrtScr	Cobbles	*Urticina sp., Crossaster papposus, Filograna implexa?, Asterias rubens, Echinus esculentus*
SS.SCS.CCS/CR.MCR.EcCr	SS.SCS.CCS.PomB/CR.MCR.EcCr.FaAlCr.Pom	Cobbles	*Pomatoceros triqueter, Urticina sp., Asterias rubens, Echinus esculentus, Crossaster papposus*
SS.SCS.CCS/CR.MCR.EcCr	SS.SCS.CCS.PomB/CR.MCR.EcCr.FaAlCr.Pom	Cobbles	*Echinus esculentus, Asterias rubens, Crossaster papposus, Pomatoceros triqueter, Flustra foliacea*
SS.SCS.CCS/CR.MCR.EcCr	SS.SCS.CCS.PomB/CR.MCR.EcCr.UrtScr	Coarse sand	*Pomatoceros triqueter, Urticina sp., Asterias rubens, Echinus esculentus*
SS.SCS.CCS/CR.MCR.EcCr		Cobbles	*Echinus esculentus, Asterias rubens, Crossaster papposus, Pomatoceros triqueter*
SS.SCS.CCS/SS.SMx.CMx		Sand(fine-coarse)	*Pagurus sp., Asterias rubens*
SS.SCS.CCS/SS.SMx.CMx/CR.MCR.EcCr	SS.SMX.CMx.OphMx / SS.SMX.CMx.FluHyd	Cobbles/small boulders	*Echinus esculentus, Asterias rubens, Crossaster papposus, Ophiothrix fragilis, Ophiocomina nigra, Flustra foliacea, bryozoan & hydrozoan turf* (rare)
SS.SCS.CCS/SS.SMx.CMx/CR.MCR.EcCr		Cobbles	*Echinus esculentus, Asterias rubens, Pagurus sp., bryozoan and hydrozoan turf* (rare)
SS.SMU.CFiMu/SS.SSa.CFiSa	SS.SMU.CFiMu.MegMax	Muddy sand	*Nephrops norvegicus, Turitella communis, Calocaris macandreae* or *Upogebia* spp. (small burrows)*?*
SS.SMx.CMx		Shell hash	*Pagurus sp., Asterias rubens*
SS.SMx.CMx/SS.SCS.CCS		Fine sand	*Pagurus sp., Asterias rubens*
SS.SMx.CMx/SS.SSa.CFiSa		Fine sand	*Pagurus sp., Asterias rubens*
SS.SMx.CMx/SS.SSa.CFiSa		Muddy sand	*Turitella communis, Pagurus sp.*
SS.SSa.CFiSa		Fine sand	*Pagurus sp., Asterias rubens* (rare)
SS.SSa.CFiSa/SS.SMx.CMx		Pebbles	*Echinus esculentus, Asterias rubens, Crossaster papposus*
SS.SSa.CFiSa/SS.SMx.CMx		Sand(fine-coarse)	*Echinus esculentus, Asterias rubens, Crossaster papposus*
SS.SSa.CFiSa/SS.SMx.CMx/CR.MCR.EcCr		Cobbles/small boulders	*Echinus esculentus, Asterias rubens, Pagurus sp.*

Table 6. Characterising conspicuous species of the mapped biotope complexes/mosaics and the biotopes and sub-biotopes contained therein.


Moyle Interconnector Habitats (MNCR and EUNIS classification - Level 4): Section 1
Unexploded Ordnance
(see Note)
High Speed Craft
(see Note)
© Crown Copyright, 2014. All rights reserved. License No. EK001-20140410.
Not to be used for Navigation.
Projected in European Datum 1950 UTM Zone 30N
© Agri-Food and Biosciences Institute (Annika Clements)
Legend
Habitats
BiotopeL4
CR.MCR.EcCr?
SS.SCS.CCS
SS.SCS.CCS/CR.MCR.EcCr
SS.SCS.CCS/SS.SMx.CMx
SS.SCS.CCS/SS.SMx.CMx/CR.MCR.EcCr
SS.SMU.CFiMu/SS.SSa.CFiSa
SS.SMx.CMx
SS.SMx.CMx/SS.SCS.CCS
SS.SMx.CMx/SS.SSa.CFiSa
SS.SSa.CFiSa
SS.SSa.CFiSa/SS.SCS.CCS
SS.SSa.CFiSa/SS.SMx.CMx
SS.SSa.CFiSa/SS.SMx.CMx/CR.MCR.EcCr
N
3a


Moyle Interconnector Habitats (MNCR and EUNIS classification - Level 4): Section 2
Unexploded Ordnance
(see Note)
High Speed Craft
(see Note)
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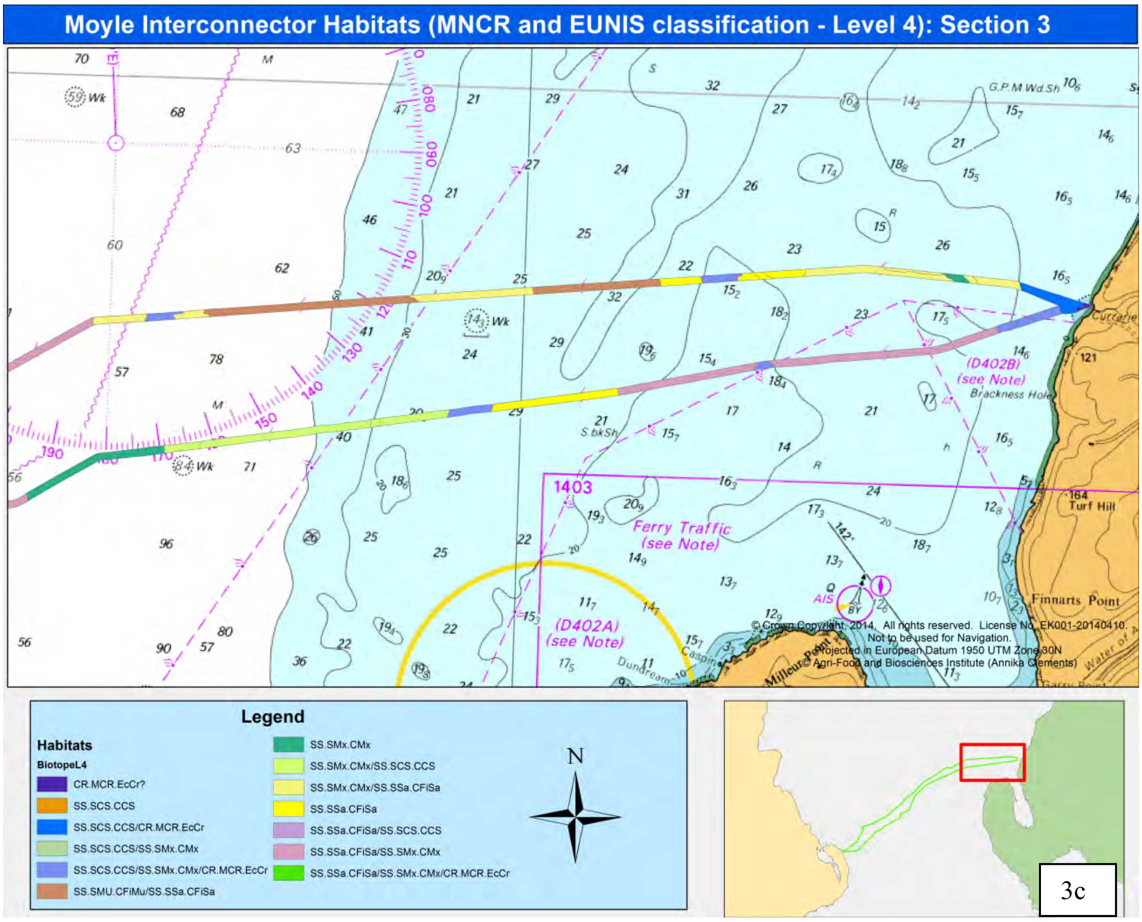
Not to be used for Navigation.
Projected in European Datum 1950 UTM Zone 30N
© Agri-Food and Biosciences Institute (Annika Clements)
Legend
Habitats
BiotopeL4
CR.MCR.EcCr?
SS.SCS.CCS
SS.SCS.CCS/CR.MCR.EcCr
SS.SCS.CCS/SS.SMx.CMx
SS.SCS.CCS/SS.SMx.CMx/CR.MCR.EcCr
SS.SMU.CFiMu/SS.SSa.CFiSa
SS.SMx.CMx
SS.SMx.CMx/SS.SCS.CCS
SS.SMx.CMx/SS.SSa.CFiSa
SS.SSa.CFiSa
SS.SSa.CFiSa/SS.SCS.CCS
SS.SSa.CFiSa/SS.SMx.CMx
SS.SSa.CFiSa/SS.SMx.CMx/CR.MCR.EcCr
N
3b



Figures 3a, b & c. Habitat maps for the proposed cable route (in three sections, moving from west to east)

In addition to classifying habitats as EUNIS biotopes, “Stony reef” and “Bedrock reef”, which are both listed under Annex I of the Habitats Directive, were identified. “Stony reef” was defined according to the recommendations of the Joint Nature Conservation Committee (Irving, 2009), with cobbles covering >10% of the seafloor, the reef appearing elevated compared to surrounding sediments and supporting epifaunal communities, and exceeding $25m^2$ in extent. Figure 4 below shows the area of the proposed cable route that could be classified as stony reef. This includes a substantial tract mid Channel and a notable area close to Islandmagee. There is also a section close to landfall on the Scottish side; the shallow sublittoral area that borders landfall in this region is also the only example of bedrock reef along the cable routes.

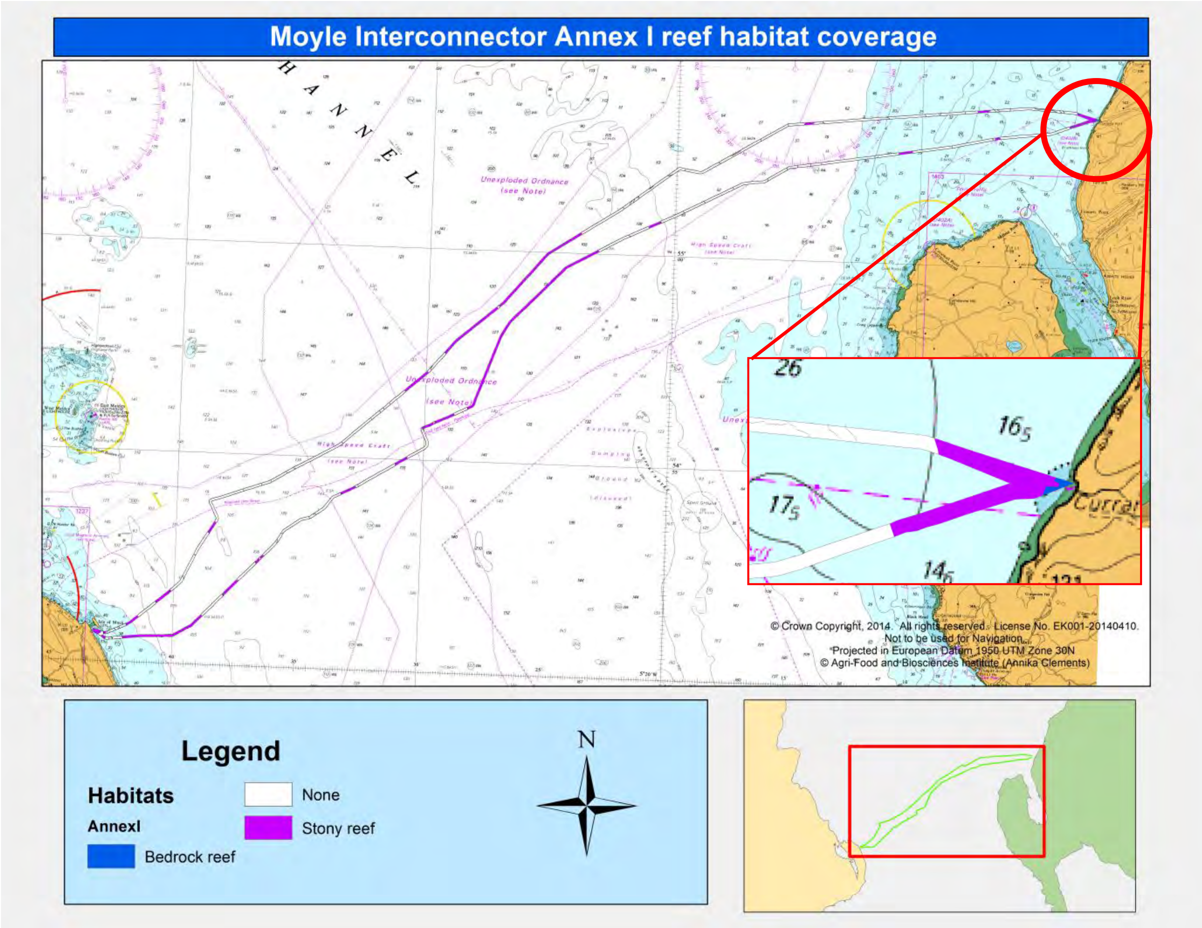


Figure 4. Potential Annex I reef habitat along the proposed cable routes (zoom in on eastern end where bedrock reef is located).

Further information on the finer sedimentary areas was provided courtesy of Marine Scotland from their *Nephrops* burrow counting survey footage, which was accompanied by particle size analysis sample data. These data confirmed the location of the *Nephrops* ground which covers notable sections of the eastern side of the cable routes, with sediments being classified according to the Folk method (Folk, 1954) as muddy sand or sandy mud. These areas are heavily bioturbated. Evidence of trawling could also be seen from trawl scars on the video footage.

Grab or core data are not available from the proposed cable route areas, and therefore infaunal communities have not been described.

3.1.2 Epifauna

Sublittoral mud: In low energy areas (low wave action and weak tidal currents) the deposition of finer sediments was found, as characterised by *Nephrops* ground (fine muddy sand and sandy muds). The mud was densely bioturbated by both *Nephrops norvegicus* and other burrowing species (including *Calocaris macandreae* – as in evidence by the shape of burrows seen on UWTV footage). Additional burrowing fauna (mud burrowing shrimps predominantly) has also been recorded by other studies in the Firth of Clyde (Smith, 1988). All three species of sea pens (*Pennatula phosphorea, Funiculina quadrangularis* and *Virgularia mirabilis*) have been observed in the wider

Clyde *Nephrops* ground (Allan *et al.,* 2012). Gadoids and flatfish have been also observed on these grounds, with brittlestars, hermit crabs, starfish, urchins, anemones, queen scallops, crabs and fan worms occasionally observed in areas bordering coarser sediments. The turret shell, *Turitella communis*, was frequently found in the sandy mud habitats. Inspection of video footage closest to the proposed cable routes showed that the sea pen *P. phosphorea* occurs frequently in patches of muddy sand.

Sublittoral sand: Sand habitat dominates the cable routes, and mostly consists of mobile coarse-medium sands. As these sediments form mobile bedforms (megaripples and ripples) there are few conspicuous epifaunal species, with the exception of occasional *Pagurus* sp. and *Asterias rubens.* The coarser, more mobile sands are found in the central Channel and to the west of the routes. Extensive patches of shell hash were found and often in the megaripple troughs cobbles were evident. In more level areas of coarse sand the anemone *Urticina* sp. was frequently found, a species that is known to be scour tolerant. To the east, finer sands correspond with slightly weaker tidal currents. These sands exhibit less extensive mobile bedforms, and some stable ground, and grade into the sublittoral mud habitat described above. Conspicuous epifauna was similar to the coarser sand, with the exception of some *Turitella communis* being present.
To better characterise the biotopes within these areas, and ensure that these do not include Priority Marine Feature biotopes, infaunal data are required as gathered from grab samples.

Sublittoral mixed sediments: Large sections of the cable routes consist of unconsolidated mixed sediments, often in mobile bedforms, with cobbles mixed with coarse sand and substantial amounts of shell hash (shell gravel) and dead whole shell. Where cobbles are embedded and therefore not mobile, scour-tolerant epifauna typifies this habitat, such as the keel worms *Pomatoceros triqueter*, the bryozoan *Flustra foliacea*, the grazing urchin *Echinus esculentus* and, in patches of relatively high frequency, the anemone *Urticina* sp. In addition, the filigree worm *Filograna implexa,* which forms a ball-like structure of calcareous tubes, was also found fairly frequently in cobble/coarse sand areas (confirmation of identification within video footage required, as no actual sample and hard to distinguish within video footage from *Salmacina dysteri*). The sun-star *Crossaster papposus* and starfish *Asterias rubens* were also seen frequently.
To better characterise the biotopes within these areas, and ensure that these do not include Priority Marine Feature biotopes, infaunal data are required as gathered from grab samples.

Stony reef: The areas dominated by cobbles and small boulders (usually surrounded by coarse sands and shell hash) are considered as 'stony reef', however the epifaunal communities of these areas are impoverished due to the impact of sand scour on hard substrata. Faunal turf, where found, is short, with encrusting species and scour tolerant species dominant (e.g. *Flustra foliacea, Pomatoceros triqueter)*. In some areas, dense brittlestar beds are found (predominantly *Ophiothrix fragilis,* but also *Ophiocomina nigra* in smaller numbers), and the rugose lobster, *Munida rugosa* is also locally common. In shallower sites, encrusting coralline algae is found on stable cobbles, and possibly also the encrusting bryozoans *Parasmittina trispinosa.*

Underwater video data is not available for the shallow sublittoral areas bordering landfall at either end of the cable routes, however Seasearch (Northern Ireland) have undertaken a number of dives within 500m of the area of interest, and additionally there are Northern Ireland Sublittoral Survey data from the same area. These dives have covered boulder slopes and boulder plains which are likely to harbour similar species to the boulder reef found adjacent to the landfall at Islandmagee. The biotopes CR.HCR.XFa (Mixed faunal turf communities on high energy circalittoral rock) and SS.SMx.CMx.OphMx (*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment) are noted, and a high diversity of epifauna including hydroid and bryozoan turf, ascidians, and encrusting sponges were found on the boulders. The presence of *Tubularia indivisa* is testament to the stronger tidal currents adjacent to the shore and increased energy at this site. Such epifaunal assemblages are not evident further out into the North Channel along the cable route, although SS.SMx.CMx.OphMx is seen. It is probably that stony reef near the Islandmagee landfall may also harbour lobster (*Homarus gammarus*), brown crab *(Cancer pagurus*) and velvet swimming crab *(Necora puber*) as these are caught by the pot fisheries within this region.

Bedrock reef: The only notable area (>25m^2) of outcropping bedrock was located adjacent to the Scottish landfall site. There is no video or diver records from this area, or from the immediate vicinity on bedrock (within 1km), and it is therefore difficult to assess whether this area could harbour sensitive biotopes and epifauna. Due to its depth, it falls largely within the infralittoral zone, so likely to be kelp park or kelp forest. Moderate tidal currents are found in the area, which are weaker than those found at Islandmagee on the western end of the cable routes.
A Phase 1 intertidal habitat survey has been completed for the Scottish landfall site (RPS, 2014), which identified one infralittoral biotope, 'Mixed kelp and red seaweed communities on medium energy infralittoral rock' - IR.MIR.KT.XKTX, which borders the bedrock reef area. This biotope is not listed in the Scottish Priority Marine Features and is considered common throughout the UK.

4. POTENTIAL EFFECTS

The potential effects from both the installation and the operation of the new marine cables is discussed below; a summary of the environmental appraisal results for the sensitivity of benthic habitats and species coupled with the magnitude of each effect is presented in Table 7.

4.1 Installation

4.1.1 Direct loss/disturbance of benthic species and habitats

It is evident that all benthic communities in the footprint of the new cables, and in their immediate vicinity, will be impacted through substratum loss and direct displacement during cable laying (through ploughing or trenching). The installation of cables will result in localised mortality, injury and displacement of sessile benthic species, such as anemones (e.g. *Urticina* sp.) and filigree worms (*Filograna implexa*). Less mobile benthic species, such as hermit crabs (*Pagurus* sp.), squat lobsters (*Munida rugosa*) and echinoderms (*Echinus esculentus, Asterias rubens* and *Crossaster papposus*) are also likely to be directly impacted with localised mortality. However, the habitats identified from this appraisal are known to be widely occurring and the sensitivity overall is deemed to be low. Some species identified are of more concern:

1. The dahlia anemone, *Urticina* sp. (confirmation of identification within video footage required- smaller specimens could be the Imperial anemone *Capnea sanguine*). According to the MARLIN sensitivity analysis (see: http://www.marlin.ac.uk/speciessensitivity.php?speciesID=4556) it is intolerant of

substratum loss, but has “moderate” recoverability, and is viewed therefore as moderately sensitive to substratum loss. These anemones are not considered rare (and are found extensively throughout the Irish Sea), and *Urticina* sp. are not listed on the Northern Ireland Priority Species list (see: http://www.habitas.org.uk/priority/splist.asp?Type=Cnidaria) or the Scottish Priority Marine Features species list (http://www.snh.gov.uk/protecting-scotlands-nature/priority-marine-features/priority-marine-features/).

2. The rugose squat lobster, *Munida rugosa*. There is no published available information on its sensitivity, however it is listed under the Northern Ireland Priority Species list, due to the potential impact of mobile fishing gear on this species and also because the population within Northern Ireland exceeds 50% of the total known population within the Island of Ireland.
3. The Dublin Bay prawn, *Nephrops norvegicus,* was found in the fine mud biotopes on the Scottish side of the cable route, at fairly high densities (burrow counts varied from 0.2 to 1.8 per m^2). *Nephrops* is known to have high intolerance of substratum loss, but moderate recovery from such physical impacts, and is thus considered to be of “moderate” sensitivity (Sabatini and Hill, 2008). *Nephrops* itself is not listed as a priority species for either Scotland or Northern Ireland, although the burrowed mud habitat in which is forms a member of the characterising fauna is listed as a priority marine feature in both Northern Ireland and Scotland.
4. The sea pen *Pennatula phosphorea.* There is no published available information on its sensitivity, however it is a characterising species of the “Mud Habitats in Deep Water” UK Biodiversity Action Plan Priority Habitat (UK-wide applicable) and is a priority marine feature in both Scotland and Northern Ireland. *P. phosphorea* is assumed sensitive to physical disturbance due to the reduction in its presence seen in heavily trawled areas.

Overall, recoverability of sediment habitats, due to their comparative lack of fragile or rare species, and the surrounding faunal stock that can re-colonise disturbed sediments, is likely to be rapid, and therefore the magnitude of the effect is deemed negligible. Bivalves and gastropods are likely to take longer than polychaetes to re-colonise areas but even considering this it is unlikely to exceed weeks.

Stony reef and bedrock reef are considered to be of higher environmental value, as they include potential Annex I habitat, and may contain more delicate species such as squat lobsters, ascidians and sponges that take longer to re-colonise hard substrata and grow to adult size. However, the examples of stony reef seen in the area are heavily grazed and scour tolerant, which suggests they are adapted to moderate-high physical disturbance and abrasion and contain few highly sensitive species. Recoverability of such habitats is expected to take longer, and therefore overall magnitude of effect is assessed as medium.

Burrowed mud is a Scottish Priority Marine Feature and good examples of this habitat are found on the Scottish section of the proposed cable routes. There was some evidence of trawl scars on the video footage examined, but also some less disturbed areas where the sea pen *P. phosphorea* was found in notable abundances. Cable-laying will impact upon the quality of this habitat where it has been previously undisturbed (e.g. if in an area not already trawled), however the impact will be highly localised and recoverability is likely to be good following the ploughing or trenching activity, therefore the overall magnitude of effect is assessed as low.

4.1.2 Smothering from displaced sediment

The immediate impact from displaced sediment as a result of ploughing or trenching is likely to be very localised, and therefore will only affect species in the immediate vicinity of the cable trench. As such, sessile or less mobile species are most likely to be impacted, as above. The same considerations of sensitivity to direct loss/disturbance apply to physical smothering through sediment displacement; bearing in mind that species identified are widely occurring (with the possible exception of *Filograna implexa* and the sea pen *P. phosphorea*) and the rapid recolonisation is likely from surrounding areas, the recoverability is likely to be high and therefore the magnitude of the effect is considered to be medium.

4.1.3 Suspended sediment dispersion and deposition

The surrounding area is likely to be impacted to varying degrees from the suspension and subsequent deposition of sediments as a result of ploughing or trenching operations. The finer sediments are likely to be transported a greater distance from their source and deposited in a fine layer over a wider area, while coarse sediments are likely to settle out of the water column rapidly and not travel over such a wide area. Smothering is most likely to affect sessile or limited mobility epifaina, or infauna in surficial sediments (near sediment-water interface). As with the direct loss or disturbance of sediment effect detailed above, overall sensitivity of the benthos is deemed low, in part due to the scour-resistant nature of the epifaunal communities. The two exceptions may be:

(1) Sandy muds or muddy sands with burrowing megafauna and sea pens. Sea pens are likely to be sensitive to such disturbance but sea pens are reportedly able to self-clean and this may reduce the impact of smothering. Also due to the small grain size it is likely that sediment will spread over a larger footprint in a fine layer, which will result in minimal burial/smothering.

(2) Stony reef and bedrock reef. Although the majority of such reef areas exhibit scour-tolerant assemblages, the shallower subtidal area by Islandmagee is likely to harbour some species that are less tolerant, e.g. *Tubularia indivisa, Haliclona viscosa* and *Epizoanthus couchii.*

In both cases species are widely occurring and re-colonisation is likely to occur within months- in addition the effects on bedrock or stony reef are likely to be very localised. Recoverability is therefore deemed to be fast, and overall magnitude of effect is considered to be low.

4.1.4 Smothering from rock installation or mattress berms

Where target cable burial depths cannot be reached it is necessary to protect the cable from damage through “rock dumps” or mattress berms. In the majority of cases this effectively introduces a hard substratum over the top of soft substratum, permanently smothering the sediment and resulting in a loss of that habitat in the footprint of the rock installation (and creation of a new hard substratum habitat). The sedimentary habitat area likely to be lost due to rock installations is small, and as habitats and species identified are widely occurring, the magnitude of effect is considered medium.

4.2 Operation

4.2.1 Introduction of new substrate (cable, rock or mattress berms)

It will be the intention to bury the cables at a depth of 1m, but where this is not possible the installation of rock ("rock dumps") or mattress berms will be used to protect the exposed cable. In sedimentary regions this effectively introduces a hard substratum which will be colonised by epifauna, and therefore modify the local benthic community structure. This has been observed from video footage of the existing cables, with aggregations of *Echinus esculentus* on the rock installations, and frequently *Flustra foliacea* and *Pomatoceros triqueter.* Notably due to the coarse surrounding sediment, assemblages consist of scour tolerant species. As these areas are likely to be spatially restricted and small, it is unlikely to have an impact on the wider ecosystem functioning or detrimentally affect the surrounding sedimentary communities. The magnitude of this effect is deemed low.

4.2.2 Electromagnetic Fields (EMFs)/Induced Electric Fields

The impact of EMFs on benthic species is widely unknown. As benthic communities are typified by sessile or low-mobility species, which are unlikely to navigate using magnetic fields and anomalies, these species are less likely to be impacted than more mobile species such as teleost fish or elasmobranchs. The exception could be crustaceans, such as edible crabs (*Cancer pagurus*), lobster (*Homarus gammarus*) and prawns (e.g. *Nephrops norvegicus*). Some of these crustaceans are known to migrate using the geomagnetic field or use the magnetic fields induced by tidal currents to act as cues for diurnal behaviours such as burrow emergence (in the case of *Nephops*). No studies have yet demonstrated any significant impacts of EMFs on mortality or morbidity to benthic invertebrates. A study examining the behavioural responses of Dungeness crab and American lobsters to EMFs (Woodruff et al., 2013) showed no statistically different responses in their use of space or activity patterns, but due to high variability in these responses further study has been recommended, as initial results do allude to some changes.

CMACS (2014a) assessed the electric and magnetic fields induced by the proposed new return cables and showed that effects are highly localised, only exceeding background geomagnetic field strengths within 4m of the cable. As such these are deemed to have minimal impacts upon marine invertebrates, although may impact upon benthic or demersal fish, elasmobranchs and European eels (*Anguilla anguilla*) and lamprey (*Petromyzon marinus* and *Lampetra fluviatilis*). In some cases a barrier effect has been demonstrated for eels and lamprey at cables, however this could not be directly attributed to EMFs.

The wider impact of EMFs on the ecosystem, through disturbance of fish, elasmobranchs, eels and lamprey for example, may cascade down to benthic communities if predation patterns change. However, as the identified habitats and species are widely occurring the overall magnitude of this effect is considered low.

4.2.3 Thermal radiation

The cables will produce heat while in operation, as a consequence of the internal resistance in the conductors. The temperature change in the surrounding sediment is unlikely to exceed 2°C at 20cm depth from the sediment-water interface (OSPAR, 2009), for a cable buried at 1m sediment depth. Water adjacent to the cable in between rocks used in rock installations is likely to be heated to a similar level. The majority of the sediments on the cable routes are coarse grained, with the exception of the *Nephrops* grounds towards the Scottish side. Coarse grained sediments have larger interstitial spaces, allowing more water movement which acts to buffer the temperature rise through mixing, and prevent localised stratification. Similarly the water filled spaces between the rocks and cables used in rock installations are likely to be well flushed, especially given the tidal currents in the area. The immediate impact of localised heating within sediments will be restricted, which if buried to a depth of 1m will cause a maximum rise of 2°C at 20cm sediment depth where the majority of infaunal species or burrowing megafauna are found. This is within the tolerance of most notable infaunal species in the area, and the effect is very localised so considered of minimal consequence (CMACS, 2014b). As most infaunal species have some limited mobility, it is likely that should the rise in temperature disturb them, they will move further away. Due to the widespread nature of the habitats and species identified in the region, these fine scale changes in species distribution around the cable are deemed negligible.

5. MITIGATION

5.1 Installation

5.1.1 Direct loss/disturbance of benthic species and habitats

Where possible cable routing should seek to avoid good examples of these two habitats (burrowed mud (*Nephrops* with sea pens), and high energy stony reef), and where possible disturbance through deployment of equipment or vessels onto the seabed should be kept to a minimum.
Further investigation of the bedrock reef area is necessary to establish the epifaunal community composition.

5.1.2 Suspended sediment dispersion and deposition

No specific mitigation methods are proposed, as this will largely be influenced by the choice of trenching/ploughing equipment.

5.2 Operation

Further research into the following would be beneficial to understand the full impact of the cable operations:

(a) The composition of the infaunal communities, particularly in the fine sediment areas (and thus the potential impact of thermal radiation); and

(b) The knock-on impact of disturbance to fish (including elasmobranch) populations and/or lobster populations (migratory species) from EMFs on the benthos

6. RESIDUAL EFFECTS

6.1 Installation

6.1.1 Direct loss/disturbance of benthic species and habitats

A very localised area in the footprint of the cable trench will be affected by cable installation, which overall represents a tiny fraction of the habitats observed in the area.
Many of the habitats observed are characteristic of moderately strong tidal currents, and given the dominance of sand and coarse sediments, which often occur as mobile bedforms, can be viewed as adapted to physical disturbance. The habitats identified do not exhibit rare, slow-growing or fragile species, with the possible exception of the shallow stony reef adjacent to Islandmagee, and the mud with burrowed megafauna and sea pens on the Scottish side. These latter habitats are not considered rare, but may contain priority species and assemblages, and may by their nature be more sensitive to disturbance.

Many infaunal species may live at depths where they will be protected from surface disturbance, and in areas where direct loss occurs it is likely that adjacent areas will act to replenish communities rapidly as most infaunal species are mobile.

Nephrops are likely to seek refuge in their own burrows from disturbance, and therefore localised mortality could be high for such burrow dwellers. However, recruitment to disturbed sites once installation is complete is likely to replenish any population loss as a result of direct disturbance. Similarly, sessile species such as sea pens and anemones are likely to suffer from localised mortality, but if adequate conditions prevail following installation, recolonisation is highly likely as long as disturbance isn't regularly repeated.

Physically fragile species, such as *Filograna implexa* and *Echinus esculentus* are likely to incur physical damage and related mortality during cable trenching. Due to the frequency of such species in the area it is highly probable that numbers will recover rapidly.

On potential Annex I reef habitat the removal of epifauna is likely to take longer to recover; however as much of the stony reef habitat consists of mobile or embedded cobbles, if these are displaced during cable trenching into a similar habitat/physical environment, it is likely that a majority of epifaunal species will survive (especially scour tolerant communities). The dominant epifaunal species on stable cobbles, boulders and bedrock are rapid recolonisers, capable of early reproduction and rapid growth, and therefore should recover within a year. Some species, such as sponges, anemones and tall hydrozoans turf may take longer to fully recover (in particular those species found in the shallow stony reef areas adjacent to Islandmagee, and possibly those inhabiting bedrock reef near the Scottish landfall).

If "micro-routing" of the cables to avoid the best examples (in terms of benthic community structure) of stony and bedrock reefs is accomplished, and given the highly localised nature of any impacts, this effect is assessed as **Minor Adverse.** Minor adverse effects are assessed as **Not Significant.**

6.1.2 Smothering from displaced sediment

It is unlikely that smothering will have a lasting impact on the benthos, as only a thin layer of sediment is likely to be deposited and it will therefore be possible for many species to re-burrow or move up through the sediment. Sediment movement is a key characteristic of the North Channel so most benthic communities are adapted to episodic burial and sediment movement, with the possible exception of *Nephrops* ground. In fine sediment areas it is unlikely that a thick layer of sediment will be deposited over one localised area, and if this did occur the impact is tightly constrained, and the habitat is widely represented both locally and further afield in the Clyde. The effect of smothering on benthic communities is assessed as **Not Significant.**

6.1.3 Suspended sediment dispersion and deposition

As with the effects above, due to the adaptation of benthic communities in this region to mobile sediments and sand scour, additional sediment deposition from cable laying is unlikely to have an adverse or notable impact.

Trenching (jetting or chain cutting) techniques and pre-sweeping of sandwaves will cause a greater level of sediment suspension compared to the use of ploughing equipment. Elevated concentrations of suspended sediments are commonplace in shallower higher energy environments e.g. shallow circalittoral sand biotopes, especially during and following storm events. It is also noted that the Clyde *Nephrops* ground has a high suspended sediment load due to the pervasive effect of the Clyde river discharge. The residual effects on benthic communities from sediment deposition are therefore assessed as being within the range of that experienced during existing conditions and will be localised and temporary.

Circalittoral muddy sand species are capable of burrowing through sediment to feed, e.g. the bivalve *Abra alba* is capable of upwardly migrating if lightly buried by additional sediment. Most animals will be able to re-burrow or move up through the sediment within hours or days so recovery should be immediate (Budd, 2007). Larger burrowing species such as *Nephrops* are unlikely to be adversely affected by smothering by up to 5 cm of sediment (Sabatini and Hill, 2008).

Finer particles will be swept by tidal currents further from the disturbed area, and may affect sessile filter feeders, such as sea pens. Therefore, indirect effects could extend beyond the ~10m installation corridor. A moderate increase in suspended sediment is likely to increase food availability for suspension feeders, while a significant increase may block filter feeding apparatus (Tyler-Walters, 2009) which would incur an energetic cost to clear/self-clean. However, most filter feeders are expected to recover rapidly.

The effects on benthic communities as a result of temporarily increased levels of suspended sediment dispersion and deposition are assessed as **Not Significant**.

6.1.4 ***Smothering from rock installation or mattress berms***

The proposed cable route will be largely buried to a depth of 1m. In areas of very mobile sediment, or where mixed hard substrata has made burial impossible, some rock dumping will be employed to protect the exposed cable. Sessile/limited mobility benthic species will face mortality due to rock and mattress placement. Rocks or mattresses are likely to be rapidly colonised by sessile epifauna such as hydroids, bryozoans and soft corals, along with accompanying motile epifauna such as crustaceans and echinoderms. As such, this will represent an increase in local diversity and abundance, particularly in areas of lower diversity, such as mobile sands. The effect has therefore been assessed as **Minor Adverse**. Minor Adverse effects are assessed as **Not Significant**.

6.2 Operation

6.2.1 Introduction of new substrate (cable, and rock or mattress berms)

The vast majority of benthic species inhabit the topmost 30cm of sediment. As the cable will be buried to 1m, fauna that re-colonise sediment above the cable are unlikely to be denied suitable habitat as a result of presence of the cable.

The use of rock dumping or mattressing to protect the cable in areas where 1m burial is unachievable, will introduce new hard substratum into what is an otherwise predominantly sedimentary environment. It is expected that within a short period of time the natural colonisation of the rock by marine organisms will commence and this may lead to the introduction of hard substrate communities that were previously absent. This will increase local diversity and the effect is therefore considered to be **Not Significant**.

6.2.2 Electro magnetic fields / Induced Electric Fields

EMFs will only affect magnetically sensitive mobile macro-invertebrates (e.g. lobsters, *Nephrops*) where the magnetic field exceeds the natural geomagnetic field within 4m of the cable. For most of the route the cables will be buried at 1m depth, so the magnetic field anomaly will only occur at a 3m radius of the cable line. As such, any impacts are very localised (CMACS, 2014a). However, the knock-on effects from the impact of EMFs on benthic and demersal fish (including elasmobranchs, eels and lamprey) are currently unknown. Due to the lack of direct impact on the bulk of benthic fauna, the effects on benthic communities from electromagnetic fields and induced electric fields are assessed as **Not Significant**.

6.2.3 Thermal radiation

Heat generated by the cables will be rapidly dissipated by the surrounding water column with the only organisms likely to experience heating being infauna or those burrowing into surrounding sediments or dwelling in the interstices of rock armouring. The deepest burrowing organisms likely to be present (such as *Nephrops norvegicus* and *Mya arenaria*) are expected to burrow to around 0.5m depth and could come within approximately 0.5m of the cable if it is buried to 1m. There is potential for very localised heating effects within tens of centimetres of the cables, however the vast majority of infauna are restricted to upper sediments less than 20cm deep where heating effects here are not expected to exceed a rise of 2°C when the cable is buried to at least 1m (OSPAR, 2009). An assessment of potential thermal radiation effects on marine fauna did not identify any organism that would be sensitive to such small increases in temperature (CMACS, 2011, 2014b). However, for species near the edge of their biogeographical ranges, this may result in the localised area immediately surrounding the cable (within 1m of the cable) becoming unsuitable habitat.

The effects on benthic communities as a result of heating are therefore assessed as **Not Significant**.

7. SUMMARY

The majority of the seabed along the cable routes is sedimentary, with a dominance of mobile, coarse sediments frequently forming bedforms such as megaripples. Patches of cobble and small boulders are also frequently encountered, often mixed between coarse sands and shell hash. To better characterise the biotopes within sedimentary areas, and ensure that these do not include Priority Marine Feature biotopes, infaunal data are required as gathered from grab samples. However, it is considered unlikely that biotopes of conservation importance are present due to the high sediment mobility along much of the proposed cable routes.

Two Annex I habitat types, stony reef and bedrock reef, were found within the survey area. Areas of potential stony reef were found in the central section of the cable route, but due to sand scour and sediment mobility the epifaunal cover here is diminished, and typical of scour tolerant assemblages. In some of these areas the squat lobster *Munida rugosa* was observed. Stony reef was also found adjacent to Islandmagee, where increased epifaunal diversity is noted, especially in shallower areas, from nearby Seasearch diver biotope data. A small area of shore-fringing bedrock reef was found on the Scottish side. Due to the lack of video or diver information within this area epifaunal communities and significance could not be assessed, although the adjacent Phase 1 intertidal survey at the landfall site did identify one common infralittoral rock biotope not listed as a Priority Marine Feature. Further underwater video surveys are recommended for both of these infralittoral sites.

Areas of densely packed burrows of *Nephrops* were observed in the muddy sediment sections to the east of the proposed routes; in some subsets of these areas notable numbers of the sea pen *Pennatula phosphorea* were observed. This habitat is a Scottish Priority Marine Feature.

Potential effects during installation are: the direct loss of benthic species and habitat; smothering from displaced sediment; impacts from suspended sediment dispersion and deposition; and smothering from rock installation or mattress berms. Potential effects during operation are: habitat change due to introduction of new substrate; impacts to benthic species from cable electromagnetic fields and thermal radiation (heating of surrounding sediment and interstitial water).
With the implementation of measures to mitigate these effects, including minimisation of the marine cable installation footprint, cable burial and micro-routing to avoid the best examples of potential Annex I reef habitat, all of the potential effects identified have been assessed as not significant.

A summary description of the assignment of sensitivity and magnitude and assessment of significance is provided below in Table 7 (Annex I).

8. REFERENCES

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ANNEX I

TABLE 7: DESCRIPTION OF ENVIRONMENTAL APPRAISAL										
Description of Receptor		**Description of Potential Effect**					**Description of Residual Effect**			
Receptor	**Sensitivity**	**Effect**	**Nature of Effect**	**Duration**	**Effect Magnitude**	**Potential Significance**	**Summary of Mitigation**	**Residual Effect**	**Residual Significance**	**Significant**
Benthic habitat and species (general)	Low	Direct disturbance to benthic species and habitat	Adverse	Temporary	Negligible	None	Any deployment of equipment or vessels onto the seabed (e.g. anchors of cable-lay vessels) will be kept to a minimum.	Recoverability in mobile coarse sediments (sands with shell hash and mobile cobbles) would be expected to be very high on return to undisturbed conditions as displaced fauna would re-enter the sand. In finer sediments any burrowing megafauna, such as *Nephrops*, that survive intact are likely to commence burrowing immediately with burrows being re-established within 2 days (Marrs *et al.*, 1998). The impact on sea pens will be localised and recolonisation is likely in undisturbed areas (where there is no trawling). In general individuals which are displaced but undamaged will be able to re-establish themselves and due to the highly fecund nature of the majority of species will be able to rapidly re-colonise disturbed habitats. The majority of habitats encountered along the cable route are softer sand, mud or mixed sediments, and in these areas re-colonisation is expected to begin almost immediately after cable installation	None	Not Significant
Stony reef	High	Direct disturbance to benthic species and habitat	Adverse	Temporary	Medium	Moderate	The stony reef Annex I habitats of moderate to high reefiness, with the best examples being close to landfall on the Islandmagee peninsula (further investigation of the shallow subtidal stony reef area is necessary to establish epifaunal community composition), could have impacts minimised by cable micro-routing to avoid best examples of reef communities.	The dominant species present in the cobble/small boulder reefs, including calcareous tube worms, encrusting bryozoans and erect hydroids and bryozoans are rapid colonizers, capable of rapid growth and early reproduction (Tyler-Walters, 2009). The majority of the epifauna is likely to be subject to significant physical disturbance and scour during winter storms, and from prevailing tidal regime/sediment movement and probably develops annually, through re-colonisation from any surviving individuals and from adjacent habitats. Any impacts to stony reef will be very localised: micro-routing to avoid best examples of this habitat should minimise impact.	Minor	Not Significant

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Receptor	Sensitivity	Effect	Nature of Effect	Duration	Effect Magnitude	Potential Significance	Summary of Mitigation	Residual Effect	Residual Significance	Significant
Bedrock reef	High	Direct disturbance to benthic species and habitat	Adverse	Temporary	Medium	Moderate	A small area of infralittoral bedrock reef is found adjacent to the Scottish landfall. The RPS (2014) Phase 1 intertidal survey noted the infralittoral biotope IR.MIR.KT.XKTX which is not a Scottish Priority Marine Features biotope. Further survey of this subtidal region by diver or underwater video is necessary to enable micro-routing of cables to reduce impacts on any habitats identified of conservation importance.	The bedrock reef is in a more sheltered area although still subject to moderate environmental energy. Further survey is required to fully ascertain residual effect in this area, but as impact will be very localised and the shore fringing reef is extensive, the residual effect is likely to be minor.	Minor	Not Significant
Benthic habitat and species	Low	Smothering from displaced sediment	Adverse	Temporary	Negligible	None	None proposed	Many of the benthic species including crustaceans, bivalves and infaunal polychaetes will be able to re-burrow or move up through sediment if lightly buried and recruitment will also occur from adjacent areas	None	Not Significant
Benthic habitat and species	Low	Suspended sediment dispersion and deposition	Adverse	Temporary	Negligible	None	No specific mitigation measures are proposed to reduce potential levels of suspended sediment, which will be influenced by the choice of trenching equipment and sediment type.	Benthic organisms present along much of the proposed cable route are well adapted to mobilised sediment and rapidly changing suspended sediment levels, as is evident from the mobile bedforms and the high suspended sediment observed over the Clyde *Nephrops* ground. Effects on benthic communities from sediment deposition are thus assessed as being within the range of that experienced during existing conditions and will be localised and temporary. In muddy sediments most animals will be able to re-burrow or move up through the sediment within hours or days so recovery should be near immediate (Marrs *et al.*, 1998). Larger species such as *Nephrops* which live in burrows are unlikely to be adversely affected by smothering by up to 5 cm of sediment (Sabatini and Hill, 2008). Filter feeders are expected to recover rapidly, through self cleaning. Where any localised losses are incurred as a result of increased suspended sediment deposition, recolonisation from adjacent areas is likely to be rapid.	None	Not Significant

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Receptor	Sensitivity	Effect	Nature of Effect	Duration	Effect Magnitude	Potential Significance	Summary of Mitigation	Residual Effect	Residual Significance	Significant
Benthic habitat and species	Low	Smothering from rock installation or mattress berms	Adverse	Temporary	Medium	Minor	None proposed	Rocks or mattresses are likely to be rapidly colonised by sessile epifuanal organisms such as tube worms, hydroids, bryozoans and anemones, along with accompanying motile epifauna such as crustaceans and echinoderms. As such, this will represent an increase in local diversity and abundance, particularly in areas of lower diversity, such as mobile sands. Loss of small areas of sediment habitat as a results of “rock dumps” represent a tiny proportion of the habitat area.	Minor	Not Significant
Benthic habitat and species	Low	Reduction in habitat availability	Adverse	Permanent	Low	None	Where seabed conditions allow the cable will be buried to 1m	As the cable will be buried to 1m depth, fauna that re-colonise sediment above the cable are unlikely to be denied suitable habitat as a result of presence of the cable	None	Not Significant
Benthic habitat and species	Low	Electromagnetic fields/Induced Electric Fields	Adverse	Permanent	Negligible	None	Where seabed conditions allow, it is anticipated that the cable will be buried to 1m depth along the cable corridor and when burial is not possible rock placement be used The impacts of EMFs on fish species and the cascade of any effect (via species interactions) on the benthos requires further research. Some evidence of disturbance to magnetically sensitive mobile macro-invertebrates has been documented (CMACS, 2014a) however this would be highly localised and cannot be further mitigated.	There may be possible impairment of navigation, behavioural changes and/or physiological effects upon mobile marine macro-invertebrates. However, these would be spatially constrained to within 4m of the cable (CMACS, 2014a). The knock-on effect on the benthos from the impact to fish species’ navigation and potential changes to predation are currently unknown, but given than the benthic communities are widely found it is unlikely to be significant.	None	Not Significant
Benthic habitat and species	Low	Thermal radiation	Adverse	Permanent	Negligible	None	Where seabed conditions allow, it is anticipated that the cable will be buried along the cable corridor and when burial is not possible rock placement be used	Heating effects are not expected to result in temperature increase of more than 2°C and an assessment of potential effects on marine fauna has not identified any organisms that would be sensitive to such small increases in temperature (CMACS, 2011, 2014b).	None	Not Significant

A.2.2 - Fishing Activity Report

Fishing Activity Report

Prepared by AFBI Fisheries and Aquatic Ecosystems Branch

Document version control:

Version	Issue date	Modifier	Note	Issued to
1.0	07/08/2014	AFBI_CMC	First Draft	Intertek
1.1	12/08/2014	AFBI_CMC	Addition section 8 Diving and editing of figure references	Intertek
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1.3	**11/09/201**	**AFBI_CMC**	**Amendments**	**Intertek**

Further information

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Contents

1. Introduction

This report has been prepared by the Agri-Food and Biosciences Institute (AFBI). It examines the fisheries which are targeted along the Moyle interconnector cable route which must be taken into account when considering impacts to fisheries from the proposed installation of replacement LV return cables. Whilst this report compiles data from AFBI, Marine Scotland and the Department of Agriculture and Rural Development (DARD) it does not set out to establish any potential impacts of the development on the fisheries but provides a description of the fisheries in the area of the development based on the best available data. The data provided in this report will inform the baseline description and fisheries impact assessment in the Commercial Fisheries chapter of the Non-Statutory Environmental Report being produced by Intertek in support of the Marine Licence application.

The proposed replacement cables will be installed in a corridor between 50m to 100m south of the existing north cable, and in a corridor between 50m to 100m south of the existing south cable along the majority of the route. In near-shore areas, however, they will be installed as close as practically possible to the existing cables.

The preferred method for installation is burial of the cable to 1.5m. Rock placement will only be used where marine cable burial is not possible either at a cable or pipeline crossing or in areas of harder substratum where seabed conditions do not allow cable trenching. Predictions on areas along the route where rock protection may be required are provided Figure 1. It should be noted that these locations are based upon a preliminary review of existing information available on the seabed characteristics. Final rock protection locations will be informed by the pre-installation geophysical and geotechnical surveys. Further consultation will be undertaken with the Fishermen's Organisations and their representatives on rock protection requirements as part of on-going consultation.

The route of the existing north and south cables is outlined in Figure 1. The cable routes transect ICES areas VIa and VIIa and sub-rectangles 38E4 on the Northern Ireland side and 39E4 on the Scottish side. As fisheries effort is generally by ICES sub-rectangle it will be these two areas, 38E4 and 39E4, which will be used as the "area of interest" throughout this report.

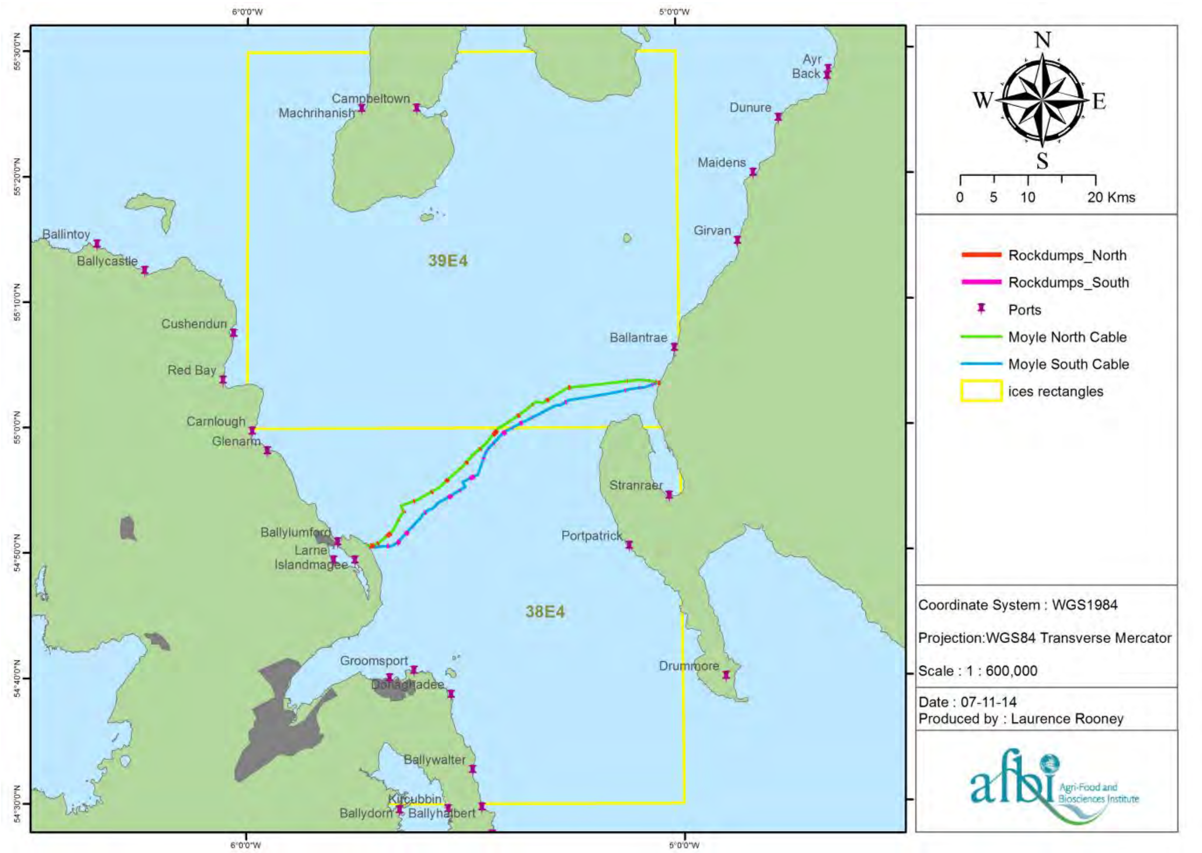

Figure 1 The area of the Moyle interconnector cable route which transects ICES sub-rectangles 38E4 and 39E4. The possible rock protection locations are indicated by the red dots running the length of the cable route.

2. Northern Ireland and Scottish Fleet

The total number of vessels (both offshore and inshore) within the Northern Ireland fleet between 2009 and 2012 averaged around 380. The total Scottish fleet is almost 6 times greater with an average of 2,130 vessels registered in the same period. In recent years there has been a move towards inshore fishing due to pressures placed on the offshore fleet. This move towards the inshore sector is characterised by the change in the structure of the fleet. For example, the Northern Ireland fleet has now become dominated by smaller vessels. In 2000 52% of the fleet was greater than 10m in length, by 2010 this had dropped to 38%, meaning that three in every five Northern Ireland fishing vessels are now less than 10m in length. In Scotland, in 2010, 69% of all fishing vessels were less than 10m in length. With this change in length there has also been a change in the structure of the ports with more fishermen fishing from smaller ports closer to their home to reduce fuel costs. This increase in effort placed inshore means that there is some form of fishing taking place along almost the entire coastline, including the areas at either end of the cable route which are important fishing grounds for several species.

3. Species Targeted

Brown crab

Cancer pagurus, commonly known as the 'brown crab' or 'edible crab', has a heavy oval reddish-brown carapace. The margin of the carapace is distinctively crimped and is sometimes referred to as a 'piecrust'. The large claws are black tipped. Typically brown crabs are around 90mm in length and 150mm in width however they can grow up to 250mm. The brown crab is thought to undergo extensive seasonal migrations associated with reproduction, with large males moving the greatest distances.

Velvet crab

Commonly known as the velvet crab, *Necora puber* has quite a flat carapace and is much smaller than *Cancer pagurus* with an average length of 50-65mm and width of 60-70mm. The dorsal surface of the crab is blue but is masked by a brown velvety texture with red prominences. The hind legs have sections which are flattened, fringed with hairs and oval in shape for swimming. This species is fast moving and can also be quite aggressive explaining the alternative name of "Devil crab". Unlike brown crab, velvet crabs are thought to remain in the same area, not undergoing migrations.

Lobster

Also known as the common lobster or European lobster, *Homarus gammarus* is a shelter seeking animal locally common around all coasts of Britain and to depths of about 50m (although they can be found deeper). *H. gammarus* are variable in length with larger specimens reaching 500mm.

Scallops

The King scallop (*Pecten maximus*) is a large, long lived bivalve which can commonly grow to 150mm or more (Ansell *et al.,* 1991). The shell is unequivalve with the right valve being convex whilst the left is flat. Both shells are externally ridged with up to 17 thick rounded ribs. Scallops recess into the substrate with the upper flat valve level with the seabed.

The Queen scallop (*Aequipecten opercularis*) is smaller than the King Scallop, growing up to 90mm in length. It also has a much shorter life span. Both shells of the Queen scallop are convex, although the left valve is more curved. The Queen scallop occurs on substrates similar to that of the King scallop but as it does not recess into the seabed it can also live on harder substrates. Queen scallops can swim much more actively than King scallops.

Nephrops norvegicus

Commonly referred to as the Dublin Bay Prawn in Ireland and Langoustine in the Mediterranean, the term *Nephrops* can be translated as 'kidney eye'. *N. norvegicus* is pale orange in colour and may grow up to 240mm long. They are entirely sublittoral living in soft sediments such as fine and silty mud, at depths of 14-800m (Briggs, 1997) and inhabit burrows, only emerging to feed or mate, usually at dawn and dusk.

4. Fishing Method

Pot fisheries

Lobsters and crabs are traditionally fished using pots or creels. Other species which can be targeted by static gear include *Nephrops*, *Palaemon* and whelks. Within the area of interest the species targeted are brown crab (*Cancer pagurus*), velvet crab (*Necora puber*) and the lobster (*Homarus gammarus*). In addition, along the Scottish coast within the area of interest there is potting for *Nephrops*.

Figure 2 shows examples of different types of pots used. In traditional style creels, the animal climbs in to the pot to feed on the bait through the entrance at the top which can either be soft or hard eyed. However the animal can get back out and therefore these pots have to be checked regularly to prevent loss of catch. Alternatively, parlour pots have two chambers which make it more difficult for the animal to get back out. These pots are traditionally used in areas where weather can prevent the fishermen getting out to the pot regularly and are used within the area of interest.

Whilst pots can be placed individually, a number of pots (averaging 10-20 pots but can be greater than 50) may be attached to a single string which is marked by a buoy at each end.

The pots are baited and placed on the seabed to soak for a number of days before being hauled.

Whilst mobile gear such as dredges and trawls can damage the sea bed, pot fishing is seen as a relatively benign form of fishing having little impact on the environment (Kinnear *et* al. 1996; Holt *et al*. 1998; Eno *et al*. 2001; Adey *et al*. 2006). Indeed, in areas where other forms of fishing have been prohibited, the use of static gear has been allowed to continue.

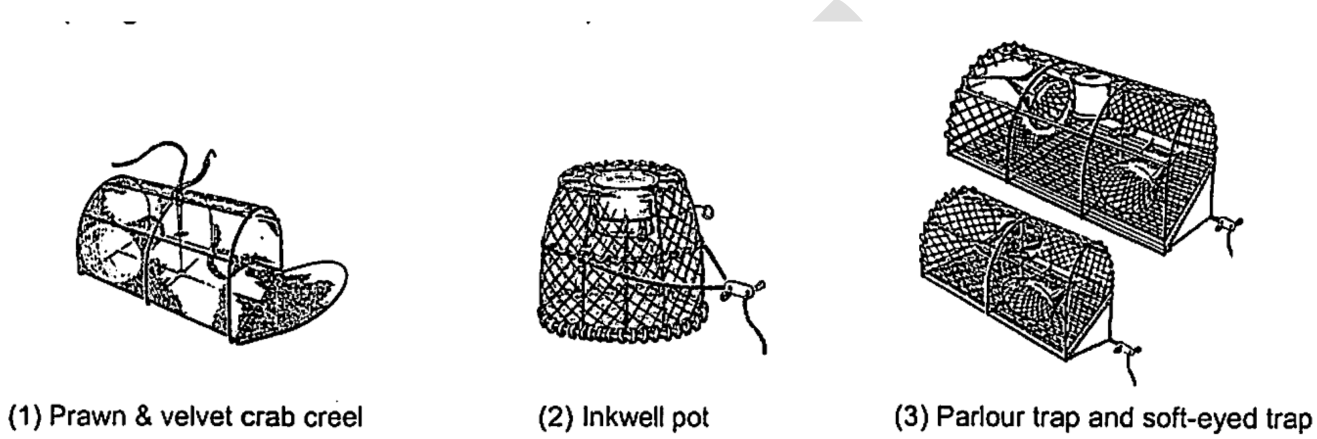

Figure 2 Diagram of the three main types of crustacean pots deployed within Britain and Ireland. Taken from Swarbrick and Arkley, (2002)

Scallop dredging

Scallops are fished using dredges with metal teeth set vertically along the front edge of the dredge (Figure 3). The teeth rake up the scallops which are caught by the mesh bag positioned behind the tooth bar. Groups of dredges are hung from a tow bar which has wheels on either end so it can move over the seabed. Typically a fishing vessel will tow a bar on each side.

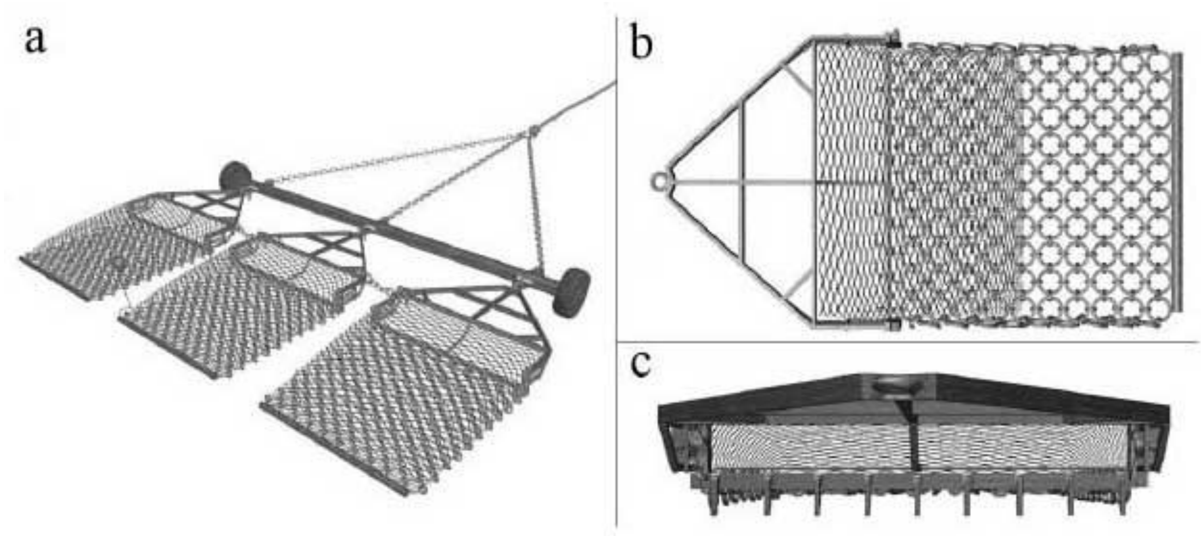

Figure 3 Commonly used scallop dredge a) three dredges attached to a tow bar b) the net bag used to catch the scallops with the associated belly rings c) the metal teeth which rake up the scallops (Source: http://www.scotland.gov.uk/Publications/2012/10/7781/4).

Trawl fisheries

Within the area of interest trawls target fin fish and *Nephrops* with the otter trawl being the primary fishing gear used. Trawling can be divided as either benthic (net towed along the seabed for species such as Nephrops), demersal (net towed just above the seabed for species such as cod and haddock) or pelagic (net towed in the water column catching species such as herring and mackerel). Trawl nets comprise of a body of net ending in a cod-end where the fish are collected. The mouth of the net must be held open and it is the method used to keep the mouth of the net open which distinguishes the type of trawl. In a beam trawl the mouth of the net is held open using a metal bean which is attached to the net at either end using metal “shoes”. The shoes act as skis helping the trawl move over the seabed and preventing it from sinking into soft bottoms. Tickler chains are attached to the bottom of the beam to disturb the fish. In an otter trawl the mouth of the net is held open using two otter boards or “doors” (figure 4). The otter boards are hydrodynamically designed so that, when towed at a certain speed, as they are pulled through the water they plane in opposite directions holding the net open (Jennings *et al.* 2001).

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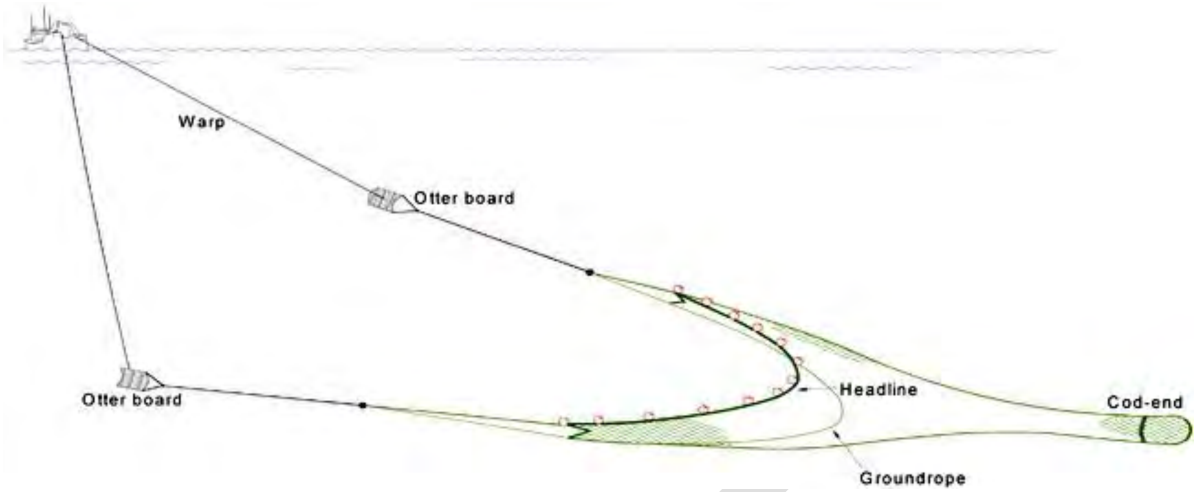

Figure 4 Layout of an otter trawl (Source: http://www.fao.org).

Diving

Scallops may be hand collected by divers and although this requires much more effort, scallops are landed in pristine condition so are more valuable. However, as divers can get to areas where vessels cannot, there are concerns that unregulated dive fishing has impacts on the stock by hand collecting from areas which have been untouched by dredges and therefore have mature scallops which may be acting as a broodstock. Harvesting scallops from a potential source of spawning undermines the sustainability of a population.

Sea Angling

Recreational sea angling (RSA) encompasses fishing from both the shore and boat using rod, line and hook. The waters around Northern Ireland and Scotland are extremely diverse, offering a wide range of fishing opportunities and species such as pollack, mackerel wrasse, sharks, skates and rays). Sea Angling websites (www.sea-angling-ireland.org and www.britishseafishing.co.uk) have highlighted a number of angling areas within the area of interest and the species that are expected to be caught in these areas. These areas have been listed in Tables 1 and 2 alongside the expected catch.

Table 1 Expected sea angling catches as highlighted by britishseafishing.co.uk for the Northern Ireland side of the area of interest.

Area	Catch
Glenarm	Plaice, coalfish, codling, dogfish, conger eels
Blackarch	Pollack, coalfish, conger eels, rock cod, Ballan wrasse, mackerel
Ballylumford Harbour	Wrasse, cod, whiting, haddock, dogfish, coalfish, Pollack, conger eel
Portmuck and Browns Bay	Pollack, wrasse, small coalfish, dogfish
Gobbins Cliffs	Wrasse, Pollack, mackerel
Blackhead Lighthouse	Ballan wrasse, dogfish, conger eel
Whitehead Promenade	Wrasse, cod, whiting, flounder, plaice, haddock, dogfish, Pollack, conger eel
Carrickfergus Harbour	Cod, whiting, flounder, haddock, dogfish, coalfish, conger eel, mullet
Bangor Pier	Large conger eel, wrasse, coalfish
Orlock Head	Mackerel, Pollack, coalfish, wrasse
Donaghadee Pier	Pollack, coalfish, wrasse, mackerel, whiting, coaly, dab, codling, rockling
Ballyhalbert Pier	Pollock, coalfish, whiting, rockling

Table 2 Expected sea angling catches as highlighted by britishseafishing.co.uk for the Scottish side of the area of interest.

Area	Catch
Rhins of Galloway	Bass, dogfish, flounder, flatfish, rays, wrasse, coalfish, conger eel
Stranraer	Rays, tope, mackerel, pollock wrasse, flounder, plaice, silver eel, scholl bass
Ardrossan	Pollock, conger eels, dogfish, wrasse, flatfish, silver eels, coalfish, pollock, cod
Saltcoats	Dogfish, wrasse, flatfish, silver eels, coalfish, pollock, cod
Largs	Dogfish, flatfish, cod, whiting
Campbeltown	Pollock, mackerel, bass, flounder, plaice, turbot, wrasse, conger eel, sea trout

5. Fisheries along the cable routes

Pots

In 2012 a total of 13,200 tonnes of crab with a first sale value of £18.6 million, and 1,100 tonnes of lobster with a first sale value of £11.7 million were landed into Scotland by vessels of five nationalities (Marine Management Organisation, 2013). The majority of fishing vessels which target crab and lobster are less than 10m in length. A vessel monitoring system (VMS) is only a requirement on vessels greater than 12m in length (greater than 15m in length prior to 2012). Therefore, it is difficult to say exactly where each vessel is fishing. In Scotland, an inshore map known as Scotmap has been prepared. Scotmap involved face-to-face interviews with fishermen who were asked details about their fishing activity including gear used and the temporal and spatial extent of their fishing. Based on these interviews maps were produced which provide information such as the effort placed on each area, using number of vessels as a proxy, for the different fisheries, and the economic value of each fishing area. The effort map (number of vessels fishing each area) produced for pot fishing is shown in Figure 5 and indicates that there is fishing activity overlapping with the cable corridors. In addition to crab and lobster, over 1,700 tonnes of *Nephrops* with a first sale value of £13.7 million were landed by pots into Scotland (Marine Management Organisation, 2013). Whilst not directly overlapping the cable routes, Figure 6 shows that pots targeting *Nephrops* are fished within the area of interest, approximately 3km North of the existing north cable.

Within the area of interest, the Marine Management Organisation reported landings into four ports within on the Scottish side of the cable routes. These ports were Ballantrae, Campbeltown, Machrihanish and Portpatrick. Figure 7 shows the landings (first sale value) by pots from these ports. In total, in 2012 the landings from pots into these four pots were worth a value of over £180,000. All the vessels landing catches from pots to these ports were less than 10m in length and therefore no VMS data is available to show the spatial extent of their fishing.

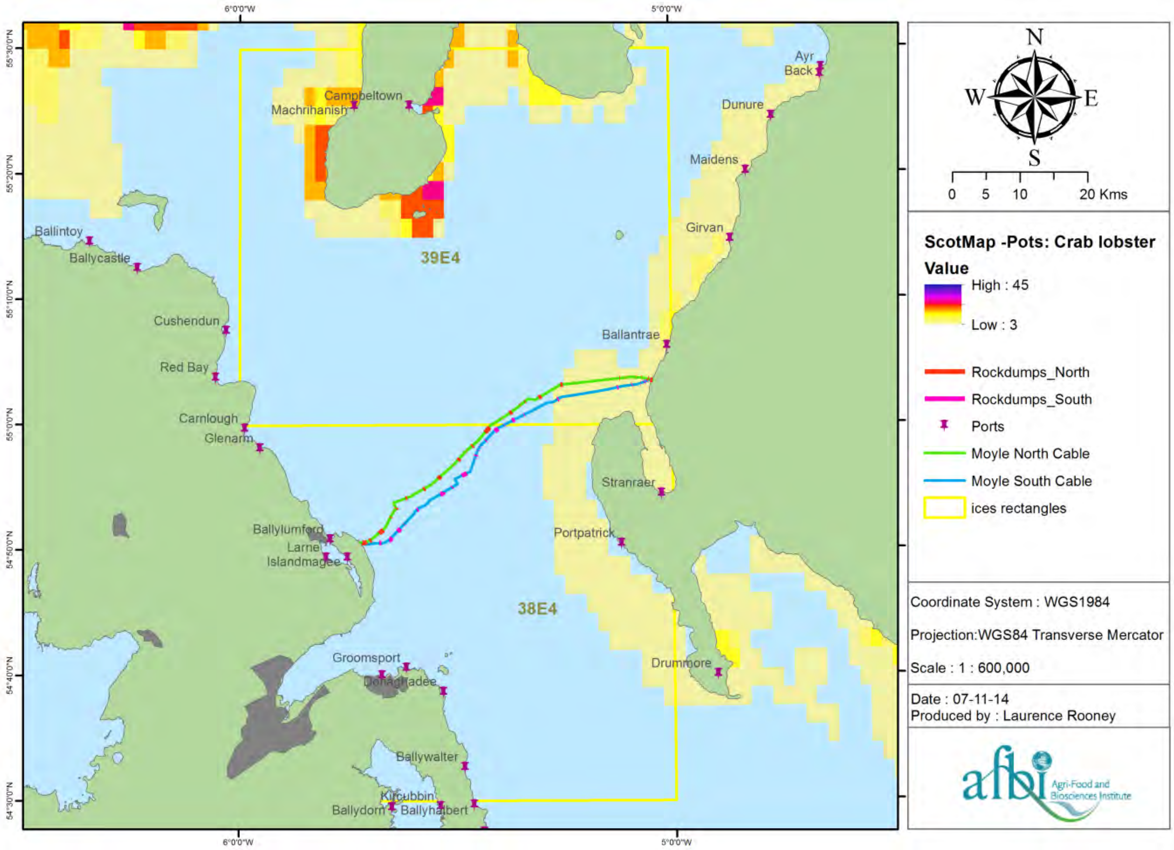

Figure 5 Scotmap showing the effort (number of vessels) of the under 15m Scottish fishing vessels fishing for crab and lobster using pots within the area of interest (Source: Kafas *et al.* 2013).

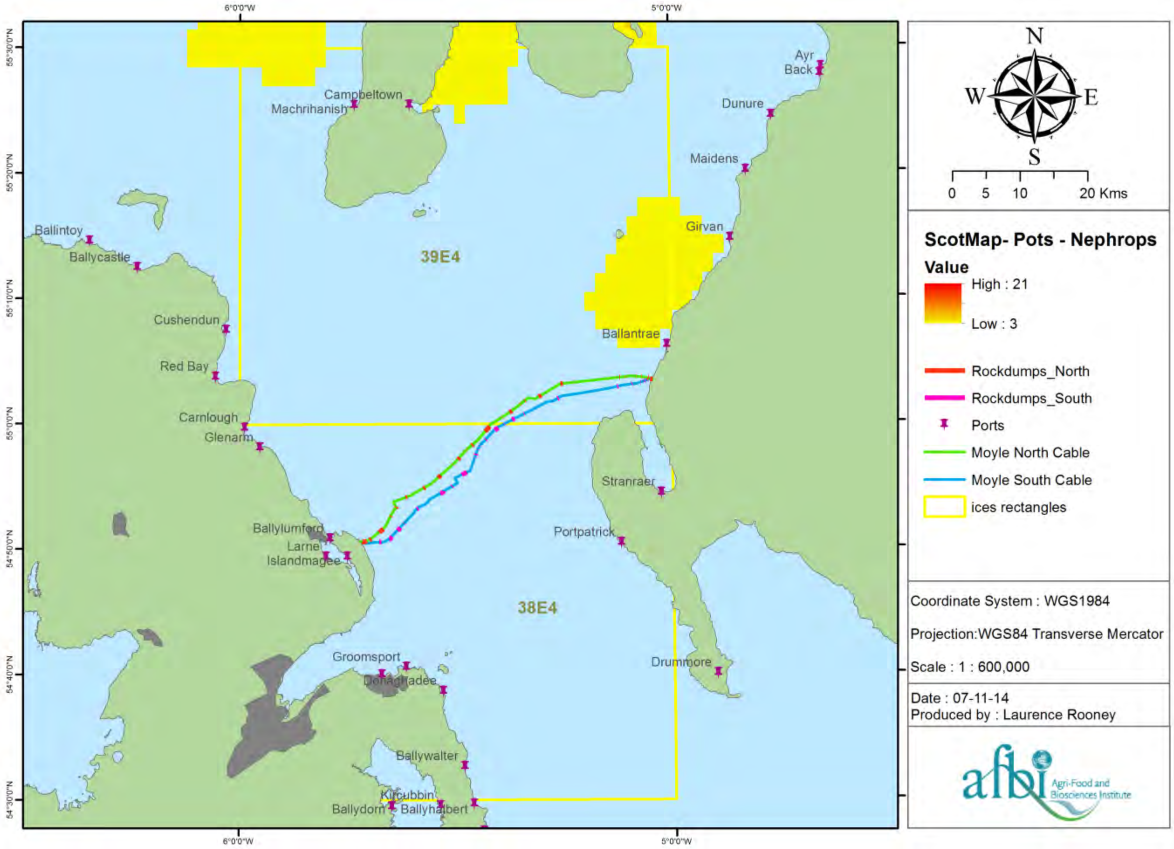

Figure 6 Scotmap showing the effort (number of vessels) of the under 15m Scottish fishing vessels fishing for *Nephrops* using pots within the area of interest (Source: Kafas *et al.* 2013).

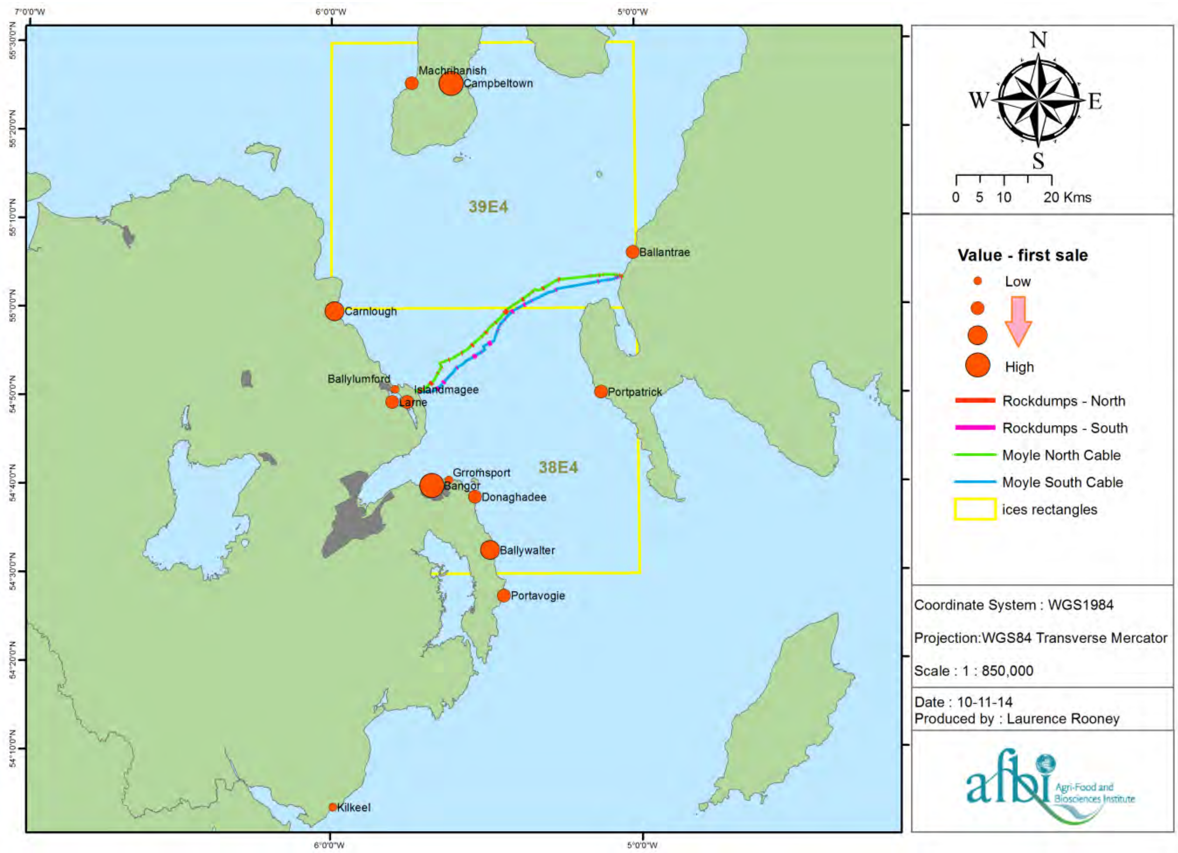

Figure 7 2012 landings (first sale value) by pots into the Scottish and Northern Ireland ports within the area of interest by both the Scottish and Northern Ireland fleet (Source: Marine Management Organisation, 2013; DARD).

In 2013, 142 vessels registered in Northern Ireland reported landings from pots worth a total first sale value of over £4 million. DARD landings figures report that 32 of these vessels fished in ICES area 38E4. These vessels landed the catch from ICES Area 38E4 into ten ports. Figure 7 shows the total landings (first sale value, £) into these ports. However, fishermen from Ballywalter do not fish as far north as the proposed cable route. It is assumed that this is also true for vessels from Portavogie and Kilkeel. The remaining seven ports had total landings from ICES Area 38E4 of £45,650 of crab and £142,300 of lobsters in 2013. Whilst these ports represent all the landings in 2013, in 2011 and 2012 landings from the area of interest were also made in to Ballyhalbert, Glenarm, Portaferry and Red Bay by an additional.

The value represented in these figures does not include money received by the fishermen as part of the v-notching scheme. Vessels fishing the area of interest may be a member of either the North Coast Lobster Fisherman's Association (NCLFA) or the North East Lobster

Co-operative (NELCO). Fishermen from both these organisations receive £6 for every berried lobster which they v-notch and return (up to a total number agreed between the association and DARD) funded through the European Fisheries Fund.

Information collected by AFBI shows that the area around the Northern Ireland end of the cable is fished for crab (velvet and brown crab) and lobster by fishermen from the local area (Figure 8). Preliminary results from the AFBI lobster tagging programme also show that lobsters in this area are rarely recaptured more than several hundred metres from where they are initially tagged. However, a tagged lobster is rarely caught during the winter months, perhaps showing a tendency for lobsters to migrate to deeper water in the winter but with a "homing" sense bringing them back to the same area when they return inshore.

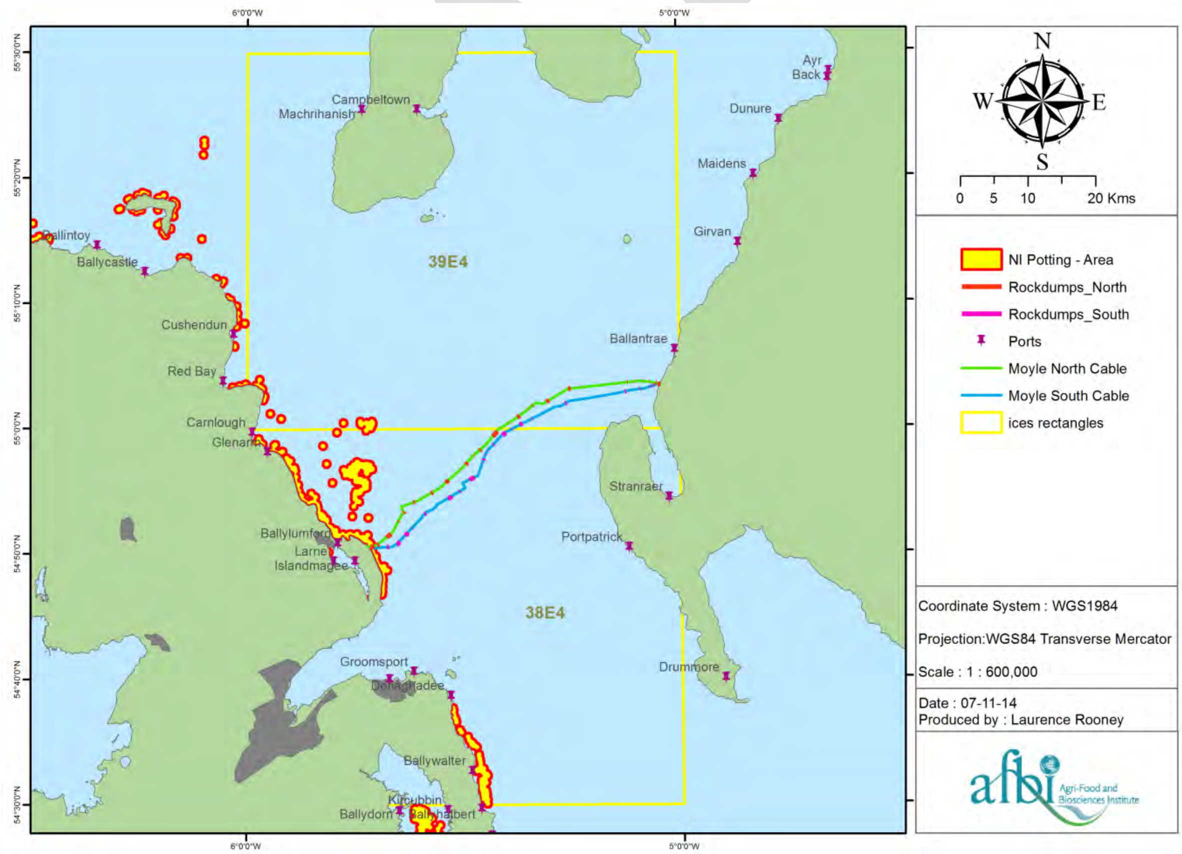

Figure 8 Data collected by AFBI shows that the Northern Ireland coastline along the area of interest if fished by pots for crab and lobster

Dredging

In 2012 a total of 17,900 tonnes of scallops with a first sale value of £23.7 million were landed into Scotland by UK vessels (Marine Management Organisation, 2013). Figure 9 below shows areas prosecuted by the under 15m Scottish vessels for scallop dredging. However, many of the vessels landing scallops into Scotland are greater than 15m. Due to the size of the vessels fishing scallops, VMS data is available (though is limited to vessels greater than 15m). Figure 10 shows the VMS data for scallop fishing within the area of interest for all UK vessels.

Within the area of interest the Marine Management Organisation reported scallops landings by UK vessels into two ports within the area of interest – Campeltown and Stranraer. Table 3 outlines scallop landings into these ports in 2012. In total almost £1.3 million of scallops was landed into the ports within the area of interest. However, with larger vessels targeting scallops, the vessels can fish within the area of interest but land to a port outwith the area.

Table 3 Landings of dredge caught scallops into Scottish ports within the area of interest (Source: Marine Management Organisation, 2013).

		Landed (tonnes)	Value (£)
Campeltown			
	Vessels < 10m in length	1.6	2,754
	Vessels > 10m in length	288	495,198
Stranraer	**(Vessels > 10m in length)**	950	777,653
Total		1,239.6	1,275,605

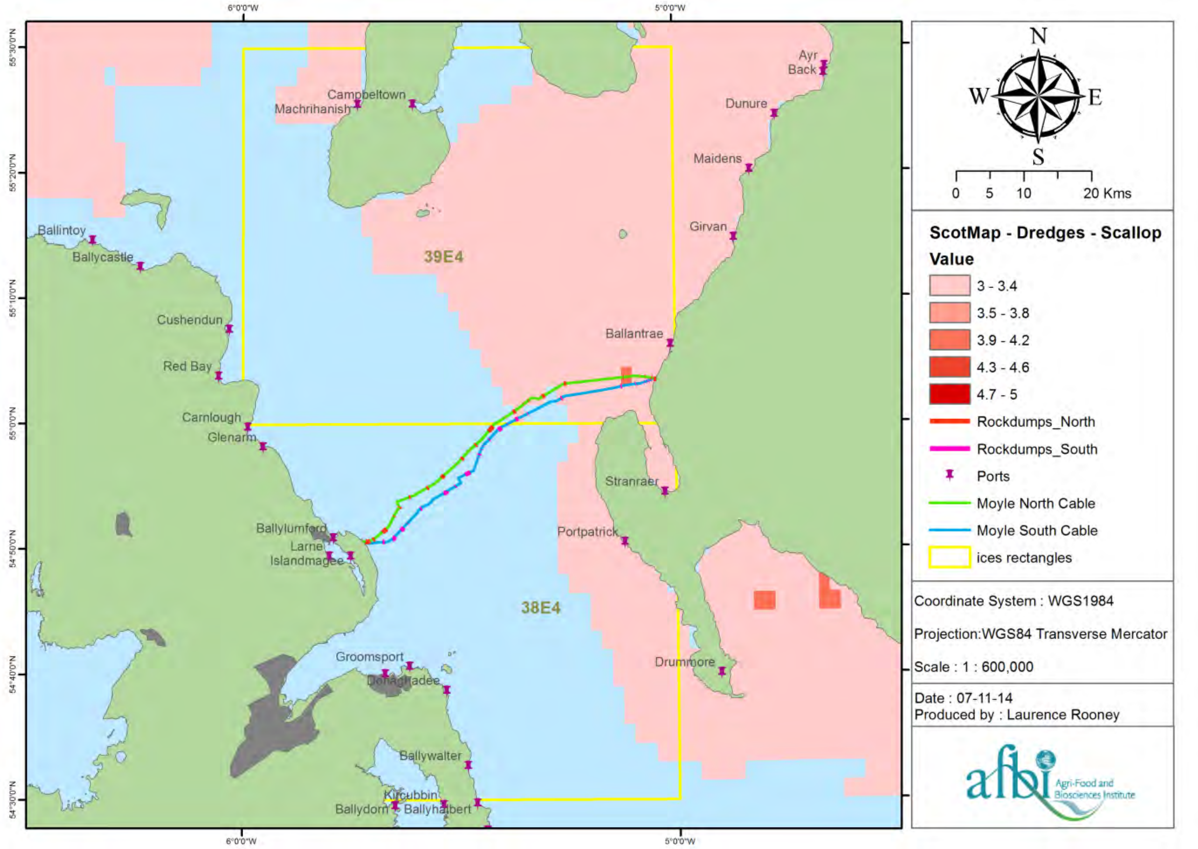

Figure 9 Scotmap showing the effort (number of vessels) of the under 15m Scottish fishing vessels fishing for scallops using dredges within the area of interest (Source: Kafas *et al*. 2013).

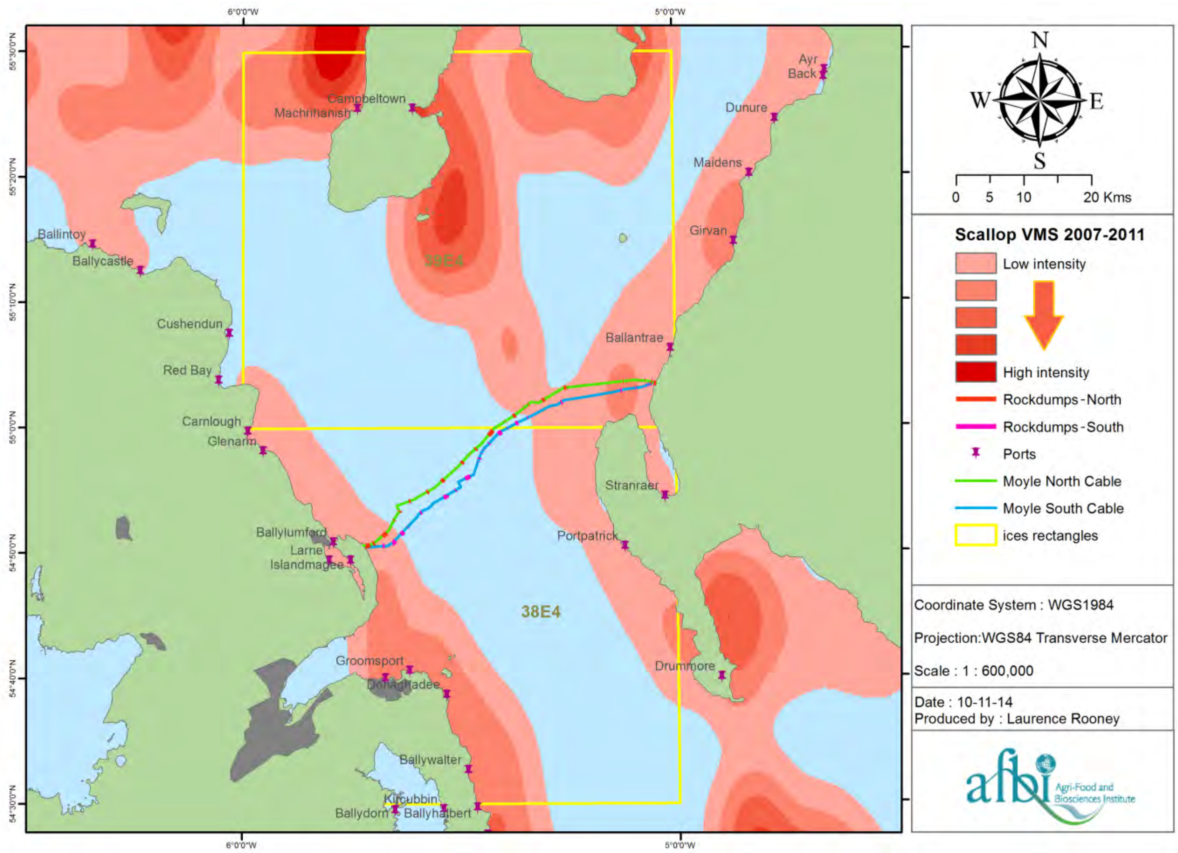

Figure 10 VMS data for all UK vessels targeting scallops by dredge within the area of interest (Source: Kafas *et al*. 2012)

In 2012 over 1,000 tonnes of King scallops was landed into Northern Ireland ports with a first sale value of £1.8 million. Within the area of interest landings of scallops were made into two ports, Bangor and Donaghadee. However, as the majority of these vessels are larger they can steam further away from their home port so landings taken from the area of interest may be landed outside the area. In addition, the majority of ports within the area of interest are fairly small and not suitable for larger vessels to land.

Between 2007 and 2013 44 vessels targeted scallops within the area of interest, landing into 16 ports. In total over 690 tonnes of scallops were fished from the area of interest with a first sale value of £1.17 million. 41% of the vessels fishing in the area of interest were greater than 12m in length. Figure 11 shows the VMS data for Northern Ireland vessels fishing within ICES area 38E4. The remaining vessels are under 15m in length and therefore not represented by VMS. In 2012 "Mapping the spatial access priorities of the Northern Irish fishing fleet" (Yates, 2012) was released. This work saw 103 fishermen interviewed to determine their priority fishing areas. The fishermen interviewed represented fishing carried out on 118 Northern Ireland registered vessels. Yates (2012) interviewed fishermen representing 22 scallop boats as to where they fish. Figure 12 shows that scallop fishermen fish along the entire coastline of the area of interest (this will include some of the fishing vessels also represented through VMS).

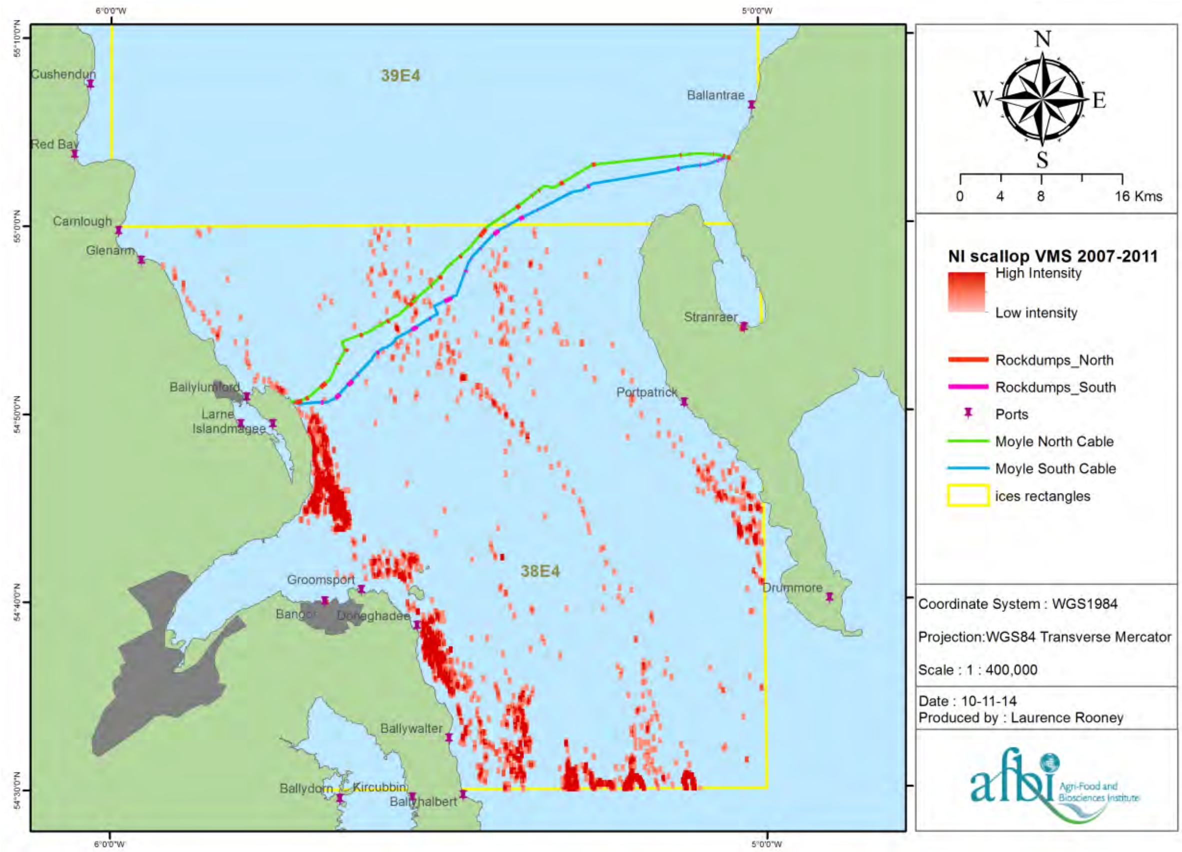

Figure 11 VMS data for Northern Ireland vessels targeting scallops by dredge within the area of interest. Data were provided by DARD for years 2007 to 2011 for all scallop fishery vessels. All data were combined and sorted in Microsoft Access. Erroneous data were filtered and removed. No speed restrictions were imposed on the data to filter specifically for fishing activity. Density analyses were undertaken in ESRI ArcGIS software and fishing intensities for the scallop fishery were derived (Source: DARD).

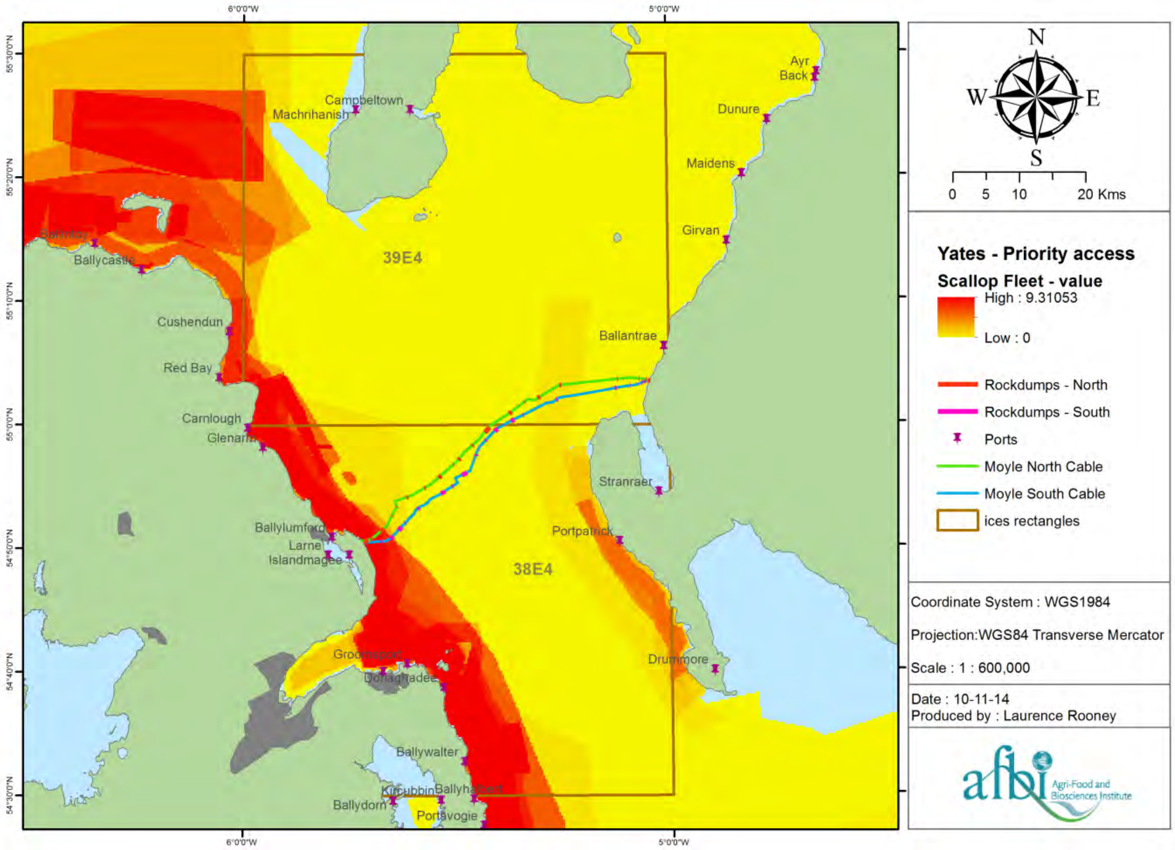

Figure 12 Map showing the priority scallop fishing grounds as selected by 22 scallop fishermen interviewed (Source: Yates, 2012)

6. Trawling - Nephrops

In 2012 over 21,000 tonnes of Nephrops were landed into Scotland with a first sale value of £82.1 million (Marine Management Organisation, 2013). Over 20,000 (92%) of the total tonnage was caught using a trawl. This catch was landed into 96 ports around Scotland (Nephrops caught in Scottish waters will also be landed into ports around the UK and elsewhere). Within the area of interest, trawl caught Nephrops were landed in to Campbeltown, and Stanraer. However, Nephrops trawlers tend to be more mobile and thus Nephrops landed to other ports may have been caught within the area of interest. Figure 13 shows the VMS activity for Nephrops within the area of interest. This figure shows that Nephrops trawling actively occurs directly over the cable route. In addition Figure 14 shows the Scotmap data collected showing the effort (number of vessels) of the under 15m Scottish fleet fishing for Nephrops using trawl gear.

Within the area of interest there is no trawling for Nephrops on the Northern Ireland side of the cable routes.

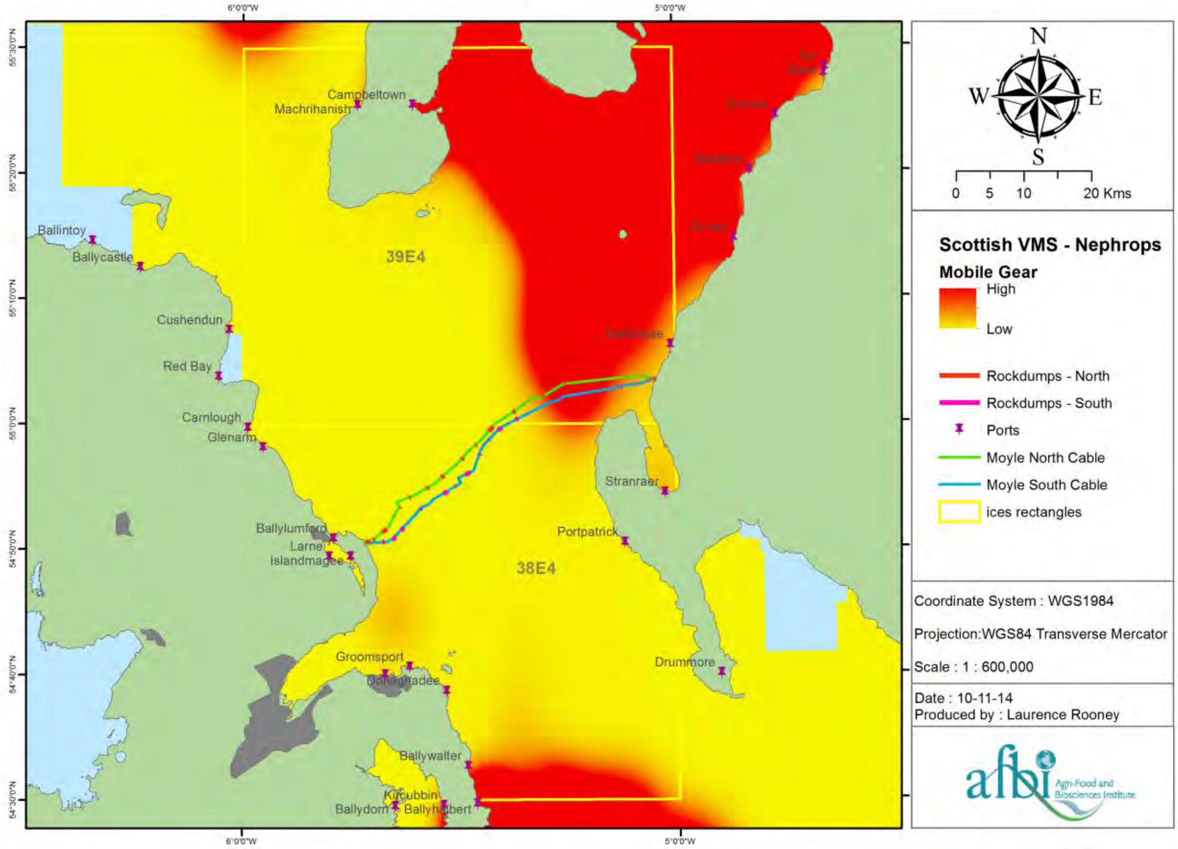

Figure 13 VMS data for all UK vessels targeting *Nephrops* by trawl within the area of interest (Source: Kafas *et al.* 2012).

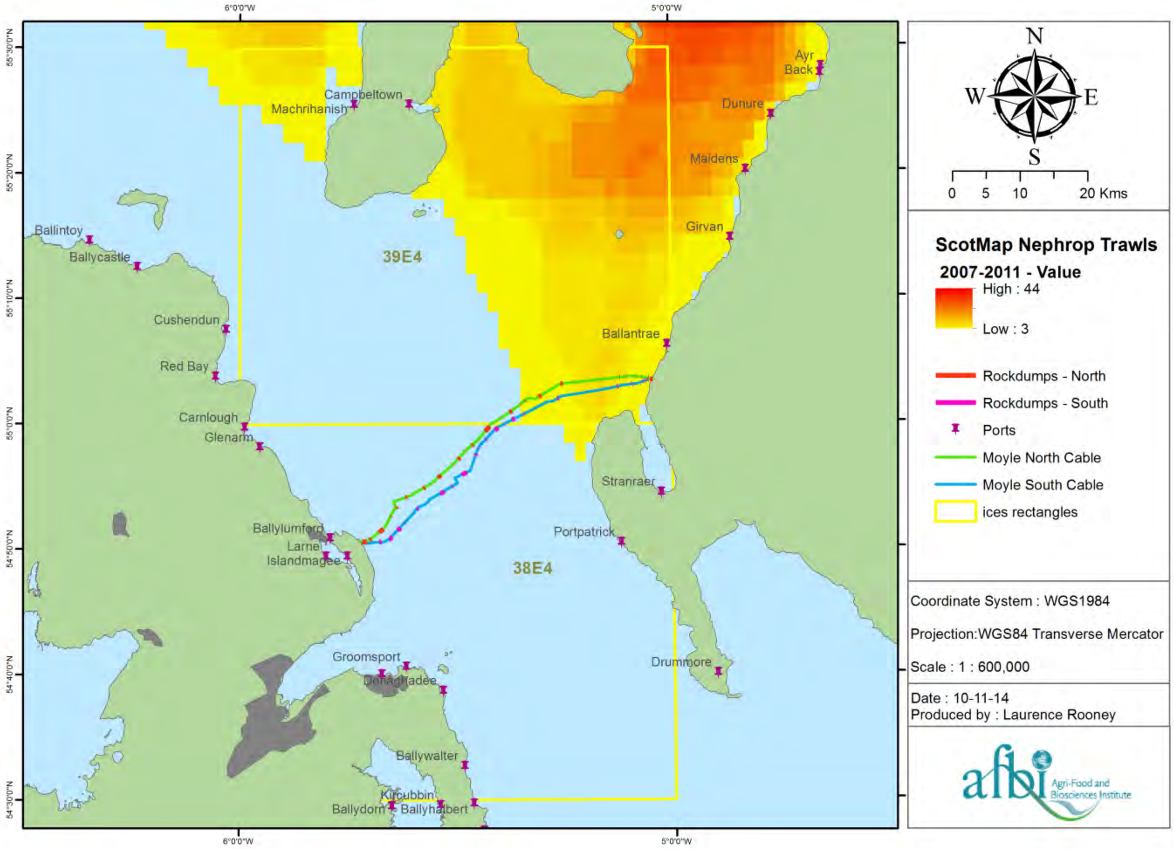

Figure 14 Scotmap data showing the effort (number of vessels) of the under 15m Scottish fleet targeting *Nephrops* using trawl gear (Kafas *et al*. 2013).

7. Demersal/Pelagic

In 2012 230,000 tonnes (live weight landings) of fish were landed into Scotland by demersal trawl/seine with a first sale value of over £230 million (Marine Management Organisation, 2013). This was landed into 55 separate Scottish ports by vessels from 10 different nationalities including Scotland. Of the five Scottish ports within the area of interest, landings by demersal trawl were landed into only Cambeltown were a total of 3.5 tonnes were landed with a first sale value of £14,000. However, with almost 90% of the landings coming from vessels greater than 10m in length demersal trawling often takes place at distances from the vessels home port.

In 2012 10,500 tonnes (live weight landings) of fish were landed into Northern Ireland by demersal trawl/seine with a first sale value of over £8.2 million. This was landed into seven Northern Ireland ports by vessels from Northern Ireland, Scotland, England and Wales. The closest landings to the cable routes were made to Bangor port.

Analysis of VMS shows that demersal fishing occurs within the area of interest and directly over the cable routes (Figures 15 and 16). The VMS data only represents vessels over 15m in length. Figure 17 shows the Scotmap indicated area for trawling by vessels under 15m.

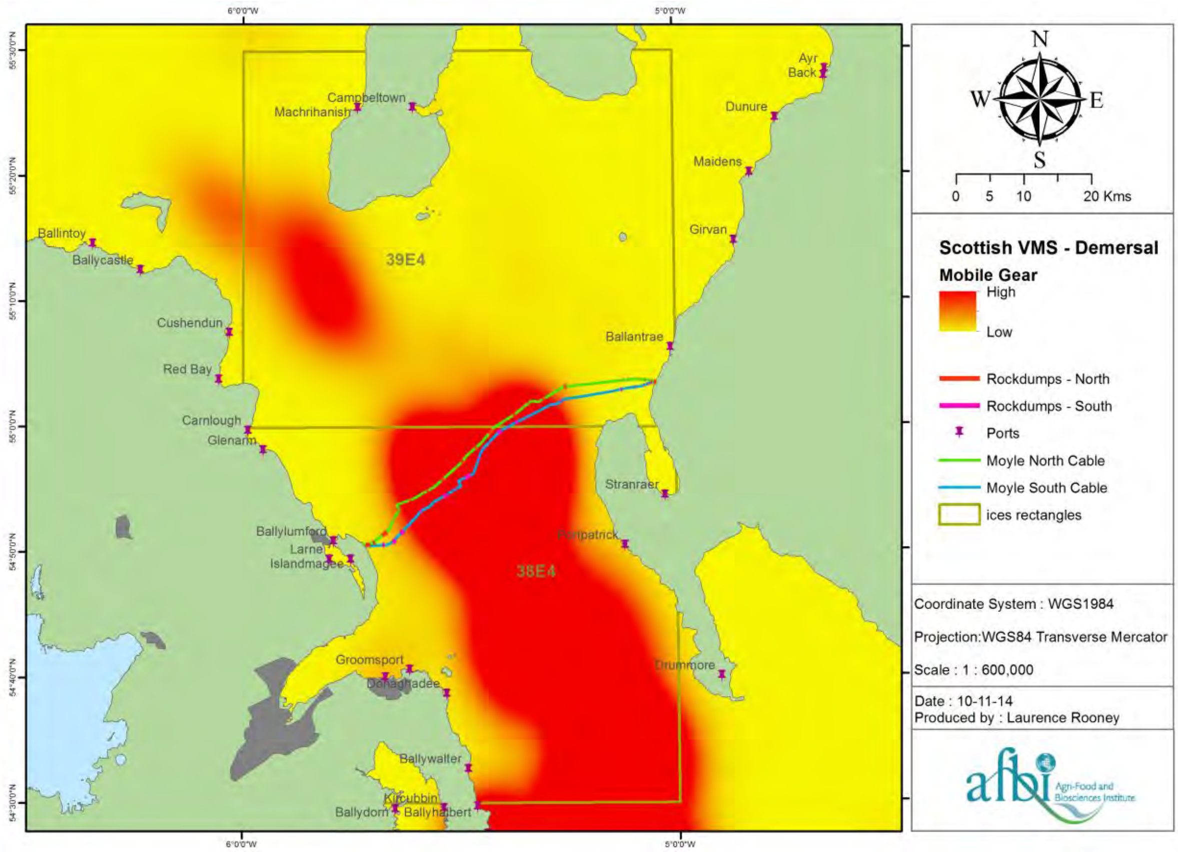

Figure 15 VMS data for all UK vessels trawling for demersal species within the area of interest (Source: Kafas *et al.* 2012).

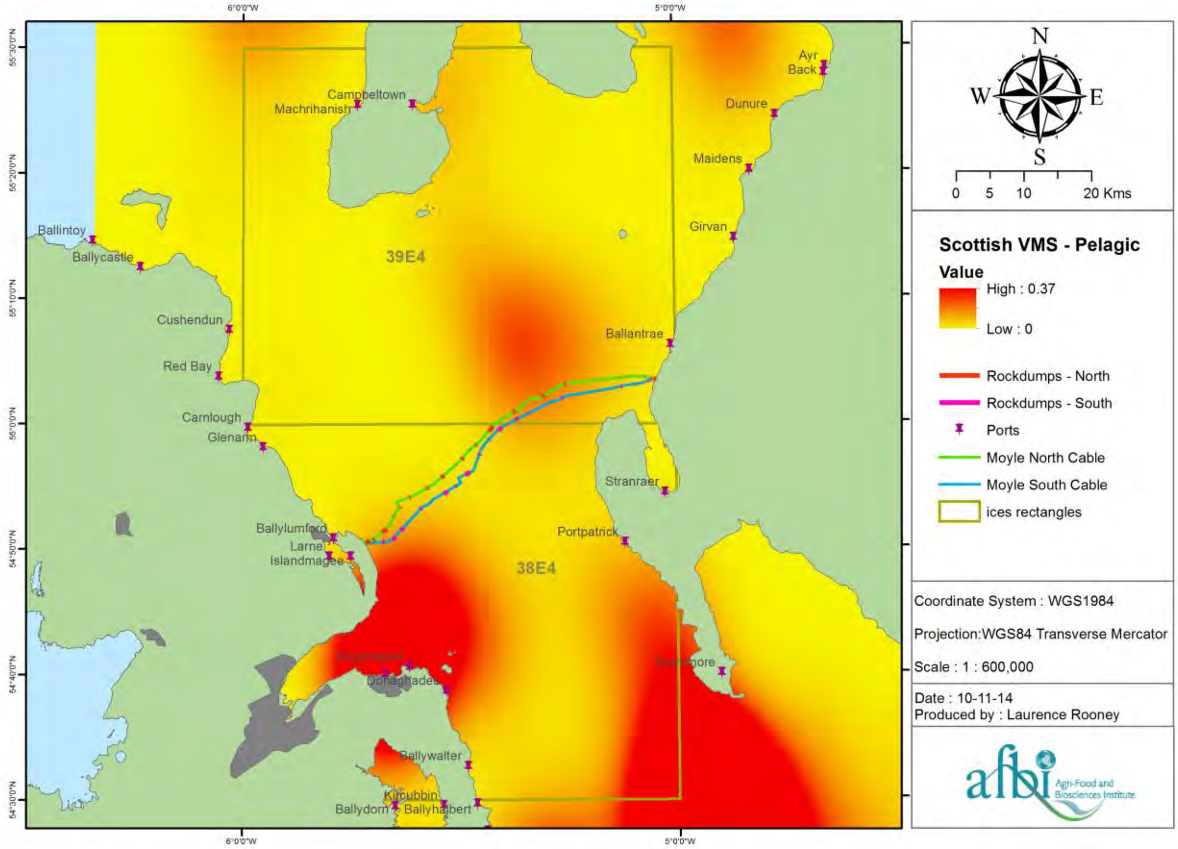

Figure 16 VMS data for all UK vessels trawling for pelagic species within the area of interest (Source: Kafas *et al*. 2012).

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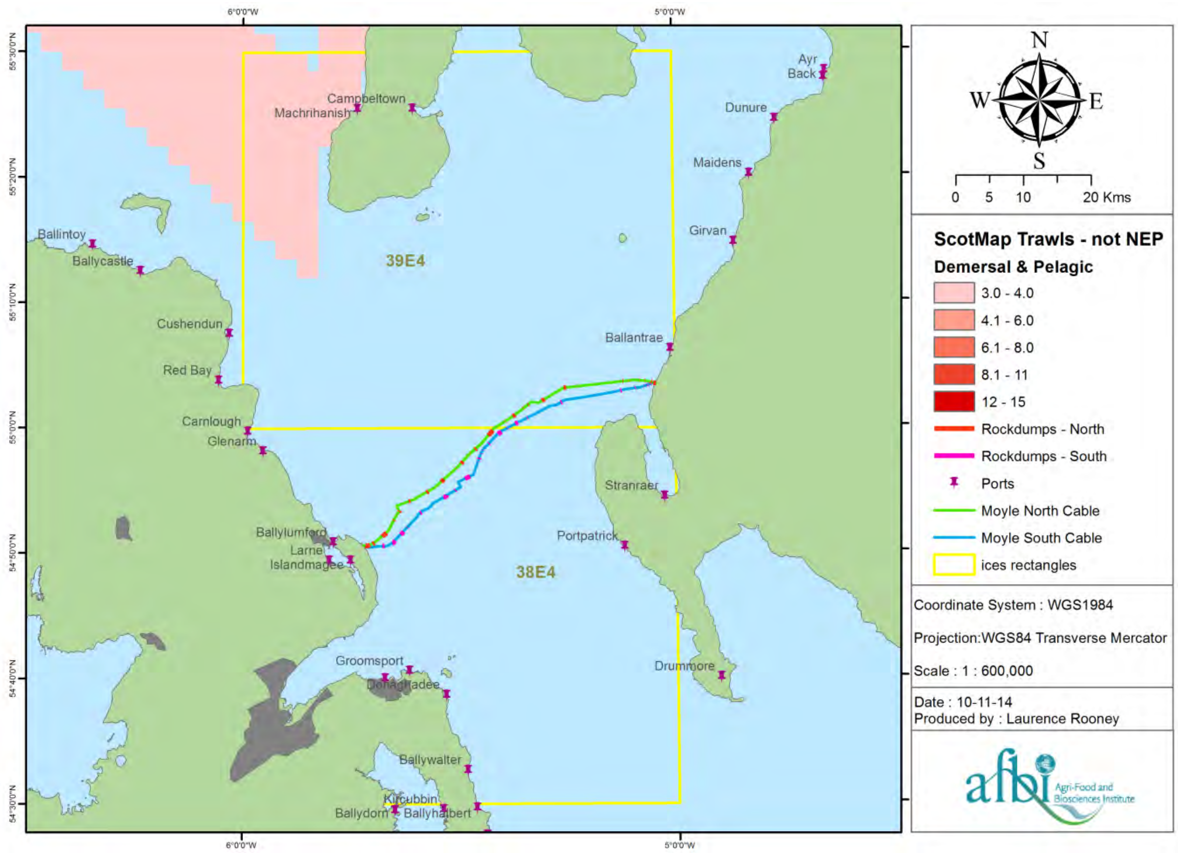

Figure 17 Scotmap data showing the effort (number of vessels) of the under 15m Scottish fleet trawling for pelagic and demersal species (Source: Kafas *et al*. 2013).

8. Diving

Diving for scallops provides a high quality high value product. Diving for scallops is common along the west coast of Scotland, with the highest effort placed around the Isle of Mull. The Scotmap which shows the spatial extent of diving for scallops (Figure 18) indicates that whilst there is a low level of diving for scallops within the area of interest, there is no direct overlap with the cable routes.

Within Northern Ireland there are no records held by DARD, landings or area targeted, on the effort placed on scallops by diving.

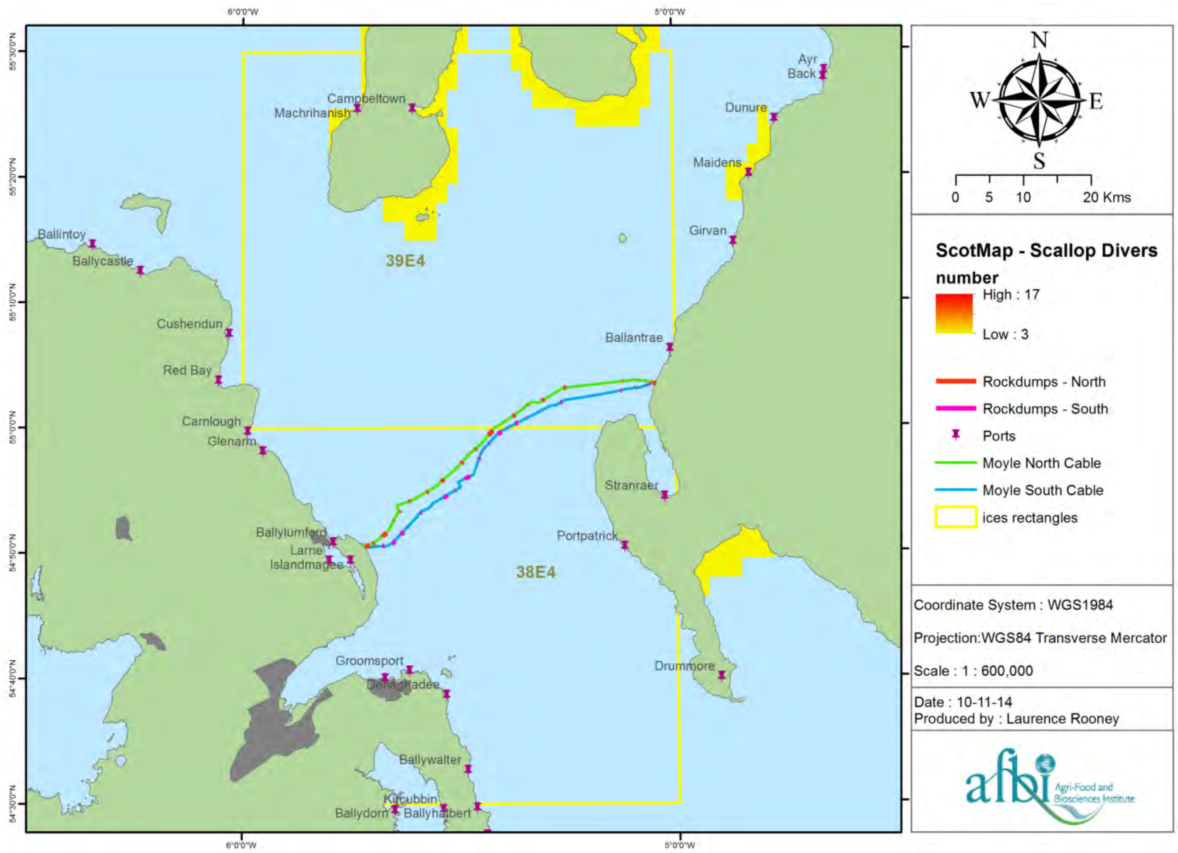

Figure 18 Scotmap data showing the effort (number of vessels) of the under15m Scottish fleet diving for scallops (Source: Kafas *et al*. 2013).

9. Conclusion

Whilst this report provides a description of the fisheries around the Moyle interconnector cables, it is based on VMS, Scotmap and landings figures from DARD and the Marine Management Organisation. There are shortfalls with using such data. Pre-2012 VMS data is only available for vessels over 15m in length and therefore excludes a large proportion of fishing vessels. This has somewhat been addressed in 2012 with legislation now requiring all vessels over 12m in length to have an onboard VMS.

For smaller vessels which do not have VMS, landings data is routinely used. However, whilst this is somewhat reliable for vessels fishing static gear, which tend to fish close to where the catch is landed, for vessels fishing mobile gear such as dredges and trawls they may fish great distances from where they land their catch. Due to these shortfalls in the information available, this report should not replace thorough consultation with the fishing sector but rather should be used as a springboard to such consultation, which should be carried out at the earliest time possible to ensure that the most up-to-date and correct information is used for all future decision making, and to avoid any negativity which might arise from lack of discussion and transparency with industry. A list, though not exhaustive, of fisheries groups which operate in the area of interest in Scotland and Northern Ireland and who should be included in any consultation is provided below.

1. Anglo-North Irish Fish Producers Organisation;
2. Ayrshire/Clyde Static Fishermen's Association;
3. Clyde Fishermen's Association;
4. Galloway Static Fishermen's Association;
5. Kintyre Waters Static Fishermen's Association;
6. Manx Fish Producers Organisation;
7. Northern Ireland Fish Producers Organisation;
8. North East Lobster Cooperative;
9. North Coast Lobster Fishermen's Association;
10. Northern Ireland Scallop Association;
11. Provincial Councils Irish Federation of Sea Angling;
12. Scallop Association;
13. Scottish Creel Fishermen's Federation;
14. Scottish Creelers and Divers
15. Scottish Fishermen's Federation;
16. Scottish Fishermen's Organisation;
17. Scottish Pelagic Fishermen's Association;
18. Scottish Sea Anglers Conservation Network;
19. Scottish White Fish Producers Organisation;
20. South West Inshore Fisheries Group

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A.2.3 – EMF Assessment Technical Report (desk based study on subtidal marine ecology)

Centre for Marine and Coastal Studies Ltd

MOYLE INTERCONNECTOR:
REPLACEMENT METALLIC RETURN CONDUCTORS

Assessment of EMF effects on sub tidal marine ecology

Client: Intertek Energy and Water Consultancy Services

REPORT STATUS: CONFIDENTIAL

Document: J3257 Moyle Interconnector EMF report v5

Version	Date	Description	Prepared by	Checked by	Approved by
1	Nov 2013	Draft	JAK	IGP	IGP
2	Dec 2013	Updated following Metoc & Screening comments	JAK	EH	-
3	Aug 2014	Revised for New LV Returns	JAK	IGP/LT	IGP
4	Oct 2014	Updated following consultee comments	JAK	IGP	IGP
5	Dec 2014	Terminology update	JAK	JAK	IGP

Executive Summary

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland. It consists of two separate High Voltage Direct Current (HVDC) cables, each rated to transfer 250MW in either direction. The system has been operational since 2002. However, since 2010 there have been four system faults (as a result of a failure in the low voltage polyethylene Integrated Return Conductor (IRC) insulation). The Interconnector is currently running at half capacity and Moyle Interconnector Ltd (MIL) is investigating options for the restoration of the Interconnector to full capacity. Intertek has been appointed by MIL to undertake an environmental assessment of the installation of replacement metallic return conductors (MRC).

This report commissioned by Intertek assesses the significance of potential impacts of electromagnetic fields predicted to be generated as a result of the installation of the replacement MRC cables upon marine organisms.

Magnetic and induced electric fields expected to be generated were calculated at increasing distances from both the existing High Voltage cables (which will remain in situ) and the two replacement MRC cable cores. These were compared with the sensitivities of marine organisms, based upon current understanding and literature review.

Potential effects of EMF impact considered included physiological effects, impairment of navigation, barrier to migration and confusion while predating. Potential impacts upon shellfish (invertebrates), teleost (bony) fish, cetaceans (whales, porpoises and dolphins) and chelonians (turtles) were assessed to be of negligible or minor significance, although uncertainty of the severity and significance of potential effects upon eels and lamprey migration was noted. Owing to their acute sensitivity to electric fields, and their use of the electrosense for wide ranging behaviours, combined with their conservation status, elasmobranchs (sharks, skates and rays) are highlighted as the most vulnerable taxa, with potential impacts assessed to be of minor to moderate significance.

Suggestions for possible monitoring are provided.

Contents

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Appendices

1. Introduction

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland. The system has been operational since 2002. However, since 2010, there have been three subsea system faults as a result of a failure in the low voltage (LV) polyethylene Integrated Return Conductor (IRC) insulation allowing water ingress (in addition to one land-based fault). The reason for failures is not confirmed. The Interconnector is currently running at half capacity and Moyle Interconnector Ltd (MIL) is investigating options for the restoration of the Interconnector to full capacity (500MW).

The preferred long-term option is the installation of two new separated (as opposed to integrated), replacement metallic return conductors (MRC) between the Northern Ireland and Scotland converter stations. The two existing HV conductors will remain *in situ* and operational as originally installed. The desired monopole circuits will therefore comprise the existing HV conductor (in the existing cable) and the replacement MRC.

The proposed MRC cables will be installed in a corridor between 50m to 100m south of the north cable, and in a corridor between 50m to 100m south of the south cable along the majority of the route. In near-shore areas, however, they will be installed as close as practically possible to the existing HV conductors (approximately 4m apart).

Each of the two existing corridors is approximately 5km long onshore in Scotland, 53km long submarine and 3km long onshore in Northern Ireland.

Finalisation of the cable routes will take into consideration environmental and technical constraints, the results of detailed surveys (if required following further review of existing seabed information) and the feedback from the consultation process. MIL intends to submit an application to MS-LOT for a Marine Licence under the Marine (Scotland) Act 2012 for the extent of the marine cable in Scottish territorial waters and under the Marine and Coastal Access Act (MCAA) 2009 for the extent of the marine cables in Northern Ireland territorial waters.

Centre for Marine and Coastal Studies Ltd (CMACS) has been contracted to provide advice on the likely environmental impacts of electromagnetic fields (EMF) generated as a result of the installation of the replacement MRC upon marine fauna. This advice will inform the environmental appraisal of the installation of the replacement cables in support the Marine Licence application.

In contrast to atmospheric emissions of EMF (e.g. terrestrial, overhead power cables, for which there are health and safety guidelines), there are no specific limits imposed on subtidal EMF generation from a marine biological perspective. However, fields of the magnitude anticipated from submarine power cabling have been demonstrated to lie within the sensitivity ranges of a variety of marine organisms (CMACS, 2003; Gill *et al.*, 2009). In view of this overlap, and given the burgeoning UK offshore renewable energy industry and the related expansion in offshore grid connections, there is concern that potential effects should be considered (Gill, 2005;

Gill & Kimber, 2005; Ohman *et al.*, 2007; Sutherland *et al.*, 2008; Gill *et al.*, 2014); especially bearing in mind that many electromagnetically sensitive species are also commercially exploited and/or of high conservation importance (e.g. salmon, thornback rays), with some having suffered severe population declines in recent decades (e.g. skates and rays: Baum *et al.*, 2003; Myers & Worm, 2003). Accordingly, regulators, key consultees and statutory advisers are keen to ensure that EMF is considered, as far as possible, during the planning, construction and operation and maintenance phases of projects requiring submarine power cabling.

Note that while NPS EN3 (DECC, 2011) advises that residual effects of EMF are not likely to be significant following burial mitigation, the document only cites information concerning a comparatively low power AC cable (Kentish Flats Offshore Wind Farm; 33kV) realistically applicable to intra-array cabling rather than export cables or Interconnectors such as those being considered here.

2. Project description

2.1. Overview

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland, stretching 63km across the North Channel of the Irish Sea between landfalls at Portmuck South, County Antrim and Currarie Port, Ayrshire (Figure 1). From the landfalls, the Interconnector then runs to converter stations at Ballycronan More in Island Magee, County Antrim and Auchencrosh in Ayrshire.

Figure 1. Moyle Interconnector Route

2.2. Cable specifications

The Interconnector consists of two separate High Voltage Direct Current (HVDC) cables (north and south cable), each with a high voltage (HV) and a low voltage (LV) conductor integrated into a co-axial design (Figure 2; Appendix 1). Both the north and south cables are rated to transfer 250MW in either direction.

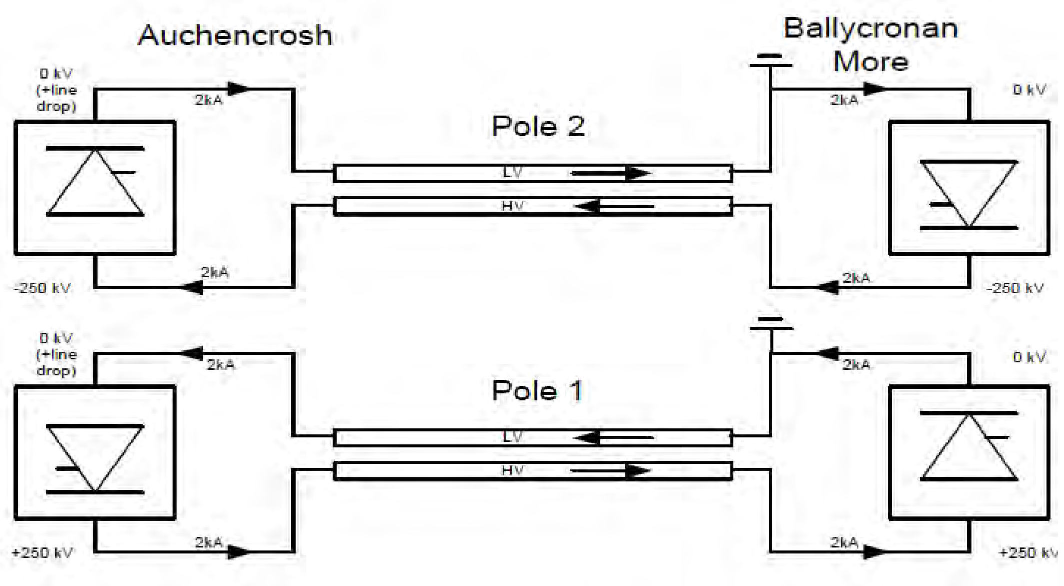

Figure 2. Moyle Interconnector general arrangement

2.3. Cable faults and repairs

The HV elements of the cables, which utilise conventional mass impregnated paper insulation, have never suffered a fault since commissioning and are expected to remain in good condition. All faults have occurred along the return, LV conductors, the initial three of which have been successfully repaired, but the most recent of which is still damaged (Table 1; Appendix 2).

Table 1. Moyle Interconnector cable fault history

Date	Location	Description	Status
09/09/10	Land-based, South cable	n/a	Repaired
26/06/11	Subsea, South cable	140m depth, partly buried & rock dumped	Repaired
24/08/11	Subsea, North cable	20m depth, buried in silt	Repaired
23/06/12	Subsea, North cable	20m depth, buried in silt	Unrepaired

There is now a lack of confidence in the LV elements of the system, which is currently running at half capacity via the south cable; any further faults along this cable would result in zero power transfer capability.

Proposals to revert to reliable maximum capacity have included:

1. A temporary change to the operational mode of the cables until delivery of Option 2. The station control would be redesigned such that full capacity could be transferred through the two HV conductors, with the currently functional south LV conductor operating as a metallic return. It is understood that this option is no longer being taken forward for consideration at this stage.

2. An enduring solution involving replacement of the integrated LV conductors by laying an additional two replacement MRC cables between 50 and 100m

away from the existing HV conductors (which would remain *in situ* and operational) for the majority of the route and 4m apart in near-shore regions.

There is also an emergency fall-back position (possible to be set up in just a few hours) using the integral HV conductors of both cables to serve the functions of one HV conductor and one LV conductor to restore half capacity.

Options 1 and 2 are expected to change EMF levels generated by the Interconnector. This document provides advice on the likely environmental impacts of such changes from Option 2 upon marine fauna, which will feed into the environmental assessment and non-statutory environmental report being produced to support the marine licence application. Changes in EMF associated with Option 2 are expected to be similar to those associated with the emergency fall-back position, and the latter is therefore not assessed separately.

2.4. Assessment methodology

MIL has commissioned separate studies of the magnetic fields anticipated as a result of the options being considered for restoration of the Moyle Interconnector to full capacity. The strength of the magnetic field expected to be generated has been calculated over a range of distances from the cable surface, primarily for the assessment of compass deviation effects on ships' compasses. A field study measuring ship's compass deviation has also been undertaken to support the magnetic field predictions by re-configuring the system at the converter stations and taking real time measurement along the cable route.

Using the modelled magnetic field levels, it was possible to estimate electric fields induced at various distances from the cable surface. These anticipated magnetic and electric field strengths were then related to the environmental sensitivities of marine species inhabiting this area of the Irish Sea.

Intertek consulted with a wide range of organisations to seek their opinion on requirements for environmental assessment through issue of a Scoping Report (Intertek, 2013). Marine Scotland (MS, Scoping Opinion dated 25 March 2014) and the Department of the Environment Northern Ireland (DOENI, Scoping Opinion dated 27 March 2013) both requested that the Developer should consider the potential ecological significance of EMF.

Species highlighted for particular focus by DOENI Marine Division were basking shark (*Cetorhinus maximus*), common or blue skate (*Dipturis batis*), white skate (*Rostroraja alba)*, angel shark (*Squatina squatina)*, porbeagle shark (*Lamna nasus*) and spiny dogfish or spurdog (*Squalus acanthias)*. Other fauna assessed include migratory species (such as salmon and eels), cetaceans and fish and shellfish in general.

Gill *et al.*, 2005 and more recently Gill *et al*., 2014 collated information on the electromagnetic sensitivity of marine organisms and summarised potential effects. Receptors that are known to be sensitive to EMF, or at least have the ability to detect them, and which are therefore considered throughout this report are as follows:

- Shellfish;
- Teleosts (bony fish);
- Elasmobranchs (sharks, skates and rays; cartilaginous fish); and,
- Marine mammals and chelonians (turtles).

Potential effects of EMF, which could lead to ecological impacts, are as follows:

- Physiological effects (e.g. impaired larval development);
- Disruption of navigation or orientation;
- Barrier to migration or movement; and,
- Impaired foraging (e.g. predators mistaking cable EMF for bioelectric fields).

The importance of each receptor was first classified, taking into account factors such as rarity, conservation status and value (the latter either within the food chain or to humans). Receptor sensitivity to electromagnetic fields was then assessed based upon current understanding and literature review, taking into account the acuteness of the sense and the behaviours the sense is utilised for. Receptor importance and sensitivity were then compared to impact magnitude and duration to estimate the significance of any potential impacts expected to be caused by EMF generated by installation of the separated, replacement MRC cables.

3. Predicted electromagnetic field generation

3.1. General

Submarine power cables generate magnetic fields due to the electric current flowing along the cables. The magnitude of the magnetic fields produced is directly dependent upon the amount of current flow. The design of the cables, including lead sheathing and armoured cores, prevents the propagation of electric (E) fields into the surrounding environment; however, these materials are permeable to magnetic (B) fields, which therefore radiate into the surrounding environment, effectively unimpeded. The B field attenuates with distance (both horizontally and vertically) from the cable conductor.

Three-core AC cables, commonly used in the offshore renewable energy industry, transmit three current flows that fluctuate between positive and negative polarity. The B fields generated by these cables are therefore constantly changing, which continuously induces varying electric (iE) fields (CMACS, 2003; Gill *et al.*, 2009).

Contrastingly, the B field generated by DC cables, such as the Moyle Interconnector existing HV and replacement MRC, is static (over short time periods assuming consistent current load) and thus varying iE fields will not be induced in the same way as by AC cables. However, harmonic currents caused by conversion between AC and DC fields at converter stations may transmit along HVDC cabling and induce iE fields. Furthermore, localised, static iE fields may be induced as seawater (tidal flow) or other conductors such as marine organisms pass through the DC cables' B fields. Owing to the dependence of iE field magnitude upon B field magnitude, iE fields will attenuate with both horizontal and vertical distance from the cable conductor.

3.2. Moyle Interconnector

Currently, electromagnetic fields generated by the Moyle Interconnector are negligible, owing to the co-axial integrated design of the two systems, whereby effectively identical B fields are generated by each of the north and south HV and LV cable cores, the opposite alignment of which leads to significant cancellation.

However, if operating with two separated MRC cables, all four cables would effectively operate as independent generators of B fields with consequent induction of iE fields when water or marine organisms pass through those B fields. For the majority of the route, the cables will be spaced 50 – 100m apart and consequently no cancellation of the opposing fields will occur. In near-shore regions (water depths of less than 22m), the replacement MRC cables will be positioned as near as practicable to the existing HV cables (approximately 4m) and therefore some cancellation of the opposing fields is expected where they overlap. The majority of this report focuses upon the more widely spaced configuration as a worst-case scenario, although assessments account for the fact that there is likely to be some cancellation of EMF in near-shore regions.

By using the equation, below, it is possible to calculate the magnitude of B fields predicted to be generated at increasing distances from each separated cable core (Table 2) at their maximum capacities of 1000A.

$$B_{field} = \frac{\mu_0 I}{2\pi r}$$

Where $\mu_0 = 4\pi \times 10^{-7}$ T.m/A, I = current (A), r = distance from conductor (m), B_{field} = Magnetic Field Intensity (T)

Using these predicted B fields, induced iE field magnitudes can then be estimated by multiplying B field by tidal flow (or marine organism velocity) (Hayley Tripp, pers. comm.[1]). Table 2 presents predicted iE fields caused by a conservative estimate of the maximum tidal flow at the seabed (0.84m/s), based upon 70% of the maximum tidal flow at the surface (1.2m/s). Whilst many complex factors can affect iE fields, including sediment and seawater conductivity (the latter of which is a function of salinity and temperature), depth, topography and width of water body, the simplified equation used is thought to provide the most useful, worst-case predictions given uncertainty surrounding many parameters and the relatively small influence they have. Note the relatively rapid attenuation of iE fields with increasing distance from the cable surfaces owing to the dependence of iE fields upon B fields.

Table 2 Electromagnetic field magnitudes predicted to be generated at increasing distance from the separated Moyle Interconnector cable cores

Distance from cable core (m)	Magnetic (B) field (µT)	Induced electric (iE) field (µV/m)*
0.058 (cable surface)	3,448	2,896
0.2	1,000	840
0.4	500	420
0.6	333	280
0.8	250	210
1.0	200	168
1.2	167	140
1.4	143	120
1.6	125	105
1.8	111	93
2.0	100	84
5.0	40	34
10.0	20	17
15.0	13	11
20.0	10	8
25.0	8	7
50.0	4	3

* Assuming maximum seabed tidal current of 0.84m/s

iE fields induced by organisms passing through the B field, rather than by tidal flow, will be dependent on the organisms' speed of movement, and whether they are moving with or against the tide. A fast moving fish swimming with a strong tide, for

[1] Hayley Tripp, National Grid, 2013

example, will induce a stronger iE field than one swimming more slowly or against the tide. It is therefore possible that electric fields induced by fast-moving organisms could be stronger than those estimated for tidal flow in Table 2, but by how much is uncertain owing to difficulties in knowing swimming speed of marine fauna.

DNV KEMA also predicted maximum harmonic currents of approximately 28A at the 12^{th} harmonic (600Hz) to be generated at minimum load, the fluctuating magnetic fields of which would be expected to induce an iE field of 1,648µV/m at the cable surface. Again, such iE fields would attenuate with distance from the cable surface. Note that the maximum iE field induced by harmonics is predicted to be of less magnitude (almost half) than that induced by maximum tidal flow. There may be additive or subtractive effects where tidally induced and harmonic EMFs overlap, but since the former are expected to be considerably stronger, they are likely to dominate. The iE fields induced by tidal current have generally been assumed to be worst-case throughout the remainder of this report, unless stated otherwise.

Normandeau *et al.* (2011)) averaged and plotted B and iE field generation predicted from a number of buried, subsea AC and DC cables of varying designs against distance from the cables (plot for DC: Figure 3). Projects incorporated in calculations included a number of wind farms, Juan de Fuca Transmission Project, Cross Sound Cable, EirGrid Irish Interconnector and Basslink Interconnector, among others. Note that the B fields predicted within a few meters of the Interconnector cables are an order of magnitude stronger than those reported (predicted) at similar distances from current offshore wind farm export cables transmitting AC (up to 18µT). The Interconnector B fields are, however more consistent with those reported (predicted) from current projects transmitting DC; i.e. slightly higher than 8 of the 9 projects utilised, but lower than the SwePol Link.

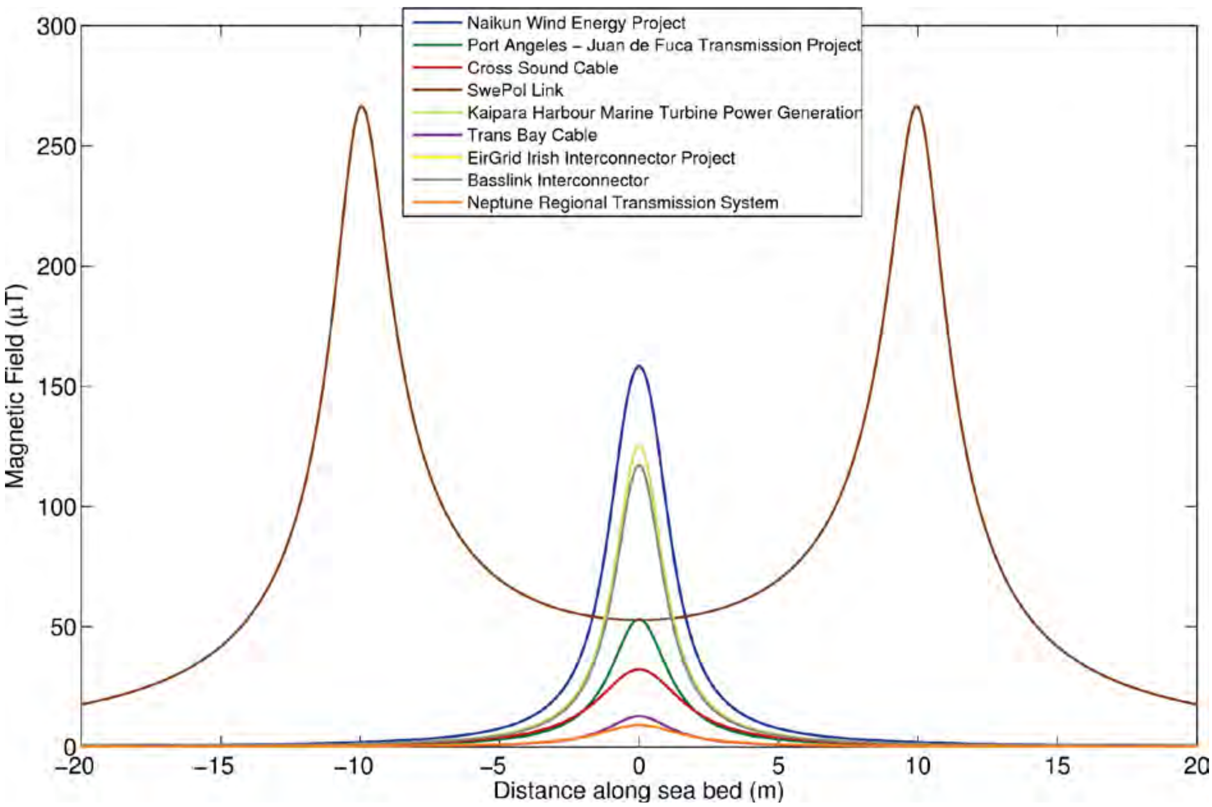

Figure 3. Average and range of DC magnetic fields calculated at seabed surface for various projects assuming 1m burial (from Normandeau *et al.*, 2011).

3.3. Cable burial

Where substrata are suitable (i.e. softer sediments), the existing Moyle Interconnector cables are buried to a target depth of 1.5m. Installation of the replacement MRC cables would be to approximately 1m depth. Surface-laying of cabling will therefore be limited to those areas where burial is not possible; at crossings with existing cables or pipelines or over ground where geology prevents penetration. Such sections will, instead, be protected by rock armour or matressing.

The further away from the seawater the cable lies, the more the field strengths will have attenuated; however, whilst B field propagation will not be diminished through the sediment any more than through water (in the absence of magnetic rocks; see Section 4.3), burial will confer benefit by reducing the maximum magnitude of EMF at the sediment-seawater interface since the very strongest fields are present on the surface of the cable (Gill *et al.*, 2005, see also Table 2). Therefore, many fauna will be prevented from approaching the strongest EMF (burrowing infauna are unlikely to reach 1m depth).

Where surface-laid cables are covered by rock armour or matresses, iE field induction by tidal flow is likely to be dampened due to the reduction in flow past the cable, and prevention of marine fauna from swimming through the strongest B fields. Equally, any organisms inhabiting interstitial spaces will not be able to move as rapidly, and the iE fields generated by their movement will also be dampened.

However, E field induction by harmonics will be unimpeded and will also occur as B fields propagate beyond the covering material.

3.4. Background fields

The background geomagnetic field in the northern Irish Sea is approximately 46 to 47µT (NOAA, 2013). By comparing this value with those in Table 2, it is evident that the B field predicted to be generated by the Moyle Interconnector will only exceed the geomagnetic field within approximately 4m of the separated cable cores.

The background electric field depends upon the tidal flow moving through the local geomagnetic field. Therefore, when the Interconnector B field attenuates to geomagnetic field levels (after approximately 4m), the iE field induced around the Interconnector by tidal flow will also attenuate to background iE field levels. iE fields induced by harmonics are expected to attenuate to below background levels at similar or shorter distances (reduced to 128 and 50µV/m at 1m for minimum and maximum load respectively). However, iE fields induced by fast-moving marine organisms may exceed the background iE field over greater distances.

Again, additive or subtractive effects may occur where tidally induced, harmonic and background EMFs overlap, depending upon cable orientation, but since tidally induced fields are expected to be considerably stronger in close proximity of the cable cores, they are expected to dominate. How, or whether, the EMF generated by the reconfigured Interconnector may be perceived by electromagnetically sensitive organisms compared to background fields is not certain. Current understanding is that whichever is more intense is likely to be more easily detected, however, owing to differences in the fields' geometries and characteristics, the two fields may be decipherable (Andrew Gill pers. com.[2]).

3.5. Magnetic anomalies

Another factor which can complicate interpretation of anthropogenic electromagnetic fields is the presence of magnetic anomalies; namely iron-bearing magnetic rocks. If the Moyle Interconnector route is compared with a map of seabed sediments in the relevant area (Figure 4), it appears the majority of sediment the cables are likely to be laid in/on will be sand and muddy sand or coarse sediment, although there are small patches of rock. Whilst the former substrata are unlikely to have significant relevance to interpretation of the effects of the Interconnector's cabling EMF, the possible presence of magnetic rocks may complicate potential interactions between marine organisms and cable EMF, although just how such anomalies would affect detection of cable EMF is uncertain.

[2] Dr Andrew Gill, Cranfield University, 2011

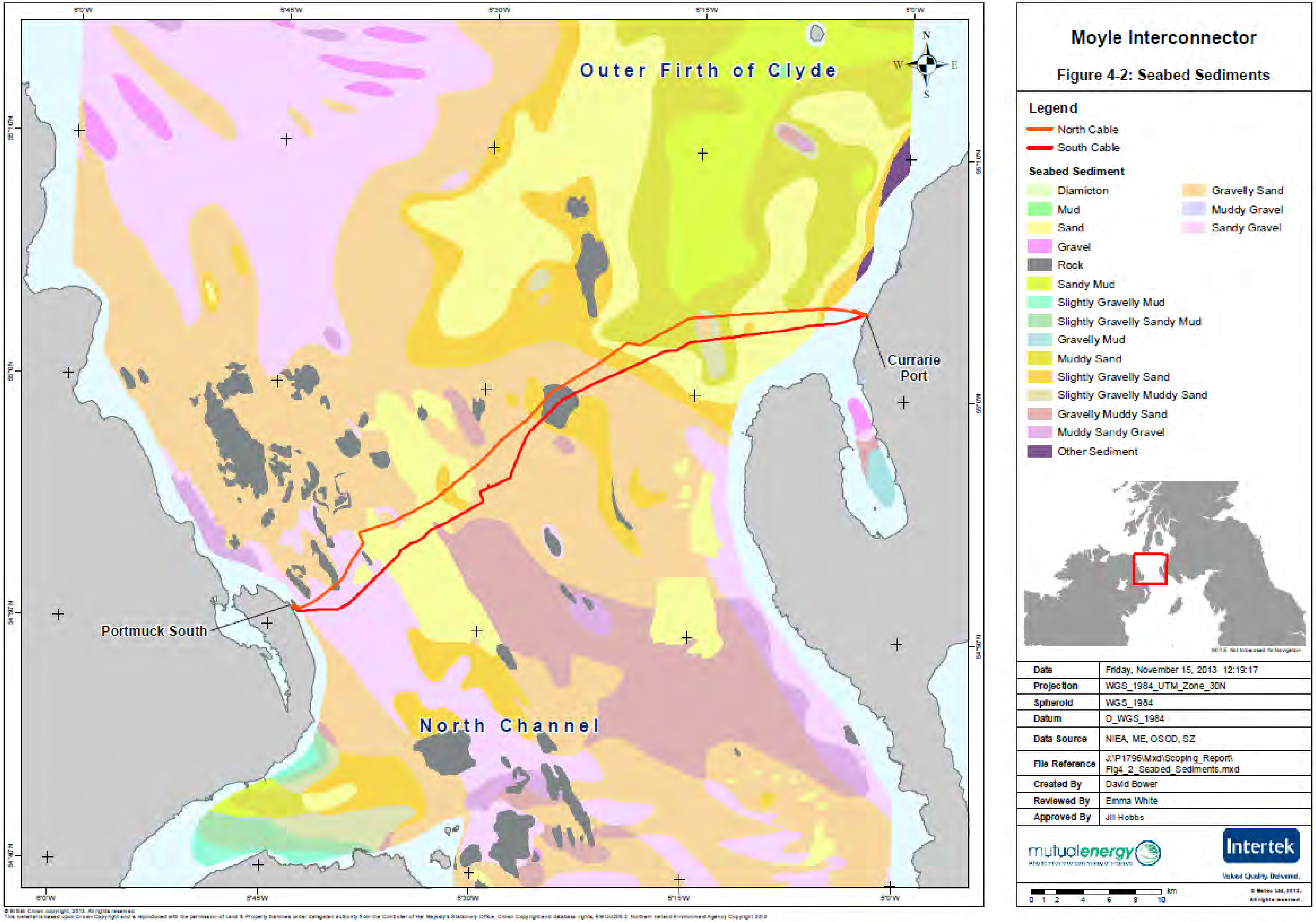

Figure 4. Seabed sediments in the North Channel, Irish Sea (reproduced from Scoping Report; Intertek, 2013)

3.6. Sea electrodes

Sea electrodes (whereby current is returned directly through seawater), which are thought to cause impacts including avoidance of strong fields at the anode, involuntary attraction to the cathode (galvanotaxis) and production of toxic substances such as chlorine and halogenated compounds at the anode via electrolysis, are not proposed to be used during cable maintenance. They are therefore not considered any further.

4. Electromagnetic field detection

A relatively large number of organisms in the marine environment are either known to be sensitive to electromagnetic fields or have the potential to detect them (Gill & Taylor, 2001; Gill *et al.*, 2005; Gill *et al*., 2014).

4.1. E field detection

The predominant electroreceptive marine organisms are elasmobranchs (sharks, skates and rays) and holocephalans (chimaeras such as ratfish), which possess specialist electroreceptive organs, ampullae of Lorenzini, that are relatively well studied and described (see Tricas & Sisneros, 2004 for review). This extremely acute sense, which is sensitive to 5 to 20nV/m (Kalmijn, 1982; Tricas & New, 1998), is used for detecting the bioelectric fields of prey, predators and conspecifics as well as for navigation.

Other species that are electrosensitive such as agnathans (jawless fishes; e.g. lampreys) do not possess specialized electroreceptors but are able to detect induced voltage gradients associated with water movement through the geomagnetic field. The actual sensory mechanism of detection is not yet properly understood but is thought they use the sense for similar behaviours as elasmobranchs (Normandeau *et al.*, 2011).

4.2. Magnetic field detection

Magnetically sensitive organisms can be categorised into two groups based on their mode of magnetic field detection: induced electric field detection; and direct magnetic field detection.

The first group relates to the electroreceptive species described in Section 4.1. These animals detect the presence of a magnetic field indirectly by detection of the electrical field induced by the movement of water through a magnetic field or by their own movement through that field. In natural scenarios induction of the electric field usually results from organisms positioning themselves in tidal currents and animals may time certain activities (e.g. foraging) by detecting diurnal cues resulting from varying tidal flows.

The second group is believed to use magnetic particles (magnetite) within their own tissues in magnetic field detection (Kirschvink, 1997). Whilst the mechanism of how these organisms detect magnetic fields is still unknown it is generally acknowledged that they are able to use magnetic cues, such as the Earth’s geomagnetic field, to orient in their environment during migration. In UK waters, such organisms include cetaceans (whales, dolphins and porpoises), chelonians (turtles), teleosts (bony fishes; e.g. salmon and eel), crustaceans (lobsters, crabs, prawns and shrimps) and molluscs (snails, bivalves and cephalopods).

5. Potential impacts of Moyle Interconnector EMF

Throughout this section, evidence of responses of marine organisms to both AC and DC fields are used to estimate sensitivities, despite the fact that the Moyle Interconnector is a DC system. This is due to the relatively small evidence base upon which assessment of potential interactions between marine fauna and anthropogenic sources of EMF must be based, and uncertainty of differences between potential effects caused by the two types of fields.

5.1. Impact magnitude and duration

The potential effects of EMF generated by the installation of the replacement MRC upon marine organisms will be continuous whenever electricity is transmitted. Therefore, any potential impacts are likely to be of **long to permanent duration** (depending upon the operational life of the repaired Interconnector).

Owing to the localised nature of potential effects due to relatively rapid attenuation of EMF with distance from cabling (see Section 3.2), the **magnitude** of the impact is considered to be **minor**.

These will be utilised in conjunction with receptor importance and sensitivity to estimate potential impact significance (Sections 5.2 to 5.5).

5.2. Shellfish

5.2.1. Importance

There are a number of commercially targeted invertebrates found within the Irish Sea including king scallop (*Pecten maximums*), queen scallop (*Chlamys opercularis*), whelk (*Buccinum undatum*), edible crab (*Cancer pagurus*), lobster (*Homarus gammarus*) and brown shrimp (*Crangon crangon*) (Ellis *et al.*, 2000) and also velvet swimming crab (*Necora puber*; Wilson, 2008). None are classified as 'rare' or 'endangered' and none are subject to non-fishery management conservation measures, although the Northern Channel is thought to be important as a nursery area for the Norway Lobster (*Nephrops norvegicus*; Coull *et al.*, 1998). Islandmagee, where the Interconnector meets the Northern Irish coast is an important area for lobster and crab stocks. There is an Oyster aquaculture bed in Loch Ryan, just south of the Interconnector landfall on the Scottish coast. Many are also important prey for animals further up the food chain such as predatory cephalopods (squid, octopus and cuttlefish), fish and marine mammals. They are therefore considered to be of **low to medium importance**.

5.2.2. iE Field Assessment

No marine invertebrates have been definitively demonstrated as being electrically sensitive (it has been suggested that certain freshwater crayfish may possess an electric sense (Patullo & Macmillan, 2007), but evidence remains lacking (Steullet *et al.*, 2007)). The iE fields expected to be induced by the Moyle Interconnector are of relatively minimal strength (compared to the fields generated by Patullo & Macmillan, 2007 using DC electrodes) and therefore unlikely to cause detrimental physiological effects to these taxa, supported by anecdotal evidence of benthic invertebrates living directly upon DC electrodes (Nielson, 1986) with no apparent effects (Walker, 2001; Swedpower, 2003). Therefore, effects of **iE fields** surrounding the reconfigured Interconnector cabling are expected to be of **negligible significance** upon these electrically insensitive and low to medium importance taxa.

5.2.3. B Field Assessment

Despite many marine invertebrates being magnetically sensitive (including crustaceans and molluscs but not echinoderms), there is little and contradicting evidence of interactions with anthropogenic sources of magnetic fields. The brown shrimp (*Crangon crangon*) has been recorded as being attracted to AC B fields of the magnitude expected around wind farms (ICES, 2003). Shore crabs (*Carcinus maenas*) have been reported to be less aggressive in the presence of an AC B field generated to match the magnitude of wind farm cabling (Everitt, 2008). There is recent evidence of subtle changes in the behaviour of Dungeness crab (*Metacarcinus magister*) (time spent buried and activity patterns), although it was suggested that additional investigation was required (Woodruff *et al.*, 2012)

Contrastingly, Bochert & Zettler (2004a)) found no effects of exposure to static B fields upon the same species, nor upon the round crab (*Rhithropanopeus harrisii*), an isopod (*Saduria entomon*) or the mussel (*Mytilus edulis*). Equally, demonstrations of B fields ranging between 1-100µT delaying embryonic development in sea urchins (Zimmermann *et al.*, 1990), and of high frequency AC EMF causing cell damage to barnacle larvae and interfering with their settlement (Leya *et al.*, 1999), contrasts with anecdotal evidence of benthic invertebrates living directly upon DC electrodes (Nielson, 1986) with no apparent effects (Walker, 2001; Swedpower, 2003). Furthermore, no neurological response to AC magnetic field strengths considerably higher than those expected directly over buried subsea cables was observed in European lobster (Ueno *et al.*, 1986).

Installation of the replacement MRC cables is predicted to generate B fields in excess of the geomagnetic field, although only to a distance of approximately 4m from the separated cable cores (and less in near-shore areas owing to cancellation associated with more closely installed cabling). Where the cabling is buried to a depth of 1m, this distance will be reduced to approximately 3m for the majority of fauna (except burrowing species such as bivalve molluscs, although even these are very unlikely to reach 1m depth). Any navigational or physiological effects are therefore expected to be limited to within very close proximity of the Interconnector. Whilst individual shellfish may be affected within these distances, population level effects are unlikely owing to the very small area of the impact zone. The oyster beds in Loch Ryan, for example, will be unaffected since they are at least approximately 9km distant.

Where the cables cannot be buried and instead surface laid and protected, invertebrates are likely to colonise any interstitial spaces and may come into direct contact with cables; they could therefore potentially be exposed to strong B fields.

Whilst some research suggests such fields may interfere with invertebrate embryonic development and larval settlement, other work suggests invertebrates are able to live directly upon operational cabling. The sheer lack of relevant research and conflicting evidence postulated in what little there is makes it difficult to confidently assess potential impacts. However, once again, the potential impact zone in question (where cables are not buried) is very small.

Owing to uncertainty within the literature, potential effects upon shellfish navigation and/or physiology caused by the Interconnector **B fields** cannot be ruled out, but are limited to within close proximity of cabling. Impacts upon these relatively **low magnetic sensitivity** and low to medium importance receptors are assessed as being of **minor significance**.

5.3. Teleost fish

5.3.1. Importance

There are many important, commercially targeted teleost fish taxa that inhabit the northern Irish Sea, including cod (*Gadus morhua*), herring (*Clupea harengus*), whiting (*Merlangius merlangus*), plaice (*Pleuronectes platessa*) and sprat (*Sprattus sprattus*) (Coull *et al.*, 1998; Parker-Humphreys, 2004) and also hake (*Merluccius merluccius*) and gurnards (Triglidae). Many such species have undergone significant population declines, predominantly owing to overfishing and are therefore listed under the biodiversity action plan (www.ukbap.org.uk) and therefore protected under the Regulations underpinning the Common Fisheries Policy. Gobies, which are widespread throughout the shallow coastal waters of the Irish Sea, are scheduled species under the Bern Convention, protected for their importance at the trophic level. Migrating species of teleost fish including salmon (*Salmo salar*), trout (*Salmo trutta*) and European eels (*Anguilla anguilla*), and also sea and river lampreys (*Petromyzon marinus* and *Lampetra fluviatilis*) are also known to be present in the area and are Annex II species[3]. Nearby salmon and trout natal rivers include the Glenarm and Lagan in Northern Ireland and the Stinchar, Girvan and Luce Water in Scotland (NB the Rivers Bladnoch, Eden, Derwent, Ehen & Dee are more distant). Lampreys are found along both the relevant Northern Irish and Scottish coastlines (although are not qualifying features of the SACs) and eels are thought to be widespread, if not numerous, throughout the Irish Sea. A number of spawning grounds and/or nursery areas are known to occur near the Interconnector landfalls (Coull *et al.*, 1998; Ellis *et al.*, 2012) including cod, whiting, saithe (*Pollachius virens*), haddock (*Melanogrammus aeglefinus*) and herring. Teleost fish are also often both important prey and predators within the marine food web. Teleost fish can therefore be considered as **medium to high importance** receptors.

[3] Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora

5.3.2. iE Field Assessment

In general, teleost fish are not believed to be electrically sensitive (except weakly electric fish, such as electric catfishes or knifefishes, but these are almost entirely tropical freshwater species). The marine Perciformes (electric stargazers, a species of which occurs off western Britain) do possess electric organs, but appear not to utilise electroreception (Bradford, 1986; Bullock *et al.*, 1983). Species such as salmon, tunas, plaice and cod have been postulated as being electrically sensitive in the past (Regnart, 1931; Rommel & McCleave, 1972; Kalmijn, 1974), but more recent reviews have cast doubt on these abilities (Bullock, 1986). Teleosts would probably only respond to strong electric fields of 6 to 15v/m or more, at which levels the fish would be repulsed (Uhlmann, 1975; Poléo *et al.*, 2001). Sturgeons (Acipenseriform fish), for example, have been shown to veer away, or slow when approaching high voltage overhead lines (110kV) passing over the water (Poddubny, 1967). One exception is the European eel (*Anguilla anguilla*), the lateral line of which has been demonstrated as being sensitive to weak electric AC and DC fields (Berge, 1979; Enger *et al.*, 1976), and which possesses some life history stages in marine and coastal waters.

With respect to the Moyle Interconnector, even the maximum iE field predicted to be generated is a number of orders magnitude less than the levels that teleost fish are expected to respond to (by avoidance; several thousand µv/m). Equally, these fish are unlikely to be affected physiologically to such weak levels of iE fields. European eels are thought to be more sensitive, but any impacts upon their movement is expected to be similar to those elicited by weak B fields; i.e. minimal and only temporary (Ohman *et al.*, 2007). Therefore, when considering **iE fields**, despite the medium to high importance of a number of relevant teleost fish species, impacts upon these **electrically insensitive** sensitivity receptors are assessed as being of **negligible significance**.

5.3.3. B Field Assessment

There is extensive evidence of teleost (bony) fish possessing magnetic receptors (see Kirschvink, 1997 for review), often supported by demonstrations of orientation behaviour, for example in species such as eels (*Anguilla rostata*; Souza *et al.*, 1988; *Anguilla anguilla*; Durif *et al.*, 2013), plaice (*Pleuronectes platessa*; Metcalfe *et al.*, 1993), salmon (*Salmo salar*; Rommel & McCleave, 1972; *Oncorhynchus tshawaytscha*; Kirschvink *et al.*, 1985; Putman *et al.*, 2013; Putman *et al.*, 2014) and trout (*Salmo gairdneri*; Chew & Brown, 1989). Whether these fish would be affected by B fields from sub-sea cables, however, is unclear. Bochert & Zettler (2004b)) found no significant effects of static B fields upon flounder, *Platichthys flesus*. Woodruff *et al*., (2012) found inconclusive effects on behaviour in coho salmon (*O. kisutch*). Swedpower (2003)) found no measurable impact of subjecting salmon and trout to magnetic fields twice the magnitude of the geomagnetic field. The European eel (*Anguilla anguilla*) has been shown to deviate from its migration route in the presence of a 5µT HVDC field, although the effect was short term and over a short distance (Westerberg, 2000; Ohman *et al.*, 2007), and such an effect is therefore thought unlikely to affect key functions such as breeding or feeding success. Hvidt *et al.* (2004)) did observe barrier effects in the same species at Nysted OWF and

Westerberg & Lagenfelt (2008)) recorded significantly lower swimming speeds near a 130kV AC cable, but neither could specifically correlate effects with EMF. Atlantic salmon migration in and out of the Baltic Sea, over a number of operating subsea HVDC cables, seems to continue unaffected (Walker, 2001).

The reconfigured Interconnector is likely to generate B fields above background levels that may be detectable by teleost fish, although attenuation below these levels is expected over distances of 4m for separated cables if surface-laid or 3m if buried (and less in near-shore areas owing to cancellation associated with more closely installed cabling). Benthic and demersal fish species such as eels, lampreys, flatfish, gurnards, cod and haddock are most likely to encounter the B fields. Potential impacts arising from the stronger B fields in close proximity of the Interconnector, ranging between temporary deviation (as demonstrated with eels to weaker B fields) or a more serious avoidance response (potentially leading to delayed migration for eels and lampreys), cannot be ruled out, although owing to the paucity of available data, uncertainty remains and the biological significance of such effects is currently unknown (Gill & Bartlett, 2010; Gill *et al.*, 2012). What is clear though, is that any effects would be limited to within close proximity of the Interconnector.

Pelagic species, such as herring, salmon and trout are less likely to be affected. Salmon, for example, predominantly migrate in the upper water layers (Aas *et al.*, 2011). More recent work confirms this, but also demonstrated that many pass through the entire water column and that some spend time at depth (Godfrey *et al.*, 2014). The potential therefore exists for some salmonids to encounter the B field generated by the Interconnector, if venturing near the seabed, although migration is expected to be largely unaffected given the more extensive use of more pelagic waters. Furthermore, any effects are expected to be very localised considering the rapid attenuation of B fields with distance. Salmonids obviously spend more time in close proximity of the seabed in very shallow waters when migrating towards or from estuaries, but even the most nearby salmon and trout rivers are over 20km away (i.e. the Glenarm, Lagan, & Girvan rivers; Figure 5). .

In areas where rock dumping is used (at cable crossings or areas of hard substrate), there is potential for smaller, rock-dwelling species to encounter strong magnetic fields of up to approximately 3,500µT. Whether any physiological effects on such rock-dwelling fish could result from these stronger fields is uncertain. Fish embryonic development has been shown to be delayed by AC B fields of 1 to 100µT (Cameron *et al.*, 1985; Cameron *et al.*, 1993) and Woodruff *et al.*, 2012 found evidence of suppressed levels of a stress-related hormone in juvenile coho salmon and suggested that embryogenesis developmental processes in rainbow trout (*O. mykiss*) may be affected by temporal exposures to B fields, and that there were potential effects on growth and development in Atlantic halibut (*Hippoglossus hippoglossus*), but not the closely related Pacific halibut (*H. stenolepis*). Again, whilst effects upon individual fish may occur, population (and stock) level effects are unlikely to occur owing to the relatively small impact zone.

Potential impacts upon the navigation and physiology of these medium to high importance and **low magnetic sensitivity** receptors by the reconfigured Interconnector **B fields** cannot be ruled out. Benthic fish are thought more likely to encounter the B fields, though the potential for some pelagic fish to do so also exists, albeit more briefly and less frequently. Effects would be limited to within close proximity of the cables and some are expected to be temporary. Overall, such impacts are therefore assessed as being of **minor significance,** but it should be noted that more research is required to determine whether more serious impacts upon benthic and demersal species may be possible, including eels and lampreys.

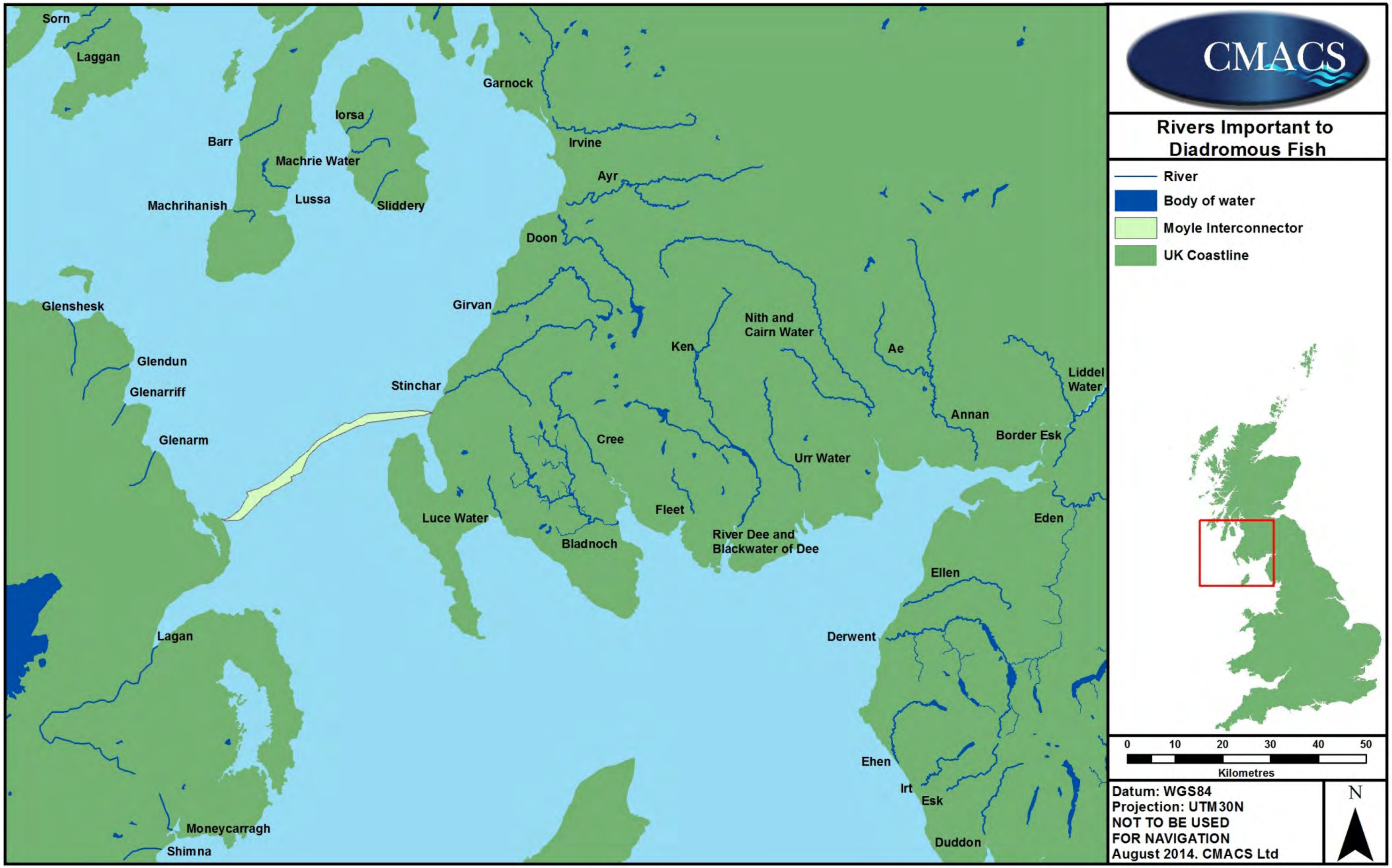

Figure 5. Map illustrating the distance of rivers important for diadramous (migratory) fish from the Moyle Interconnector

5.4. Elasmobranchs

5.4.1. Importance

The group of marine animals with the most potential to be affected by EMF are the elasmobranchs. They are known to be able to detect magnetic fields as evidenced by demonstrations of orientation towards such fields (Kalmijn, 1978; Meyer *et al.*, 2004), although to what degree is currently uncertain. However, their extreme sensitivity to even minute electric fields is undisputed (to just 5-20nV/m: Kalmijn, 1982; Tricas & New, 1998).

There are over 20 elasmobranch species occurring in the Irish Sea, some of which are fished, face population decline and are therefore protected (Parker-Humphreys, 2004; Compagno *et al.*, 2005; Agri-Food & Biosciences Institute, 2009). Certain species, such as small-spotted catsharks (*Scyliorhinus canicula*), nursehounds (*Scyliorhinus stellaris*), thornback (*Raja clavata*), blonde (*R. brachyura*) and cuckoo rays (*R. naevus*) are widespread and either stable or increasing, whereas others are depleted or severely depleted, such as angel sharks, spiny dogfish, white and common skate (Agri-Food & Biosciences Institute, 2009). For others, there simply is not enough data for reliable population estimates (e.g. porbeagle, thresher (*Alopias vulpinus*) and smoothhound sharks (*Mustelus mustelus*). Basking and angel sharks and skates are protected under Article 10 of the Wildlife (Northern Ireland) Order 1985 (as amended) and the former under the Nature Conservation (Scotland) Act and Wildlife and Countryside (UK) Act 1981. The shallow, inshore areas where the Interconnector reaches land, are thought to act as nursery areas, especially for tope (*Galeorhinus galeus*), spiny dogfish, thornback rays and common skate (Ellis *et al.*, 2012). The North Channel is also thought to be an important migration route for basking sharks, which are found in hotspots around the Isle and Man and along the western Scottish coast, and also inshore along the eastern Northern Ireland coast (Bloomfield & Solandt, 2006; Agri-Food & Biosciences Institute, 2009). Elasmobranchs are also important predators within the marine food web. Owing to many species' conservation concerns and protection, elasmobranchs are therefore assessed as **medium importance** receptors.

5.4.2. Repulsion

Elasmobranchs are known to be repelled by strong electric fields, which has previously raised concerns that cables inducing such electric fields may act as barriers to movement (e.g. between feeding, mating and nursery areas). Theoretically, this was thought to have the potential to impair growth, health, reproductive success or survival of individual elasmobranchs, which might, in turn, affect population distribution and size. Precisely what magnitude of electric field induces an avoidance response in elasmobranchs is uncertain. Other than use of very strong electric fields (80V & 100A) to prevent large, pelagic sharks attacking divers and surfers, avoidance behaviour has only been documented in a few elasmobranchs; when small-spotted catsharks were presented with DC electric fields of 1000µv/m (Gill & Taylor, 2001), and when silky (*Carcharhinus falciformis*), white tip reef (*Traenodon obesus*) and zebra (*Stegostoma fasciatum*) sharks were presented with both DC and AC fields of 1000µv/m (Yano *et al.*, 2000). Neither of these studies was designed to consider a range of field strengths and so it is difficult to infer an avoidance threshold. However, other research demonstrated repeated, unequivocal attraction behaviour to DC fields of approximately 60µV/m (Kalmijn, 1982; Kimber *et al.*, 2011), and whilst the majority of responses to DC fields of approximately 400 to 600µVm were attraction, some occurrences of avoidance were observed (Kimber, 2008). This suggests that the threshold between attraction and avoidance lies somewhere between approximately 400 and 1000µv/m.

There is considerable uncertainty as to whether laboratory demonstrated repulsion would translate into avoidance of cables in the natural environment and, if so, whether such effects would be temporary (as for eels with weak magnetic fields) or sustained. Theoretically fish should be able to swim up into the water column and over the cable, although whether predominantly benthic species such as rays would do so is uncertain. Whilst there has been no evidence of repulsion by subsea cables to date (bearing in mind there has been little research; CEFAS, 2009), in theory at least, stronger fields could cause such repulsion, and therefore potentially act as a barrier to movement and/or migration. Based upon the little information available, current thinking is that avoidance could potentially occur within close proximity of higher rated AC cables and HVDC cables.

5.4.3. Attraction

Elasmobranchs are responsive to E fields below those that elicit repulsive reactions, and utilise them for a number of behaviours; namely prey, predator, mate detection and navigation (Tricas & Sisneros, 2004). There is concern that these fish will be confused by anthropogenic iE field sources that lie within similar ranges to natural bioelectric fields. Marra (1989)) recorded details of four power transmission failures in an AT&T transatlantic fibre-optic cable in the mid-1980s. Upon raising the cable for repairs, bite marks and embedded teeth were found at the damaged sections. Further investigation revealed the damage was attributable to shark bites in all four instances. Attraction to iE fields induced around the cable (confusing them for prey) was considered the most likely reason for shark responses. Whether the sharks were harmed by biting the cables is unknown.

Laboratory behavioural studies have demonstrated both AC and DC artificial electric fields stimulating similar feeding responses in elasmobranchs. Recent work using small-spotted catsharks as a model benthic elasmobranch has demonstrated that despite the ability to distinguish certain artificial E fields (strong versus weak; DC versus AC), the sharks seemed either unable to distinguish, or showed no preference between similar strength, artificial and natural (live crab) DC E fields (Kimber *et al.*, 2011). In turn, this raises the question of whether these predators might effectively waste time and energy “hunting” electric fields such as those associated with subsea electrical cables whilst searching for bioelectric fields associated with their prey. More recent work demonstrated that the sharks are able to learn to focus upon profitable E fields (in terms of food gain) and habituate to unprofitable E fields, although adaptations were not remembered long term (Kimber *et al.*, 2013) A recent experiment which involved enclosing a section of sub-sea cable within a suitable area of seabed, using an approach known as ‘mesocosm studies’, allowed the response of elasmobranch test species to controlled electromagnetic fields (of similar intensity as those expected around offshore wind farm cabling, and therefore more likely to elicit attraction, rather than avoidance behaviour) to be assessed within a semi-natural setting (Gill *et al.*, 2009). The study provided the first evidence of electrically sensitive fish response to AC EMF emissions from subsea, electricity cables of the type used by the offshore renewable energy industry. Some *S. canicula* were more likely to be found within the zone of EMF emissions, and some thornback rays (*Raja clavata*) showed increased movement around the cable when the cable was switched on. Responses were, however, unpredictable and did not always occur, appearing to be species dependent and individual specific. What ecological implications such interactions might have upon the fish is still unclear.

5.4.4. Assessment

Table 2 suggests that iE fields greater than 400µV/m, which may elicit avoidance are only expected within approximately 0.5m of the separated cables (and less in near-shore areas owing to cancellation associated with more closely installed cabling). Where the cabling is buried to a depth of 1m, this would be negated. It should be noted that the distance may extend further when considering iE fields induced by elasmobranchs swimming swiftly through the B field, rather than tidal flow (0.84m/s assumed here). However, uncertainty exists as to the swimming speed of the relatively small, benthic elasmobranchs in question (large pelagic sharks are often cited as cruising at 0.7m/s and bursting up to 8 to 14m/s), and it is therefore difficult to predict iE fields induced in this manner.

iE fields are expected to exceed background fields for the Interconnector, although only to distances of approximately 4m from separated cables (and, again, less for near-shore cabling). Within this distance, there is potential for elasmobranchs to confuse iE fields with prey bioelectric fields. Again, it should be noted that this distance may be increased when considering elasmobranchs swimming through B fields at velocities greater than tidal flow, but precise predictions are uncertain. Once again, the ecological significance of such confusion zones is unknown. Also, there remains the possibility that elasmobranchs are able to detect iE fields even if they do fall below background fields, due to differing geometries.

Pelagic species such as basking, porbeagle and thresher sharks and tope are unlikely to be affected by the reconfigured Interconnector due to their habits causing them to be distant from the seabed and strongest iE fields, unless venturing into very shallow waters. Benthic species such as skates and rays, angel sharks, spiny dogfish and catsharks are more likely to encounter the iE fields, either while foraging or moving between feeding and/or breeding and nursery areas. Avoidance impacts cannot be ruled out, but owing to the rapid attenuation of iE fields with distance from cables, such potential interactions are expected to be very localised, and temporary as for eels with weak B fields (see Section 5.3). Whilst individual sharks and rays may be affected, population level effects are unlikely owing to the very small impact zone area. Confusion impacts may also occur within a slightly larger, but still relatively small zone, but the ecological significance is uncertain (e.g. whether populations or nursery areas might be affected) owing to a lack of research. Female small-spotted catsharks are known to shelter in rocky crevices to avoid aggressive males (Sims *et al.*, 2001) and may therefore come into close proximity of strong EMF if sheltering among cable protection where burial is not possible. Whether they would be affected (avoidance or physiological effects) is uncertain. Sisneros *et al.* (1998)) and Ball (2007)) have demonstrated embryonic thornback rays ceasing body movement that facilitates critical ventilatory movement of water upon sensing artificial E fields. This suggested the developing rays were employing detection minimisation behaviour as the E fields were similar to those of predatory animals (such as small, adult elasmobranchs, and larger teleosts and cephalopds). There is potential for iE fields generated by the Interconnector to affect this behaviour, but there is no evidence to confirm this scenario, and ecological significance is unknown.

Taking all the above into account, potential impacts of EMF generated by the Moyle Interconnector are expected to be of **minor to moderate** significance for these **medium** importance and **medium to high** sensitivity receptors.

5.5. Mammals and Chelonians

5.5.1. Importance

Although numerous species of marine mammals have been recorded off Ireland and Scotland, many are infrequent visitors. Only certain species are frequently present in the Irish Sea North Channel and often more common in summer months. Bottlenose dolphin (*Tursiops truncatus*), harbour porpoises and harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals are most common (Hammond *et al.*, 2005; Irish Whale and Dolphin Group, 2013), with Risso's dolphin (*Grampus griseus*), short-beaked common dolphin (*Delphinus delphis*) and minke whale (*Balaenoptera acutorostrata*) also present. All cetaceans (whales, dolphins and porpoises) are protected under Conservation (Natural Habitats) Regulations 1994 (Scotland) and Wildlife Order 1985 (Northern Ireland), in addition to more general legislation (Annex IV of the Habitats Directive, The Convention on the Conservation of Migratory Species (Bonn) and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas). Marine mammals are also important predators. They can therefore be considered as being **medium to high importance** receptors.

5.5.2. Assessment

Marine mammals are strongly linked with the use of geo-navigation by detection of variation in magnetic fields (e.g. Kirschvink *et al.*, 1986, who correlated strandings with local magnetic minima). However, the ability has not been demonstrated experimentally, and how the sense operates remains unconfirmed. There is no evidence of cetacean migration being affected by sub-sea cable B fields. Harbour porpoise (*Phocoena phocoena*) migration across the Skagerrak and western Baltic Sea has been observed unhindered despite several crossings over operating sub-sea HVDC cables (Walker, 2001). A recent demonstration of electroreception of AC fields in a dolphin (Czech-Damal *et al.*, 2011) suggests the widely held belief that cetaceans are not sensitive to E fields may be incorrect. However, the authors state that the system appears to be far less sensitive than those used by elasmobranchs (a 460µV/m threshold of sensitivity was established, approximately three orders of magnitude higher than elasmobranchs).

Owing to their predominantly pelagic existence, with migrations strongly linked to surface waters for breathing, these species are only likely to encounter the EMF generated by the Interconnector should they dive to feed near the seabed or should they venture into very shallow water. Owing to the rapid attenuation of the EMF with distance from the cables, combined with lack of evidence of effects upon cetaceans, it is expected these mammals will be largely unaffected by the reconfiguration (installation of the separated MRC cables), and therefore potential impacts of the Moyle Interconnector are assessed as being of **negligible significance** to these medium importance and **low to medium sensitivity** receptors. The same is postulated for chelonians (turtle) for similar reasons, some species of which are also sporadic summer visitors to the Irish Sea and south eastern Scotland (e.g. leatherback turtle, *Dermochelys coriacea*; Reeds 2004) and are protected under similar legislation.

6. Cumulative considerations

The nearest offshore renewable energy developments to the Moyle Interconnector are the planned Islay Offshore Wind Farm to the north and the operational Robin Rig Offshore Wind Farm to the south (Kintyre and Wigtown Bay farms have been cancelled). However, these farms are 112 and 128km from the nearest point along the Interconnector respectively. Since the effects of EMF are expected to be limited to within close proximity of the Interconnector cabling, no cumulative effects will occur with the offshore wind farm cabling.

The planned Western HVDC Link, that will transmit electricity between the Wirral and the south western coast of Scotland, just south of Hunterston, will cross the Moyle Interconnector. According to engineers, HVDC cables crossing each other are required to do so perpendicularly to prevent induced currents (iE field) resulting in thermal hotspots and de-rating of the cable. The Link is planned to cross the Interconnector perpendicularly and thus such interactions should be largely negated. Whilst the two overlapping cables will, never-the-less, create a slightly larger area in which EMF is generated above background levels (effectively a cross rather than linearly at the intersecting location), potential impacts upon marine fauna would still be limited to within close proximity of the cables.

7. Conclusions

7.1. Overview of possible effects

Whilst research into electromagnetically sensitive species and the effect of anthropogenic EMF upon them is ongoing and at an early stage, this report reviews all relevant literature (both AC and DC) presently available and compares current theories with estimated EMF generation by the reconfiguration of the Moyle Interconnector (installation of the separated MRC cables). The following long term to permanent effects might be expected:

Magnetic fields

- Possible impairment of navigation and/or physiological effects upon marine macro-invertebrates but only minor, in very close proximity to cables. Possible physiological effects largely negated by burial.

- Possible impairment of navigation effects upon benthic and demersal fish within very close proximity of cables. The severity and significance of such effects are uncertain. Possible physiological effects largely negated by burial. Pelagic fish are thought less likely to be affected, although the potential for some to encounter the B fields exists.

- No effects expected upon marine mammals or chelonians.

Induced electric fields

- No impacts expected upon marine macro-invertebrates.

- No effects expected upon teleost physiology. Only very minor and brief effects upon navigation expected among certain, benthic and demersal teleosts in very close proximity to cables, if at all.

- Possible avoidance/repulsion of benthic elasmobranchs by strongest iE fields (potentially a barrier to movement) but limited to within very close proximity of cables. A potentially significant impact cannot be ruled out, but there is insufficient knowledge to determine conclusively whether there would be any effect, let alone an ecologically significant one.

- Possible confusion of iE fields with bioelectric fields by elasmobranchs within close proximity of cabling. Potential to affect feeding, escaping predators, locating mates, and navigation, although ecological significance unknown.

- No effects expected upon marine mammals or chelonians.

Owing to their acute sensitivity to EMF, and their use of EMF for such wide ranging behaviours such as prey detection, predator avoidance, searching for mates, in addition to orientation and migration, combined with many species facing severe population declines due to overfishing and habitat degradation (Baum *et al.*, 2003) exacerbated by their slow life history traits (Frisk *et al.*, 2005), elasmobranchs seem the most vulnerable taxa when considering potential effects of EMF.

7.2. Monitoring and future research

Owing to uncertainty surrounding the issue of potential interactions between anthropogenic sources of EMF and electromagnetically sensitive marine organisms, a “best guess” approach is often used during assessment and mitigation planning (Punt *et al.*, 2009). There is a danger that this could either lead to an overly restrictive, precautionary approach to management, or for potential impacts to be marginalised. Adaptive management is suggested as being a more suitable method, whereby guidance and decisions can be reviewed and adapted as research and practice provide a greater insight into interactions (Gill & Bartlett, 2010).

Suggestions to help address uncertainty with respect to the Moyle Interconnector are as follows (with reference in part to Gill & Bartlett, 2010 and Gill *et al.*, 2014):

- All receptors
  - Measurements of actual magnetic and electric fields in situ, once the reconfigured Interconnector is operational, would enable better understanding of EMF generation, how EMF may differ and/or interact (cable B field vs. geomagnetic; seawater vs. organism iE fields), and likelihood of marine fauna ability to detect fields and any potential interaction.
- Salmonids
  - Because EMF is one of a great number of possible influences on salmonid migration, it is suggested that monitoring of salmonid populations in local river systems, through use of existing, established methods, should be sufficient. However, in the event that such routine monitoring reveals potential population declines that may be linked to the Project, it would be appropriate to undertake direct monitoring, as indicated below.
  - Monitoring movement of diadromous fish species within the area, and specifically across the Interconnector to determine whether migration is affected. This would likely be very challenging to accomplish through a tracking study which would be required to assess the response of individual fish. Juvenile salmonids (smolt) captured and tagged with acoustic markers in local river systems, and subsequently tracked actively or passively along the coast, would potentially provide information on effects during the initial phase of marine migration.

- Marine Species

  - Photographic or video transects along the operational, reconfigured Interconnector (existing HV and replacement MRC cables) would help understanding of whether benthic invertebrates and fish appear to be attracted to, repelled by, or indifferent to sub-sea cable EMF. Potential examples of such surveys include:

    - In shallows at Islandmagee to observe lobster and crab behaviour where the Interconnector approaches landfall.
    - Using baited video camera traps to observe benthic shark and ray behaviour where the Interconnector passes shallow sandy substrata.

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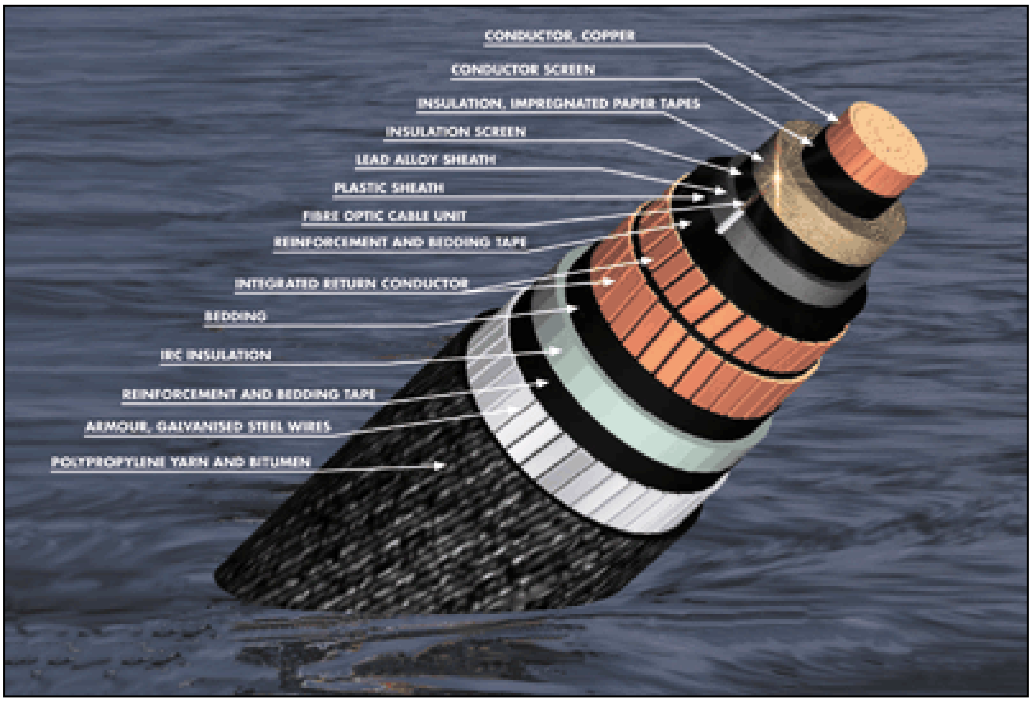
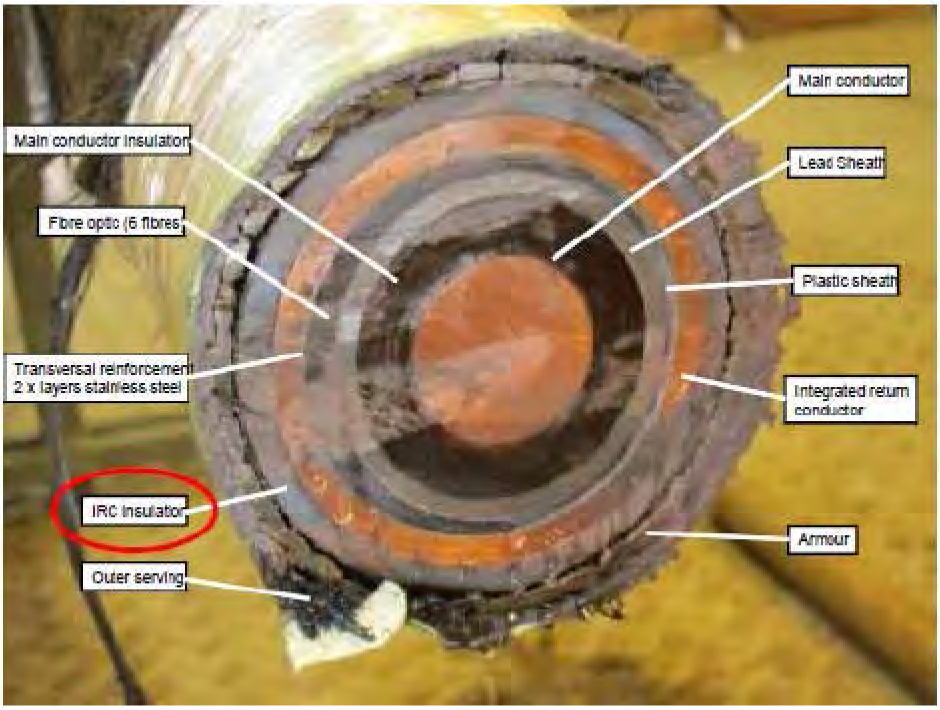
9. Appendices

Appendix 1. Moyle Integrated Return Conductor Cable



Appendix 2. Cross section of Moyle Interconnector IRC cable



A.2.4 – Underwater Noise Assessment Technical Report (desk based study on subtidal marine ecology)

Centre for Marine and Coastal Studies Ltd

MOYLE INTERCONNECTOR LTD

Assessment of the likely effects of noise during installation of a replacement metallic return conductor on sub tidal marine ecology

Client: Intertek Energy and Water Consultancy Services

Document: J3257 Moyle Interconnector Noise Report v4

Version	Date	Description	Prepared by	Checked by	Approved by
1	20/08/14	Issued Draft	JK	IGP	IGP
2	01/09/14	Minor edits	IGP	JK	IGP
3	03/11/14	Minor edits after consultee comments	KS	JAK	IGP
4	08/12/14	Terminology update	JK	JK	IGP

Executive Summary

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland. It consists of two separate High Voltage Direct Current (HVDC) cables, each rated to transfer 250MW in either direction. The system has been operational since 2002. However, since 2010 there have been four system faults (as a result of a failure in the low voltage polyethylene Integrated Return Conductor (IRC) insulation). The Interconnector is currently running at half capacity and Moyle Interconnector Ltd (MIL) is investigating options for the restoration of the Interconnector to full capacity.

Intertek has been appointed by MIL to undertake an environmental assessment of the installation of proposed replacement metallic return conductors (MRC).

This report commissioned by Intertek assesses the significance of potential impacts of noise predicted to be generated as a result of the installation of the replacement MRC cables upon marine organisms.

No significant adverse impacts from underwater noise are anticipated although behavioural responses, including temporary displacement of certain fish species and marine mammals, are expected for distances of several hundred metres to low kilometres around DP vessels and for smaller distances in proximity to other works.

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1. Introduction

The Moyle Interconnector is a High Voltage Direct Current (HVDC) link between the electricity grids of Northern Ireland and Scotland. The system has been operational since 2002. However, since 2010, there have been three subsea system faults as a result of a failure in the low voltage (LV) polyethylene Integrated Return Conductor (IRC) insulation allowing water ingress (in addition to one land-based fault). The reason for failures is not confirmed. The Interconnector is currently running at half capacity and Moyle Interconnector Ltd (MIL) is investigating options for the restoration of the Interconnector to full capacity (500MW).

The preferred long-term option is the installation of two separated (as opposed to integrated), replacement metallic return conductor (MRC) cables between the Northern Ireland and Scotland converter stations. The two existing High Voltage (HV) conductors would remain *in situ* and operational as originally installed. The desired monopole circuits would therefore each comprise the existing HV conductor (in the existing cable) and replacement MRC.

The proposed MRC cables will be installed in a corridor between 50m to 100m south of the north cable, and in a corridor between 50m to 100m south of the south cable along the majority of the route. In near-shore areas, however, they will be installed as close as practically possible to the existing HV conductors (approximately 4m apart).

The replacement cables will be buried to a minimum depth of 1m or protected by rock armour or mattressing if this this not possible (see Section 2.1).

Each of the two existing corridors is approximately 5km long onshore in Scotland, 53km long submarine and 3km long onshore in Northern Ireland.

Finalisation of the cable routes will take into consideration environmental and technical constraints, the results of detailed surveys (if required following further review of existing seabed information) and the feedback from the consultation process. MIL intends to submit an application to MS-LOT for a Marine Licence under the Marine (Scotland) Act 2012 for the extent of the marine cable in Scottish territorial waters and under the Marine and Coastal Access Act (MCAA) 2009 for the extent of the marine cables in Northern Ireland territorial waters.

Centre for Marine and Coastal Studies Ltd (CMACS) has been contracted to provide advice on the likely environmental impacts of underwater noise generated during installation of the new separated LV returns upon marine fauna. This advice will inform the environmental appraisal of the installation of the new cables in support of the marine licence application.

2. Project description

2.1 Overview

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland, stretching 53km across the North Channel of the Irish Sea between landfalls at Portmuck South, County Antrim and Currarie Port, Ayrshire (Figure 1). From the landfalls, the Interconnector then runs to converter stations at Ballycronan More in Island Magee, County Antrim and Auchencrosh in Ayrshire.

Figure 1. Moyle Interconnector Route

The existing cables are buried where possible to a depth of 1.5m within seabed sediments. The replacement cables will be buried where possible to a minimum depth of 1m. Where this is not possible, for example over hard ground or cable/pipeline crossings, rock armour or matressing has been used to protect the cable.

2.2 Cable Specifications

The Interconnector consists of two separate HVDC cables (north and south cable), each with integrated HV and a LV conductors in a co-axial design (Figure 2 and Appendix 1). Both the north and south cables are rated to transfer up to 250MW in either direction.

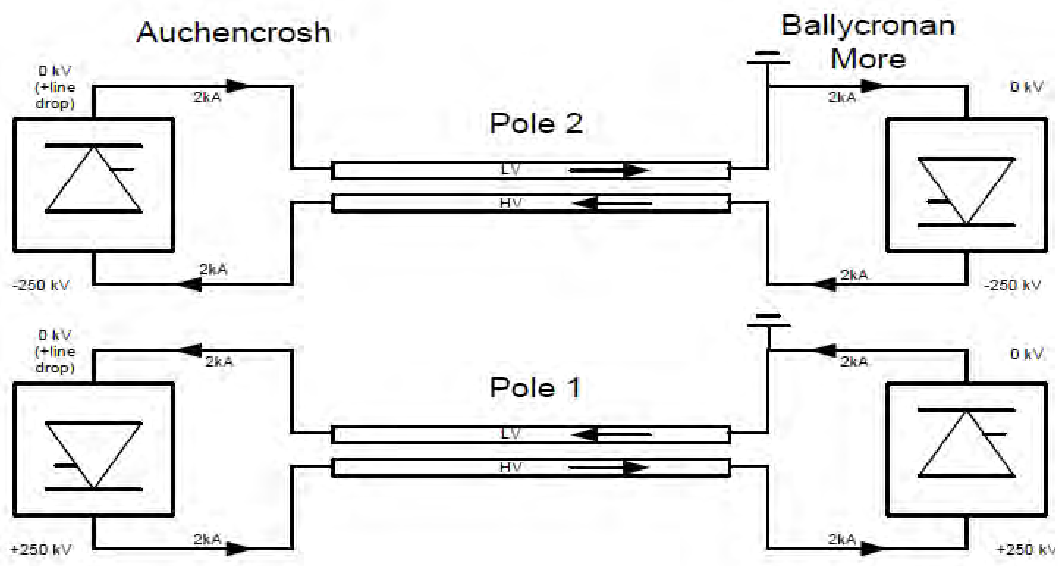

Figure 2. Moyle Interconnector general arrangement

The HV elements of the cables, which utilise conventional mass impregnated paper insulation, have never suffered a fault since commissioning and are expected to remain in good condition. All faults have occurred along the return, LV conductors, the initial three of which have been successfully repaired, but the most recent of which is still damaged (Table 1; Appendix 2).

Table 1. Moyle Interconnector cable fault history

Date	Location	Description	Status
09/09/10	Land-based, South cable	n/a	Repaired
26/06/11	Subsea, South cable	140m depth, partly buried & rock dumped	Repaired
24/08/11	Subsea, North cable	20m depth, buried in silt	Repaired
23/06/12	Subsea, North cable	20m depth, buried in silt	Unrepaired

There is now a lack of confidence in the LV elements of the system, which is currently running at half capacity via the south cable; any further faults along this cable would result in zero power transfer capability.

Proposals to revert to reliable maximum capacity have included:

1. A temporary change to the operational mode of the cables until delivery of Option 2. The station control would be redesigned such that full capacity could be transferred through the two HV conductors, with the currently functional south LV conductor operating as a metallic return. It is understood that this option is no longer being taken forward for consideration at this stage.

2. An enduring solution involving replacement of the integrated LV conductors by laying an additional two MRC cables between 50 and 100m away from the existing HV conductors (which would remain *in situ* and operational) along the majority of the route and 4m from the HV conductors in near-shore regions.

There is also an emergency fall-back position (possible to be set up in just a few hours) using the integral HV conductors of both cables to serve the functions of one HV conductor and one LV conductor to restore half capacity.

This document provides advice on the likely environmental impacts of noise predicted to be generated from installation of Option 2 upon marine fauna, which will feed into the environmental assessment and non-statutory environmental report being produced to support the Marine Licence applications. No underwater noise effects are associated with the emergency fall-back position, and the latter is therefore not assessed.

2.3 Assessment Methodology

Intertek consulted with a wide range of organisations to seek their opinion on requirements for environmental assessment through issue of a Scoping Report (Intertek, 2013). In relation to underwater noise effects, Marine Scotland in their Scoping Opinion (dated 25 March 2014), stated that they:

> *'would expect to see a full investigation of the potential for noisy activity to impact upon marine mammals, and cetacean species in particular, since they are EPS. We would include rock dumping, trenching, piling, use of explosive among activities that we consider to be noisy, although this list is not exhaustive.'*

Marine Scotland also requested that the developer consider the potential effects of noise on diadromous fish.

This report provides a review of information relating to the likely effects of noise generated by the installation of the replacement cables on marine fauna, including groups mentioned above in addition to other taxa, based on estimated noise levels obtained from literature sources related to the sensitivity of marine fauna. Operation of the HVDC link after remediation works will not generate significant noise levels and is not expected to differ in terms underwater noise from the original cable configuration; however, information is provided in relation to potential noise impacts of future cable decommissioning.

3. Cable Installation Methodology

The following information is taken from the Moyle Interconnector Scoping Report for New LV Returns (Intertek, 2013).

It is intended to bury the cables along their entire length; apart from where this is not possible, for example at crossings with existing cables or pipelines, or where the seabed characteristics are inappropriate for burial.

Prior to offshore cable installation, a Pre-Lay Grapnel Run (PLGR) operation will be undertaken to attempt to ensure that all obstacles are removed from the path of the planned cables (Plate 1).

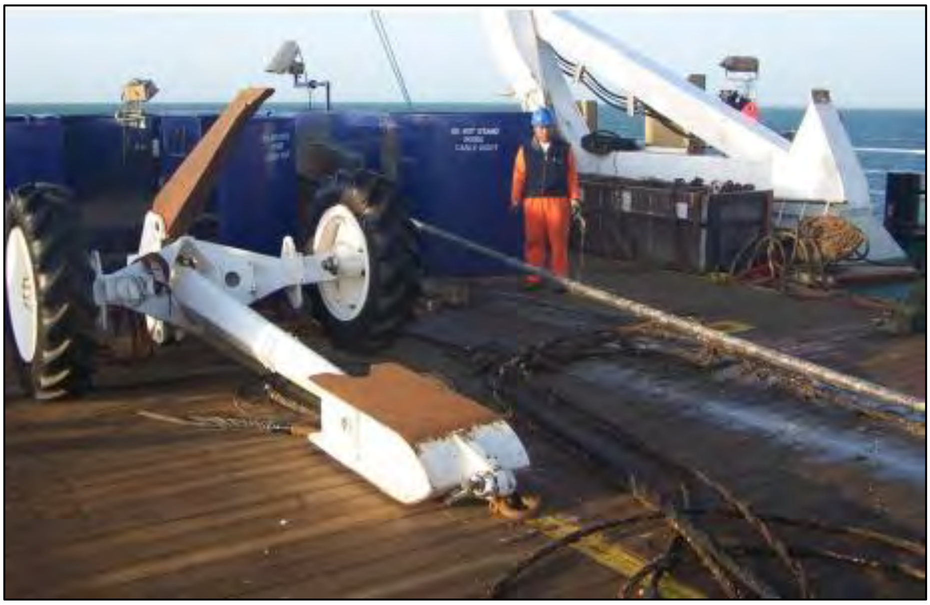

Plate 1. Wheeled grapnel aboard a cable ship

Minimum depth for cable burial is 1m below mean seabed level, although this may vary depending upon the nature of the substratum: in areas where there is evidence of trawling activity or areas of mobile seabed, this may be increased.

It may be necessary to use rock protection or ‘mattresses’ over some parts of the routes to protect the cables in areas of hard bedrock, areas of potential scouring by tidal currents and at cable/pipeline crossing locations.

The exact specification of the installation machinery will be determined in the detailed design phase, the sediment type along the route and also the availability of suitable equipment will be among the factors considered. Typical equipment is shown in Plate 2.

Table 2. Cable burial methods

Burial Method	Description
Ploughing	Ploughing is suitable for most types of seabed material, with the exception of rock and some glacial material. The cable is fed from the vessel, through the plough share into the seabed. The forward blades of the plough cuts a narrow trench into the seabed and holds it open long enough to depress the cable into the bottom of the trench. The seabed then closes behind the plough.
Jetting	Jetting is most effective in sandy sediment, and may not be capable of burying cable in more cohesive sediment. Two methods of jetting are typically available: Fluidising the seabed: the cable is laid on the seabed, where a jetting sledge flushes water below it, fluidising the sand. The cable sinks by its own weight to the depth set by the operator. This will result in increased suspended sediment compared to ploughing or forward jetting. Forward jetting a trench: Water jets are used to jet a trench ahead of the cable lay. The cable can typically be laid into the trench behind the jetting tool.

Plate 2. Jetting Trencher (right), Mechanical Trencher (upper left) and Cable Plough (lower left) equipment used in typical subsea cable burial operations

The exact details of the installation technique will be confirmed when the contract for installation is awarded. It is envisaged that a variety of installation and burial techniques will be required due to the highly variable nature of the seabed along the cable route.

Although exact details may alter, it is likely that the vessels to be used will consist of:

- **Cable lay vessel(s)**: there will be a dedicated cable-lay vessel (or vessels) (Plate 3) which will place the cables onto the seabed. The vessel will be equipped with specialised equipment including cable tensioners and a full survey suite to provide accurate details of the final cable positions.
- **Cable lay barge**: a cable lay barge capable of beaching (grounding) (Plate 4) may be required to lay and bury the cables at landfall locations depending on the seabed conditions encountered along the route and based on environmental factors. The vessel would be equipped with specialised equipment including cable tensioners, cable burial tools and a full survey suite to provide accurate details on the final cable positions. Burial work may take place simultaneously or a short time after the laying operation.
- **Cable burial vessel**: dedicated cable burial vessels (Plate 5) will bury the cables using a variety of equipment depending on the seabed conditions encountered along the route and based on environmental factors. This work may take place simultaneously with or a short time after the laying operation.

Plate 3. Typical cable installation vessel

Plate 4. Typical cable lay barge

Plate 5. Typical cable burial vessel

The above methodologies represent standard cable installation technologies. The predominant noise generating activities identified are:

- cable ploughing and trenching;
- rock placement;
- vessels using dynamic positioning systems; and,
- use of support vessels.

Available information on underwater noise levels associated with typical cable installation projects and the above activities is summarised in Section 4.2, following an initial review of the sensitivity of marine fauna to underwater noise (Section 4.1). Potential impacts are then considered in Section 5.

4. Cable Installation and Noise

4.1 Sensitivity of Marine Fauna to Underwater Noise

4.1.1 Marine Mammals

Marine mammals have evolved to use sound as an important aid in navigation, communication and hunting (Richardson *et al.* 1995). These behaviours may potentially be affected by disturbance caused by increasing anthropogenic and industrial processes, such as seismic surveys and underwater construction activities.

High intensity noise can cause direct impacts on marine mammals in several ways. Loud and prolonged noises can mask communicative or hunting vocalisations preventing social interactions and effective hunting. Very high intensity noises such as air gun blasts and underwater explosions can cause temporary or permanent hearing loss if animals are exposed at close proximity (Richardson *et al*. 1995). In extreme cases, close proximity to extremely high source levels can result in internal injuries caused by underwater pressure waves.

Cetaceans are legally protected within UK waters under the Wildlife and Countryside Act 1981 and under Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (The Habitats Directive). It is illegal to knowingly harm or disturb a cetacean.

Seals are not afforded the same level of protection as cetaceans, although if they are an interest feature of a protected site such as a Special Area of Conservation (SAC) potential impacts need to be considered carefully and could require mitigation. Seals vocalise using lower frequencies and so can be expected to have good hearing at lower frequencies than cetaceans such as harbour porpoise, which use higher frequency sound. For example, Thomsen *et al*. (2006) cite work by Thomsen and Schustermann (1998), which found that the hearing range of harbour seals extended over a very wide range but was acute over lower frequencies and more sensitive than harbour porpoise below 1 kHz.

The definition of safe limits for exposure of marine mammals to underwater noise is controversial and suffers from a lack of good evidence; however, recent progress has been made following a comprehensive review of the subject by Southall *et al*. (2007).

Southall *et al*. (*op. cit.*) define injury as a permanent threshold shift (PTS) in hearing. PTS is an irreversible elevation of the hearing threshold (i.e. a reduction in sensitivity) at a specific frequency (Yost, 2000 cited in Southall *et al*., 2007). With no reliable data to provide noise level thresholds for PTS, Southall *et al*. suggest a precautionary approach whereby it is assumed that a noise exposure capable of inducing 40dB of TTS will cause PTS onset in marine mammals. Southall *et al*. acknowledge that this is relatively precautionary since recovery from higher degrees of TTS has been recorded. Suggested threshold criteria are summarised in Table 3.

The authors divide cetaceans into three functional groups based on their hearing sensitivity (auditory bandwidth: low, 7Hz to 22 kHz; mid, 150Hz to 160 kHz; and high, 200Hz to 180 kHz. Harbour porpoise are classed as high frequency cetaceans, dolphin species as mid-frequency). Proposed injury criteria are summarised in Table 3, below. It can be seen that for cetaceans, the thresholds for sound pressure and exposure levels are the same for each functional group. Pinnipeds are reported to be somewhat more sensitive than cetaceans and therefore expected to incur PTS at lower exposure levels.

Table 3: Proposed injury criteria for individual marine mammals (from Southall *et al.*, 2007)

Marine mammal group	Sound type: Single pulses	Sound type: Multiple pulses	Sound type: Nonpulses
Low-frequency cetaceans	Cell 1	Cell 2	Cell 3
Sound pressure level	230 dB re: 1 μPa (peak) (flat)	230 dB re: 1 μPa (peak) (flat)	230 dB re: 1 μPa (peak) (flat)
Sound exposure level	198 dB re: 1 μPa^2-s (M_{lf})	198 dB re: 1 μPa^2-s (M_{lf})	215 dB re: 1 μPa^2-s (M_{lf})
Mid-frequency cetaceans	Cell 4	Cell 5	Cell 6
Sound pressure level	230 dB re: 1 μPa (peak) (flat)	230 dB re: 1 μPa (peak) (flat)	230 dB re: 1 μPa (peak) (flat)
Sound exposure level	198 dB re: 1 μPa^2-s (M_{mf})	198 dB re: 1 μPa^2-s (M_{mf})	215 dB re: 1 μPa^2-s (M_{mf})
High-frequency cetaceans	Cell 7	Cell 8	Cell 9
Sound pressure level	230 dB re: 1 μPa (peak) (flat)	230 dB re: 1 μPa (peak) (flat)	230 dB re: 1 μPa (peak) (flat)
Sound exposure level	198 dB re: 1 μPa^2-s (M_{hf})	198 dB re: 1 μPa^2-s (M_{hf})	215 dB re: 1 μPa^2-s (M_{hf})
Pinnipeds (in water)	Cell 10	Cell 11	Cell 12
Sound pressure level	218 dB re: 1 μPa (peak) (flat)	218 dB re: 1 μPa (peak) (flat)	218 dB re: 1 μPa (peak) (flat)
Sound exposure level	186 dB re: 1 μPa^2-s (M_{pw})	186 dB re: 1 μPa^2-s (M_{pw})	203 dB re: 1 μPa^2-s (M_{pw})
Pinnipeds (in air)	Cell 13	Cell 14	Cell 15
Sound pressure level	149 dB re: 20 μPa (peak) (flat)	149 dB re: 20 μPa (peak) (flat)	149 dB re: 20 μPa (peak) (flat)
Sound exposure level	144 dB re: $(20 \mu Pa)^2$-s (M_{pa})	144 dB re: $(20 \mu Pa)^2$-s (M_{pa})	144.5 dB re: $(20 \mu Pa)^2$-s (M_{pa})

Note: All criteria in the "Sound pressure level" lines are based on the peak pressure known or assumed to elicit TTS-onset, plus 6 dB. Criteria in the "Sound exposure level" lines are based on the SEL eliciting TTS-onset plus (1) 15 dB for any type of marine mammal exposed to single or multiple pulses, (2) 20 dB for cetaceans or pinnipeds in water exposed to nonpulses, or (3) 13.5 dB for pinnipeds in air exposed to nonpulses. See text for details and derivation.

Cable laying and vessel noise are 'nonpulse' activities. From Table 3, it can be inferred that no injury effects would be expected provided source noise levels (sound pressures) were below 230 dB re 1 μPa for cetaceans and 218 dB re 1 μPa for pinnipeds.

For operations that progress over time such as cable laying, the potential for cumulative exposure effects needs to be considered. The limit proposed by Southall *et al*. (2007) for cetaceans is 215 dB re 1μPa^2s and for pinnipeds in water 203 dB re 1μPa^2s (Table 3, values for nonpulses).

Southall *et al*. (2007) also provide a mechanism for assessment, although the process is necessarily more subjective and relies on allocating behavioural responses to a severity scale (0 to 9) based on a classification of behavioural responses observed in a limited number of test species (free ranging and laboratory subjects). Response scores to various levels of underwater noise are proposed for high frequency cetaceans such as harbour porpoise in Table 4Table 4 and pinnipeds in Table 5.

Table 4: Number of high-frequency cetaceans (individuals and/or groups) reported as having behavioural responses to nonpulse sounds. Response scores range from 0, no observable response; to 4-7, moderate behavioural changes; and 7+ extensive responses (from Southall *et al.*, 2007).

Response score	Received RMS sound pressure level (dB re: 1 µPa) 80 to < 90	90 to < 100	100 to < 110	110 to < 120	120 to < 130	130 to < 140	140 to < 150	150 to < 160	160 to < 170	170 to < 180	180 to < 190	190 to < 200
9												
8												
7												
6	**0.3** (4)	**0.3** (4)	**0.9** (1, 2, 4, 5, 6, 7)	**3.3** (1, 2, 4, 5, 6, 7)	**1.0** (3, 7)		**52.1** (2)	**9.3** (2)	**4.6** (2)			
5												
4			**0.1** (4)	**0.1** (4)								
3												
2												
1												
0	**12.8** (1, 5)	**23.1** (1, 2, 5, 6)	**0.4** (4, 7)	**0.1** (7)	**0.3** (3)							

Table 5: Number of pinnipeds in water (individuals and/or groups) reported as having behavioural responses to nonpulse sounds. Response scores as indicated in Table 4, above (from Southall *et al.*, 2007).

Response score	Received RMS sound pressure level (dB re: 1 µPa) 80 to < 90	90 to < 100	100 to < 110	110 to < 120	120 to < 130	130 to < 140	140 to < 150	150 to < 160	160 to < 170	170 to < 180	180 to < 190	190 to < 200
9												
8												
7												
6			**1.0** (3)									
5												
4					**1.0** (2)	**5.0** (2)						
3					**1.0** (2)	**2.0** (2)						
2												
1												
0	**1.0** (3)	**1.0** (3)		**1.0** (2)	**5.0** (1, 2)							

4.1.2 Fish and Other Groups

Thomsen *et al*. (2006) provide a useful overview of hearing in fish. Importantly, they highlight the diversity of hearing structures of fish and the resultant diverse range of auditory capabilities between species. In general, most fish hear well in the range within which most energy from anthropogenic noise sources is emitted, i.e. relatively low frequency sound below 1 kHz. Sound pressure is only detected by those fish species possessing a swim bladder; the otolith organ acts as a particle motion detector and where linked to the swim bladder, converts sound pressure into particle motion, which is detected by the inner ear. In some hearing specialist species such as herring, the swim bladder and inner ear are intimately connected and the fish are able to hear relatively high frequency sounds (to over 3 kHz) with optimum sensitivity between 300 Hz and 1 kHz. Most fish are hearing generalists and only detect sounds up to around 1 kHz with peak perception between approximately 100 – 400 Hz and relatively poor sensitivity compared to specialists.

Salmonids, although possessing a swim bladder, have no connection between this and the auditory apparatus and have relatively poor ability to respond to sound pressure changes (Hawkins and Johnston, 1978 cited in Gill and Bartlett, 2010). Likewise, there is not believed to be any link between the swim bladder and auditory perception system in anguillid eels; however, both eels and salmonids have been demonstrated to respond to very low frequency noise (infrasound), avoiding areas of high intensity sound below 10Hz (Knudsen *et al*., 1994 and Sand *et al*., 2000 both cited in Gill and Bartlett, 2010). Recent research suggests that there may be behavioural consequences of anthropogenic noise in eels, Simpson *et al*. (2014) reported that European eels exposed to ship noise (sound playback) were 50% less likely and 25% slower to startle in response to an 'ambush predator' and were caught more than twice as quickly by a 'pursuit predator'.

Nedwell *et al*. (2007) provide an interesting comparison of the relative sensitivity of fish and marine mammals to anthropogenic noise (from pile driving) based on *in situ* noise measurements and inferred or measured hearing sensitivities (see Section 0 for a description of the dB_{ht} filter method) coupled with propagation modelling based on in situ data (Table 6). The representative fish hearing specialist (herring) is predicted to exhibit a behavioural response at greater distances than the most sensitive marine mammal (harbour porpoise). To some extent, this is related to the relatively good propagation of lower frequency sound to which fish are relatively more sensitive than high frequency attuned cetaceans.

Table 6: Summary of perceived source noise level (dB above hearing threshold *not* absolute source level) and predicted behavioural impact range for pile driving operations (based on data from North Hoyle offshore wind farm, from Nedwell *et al*., 2007).

Species	Peak-to-peak perceived Source Level (dB_{ht} @ 1 m)	Behavioural impact range (based on 90 dB_{ht} peak-to-peak level)
Cod (*Gadus morhua*)	166	5.5 km
Herring (*Clupea harengus*)	177	11 km
Salmon (*Salmo salar*)	155	2 km
Bottlenose dolphin (*Tursiops truncates*)	185	5.7 km
Harbour porpoise (*Phocoena phocoena*)	191	9 km
Common seal (*Phoca vitulina*)	154	3 km

Other marine groups present in the Irish Sea are believed to be no more sensitive to anthropogenic noise than marine mammals or fish. Certain invertebrates, such as cephalopods, are known to detect particle motion using the statocyst, which is morphologically similar to the inner ear of the fish (Kaifu *et al*., 2008). The common prawn (*Paleamon serratus*) has been shown to be sensitive to particle motion due to low frequency sound waves from 100 Hz up to 3 kHz, with a hearing acuity similar to generalist fish species (Lovell *et al*., 2004).

4.2 Anticipated Noise Levels

4.2.1 Cable Trenching, Ploughing and Cutting

Information on noise levels associated with cable installation by trenching and ploughing (which are expected to result in similar noise levels) and cutting (which by nature of the high energy contact between metal cutting edges and hard rocks is expected to produce relatively higher noise levels) is available from studies undertaken in relation to offshore wind energy developments which have installed many hundreds of kilometres of cabling in recent years.

Measurements during cable installation works understood to have involved trenching were made by Subacoustech Ltd on behalf of COWRIE (Nedwell *et al.*, 2003). Measurements were made of noise levels during cable installation works at North Hoyle using a hydrophone 160 m from the source at a depth of 2m. The sound pressure recorded was 123 dB re 1 Pa. Because of the variability of the noise it was difficult to establish the unweighted Source Level but assuming a transmission loss of 22 log (R) this was around 178 dB re 1 µPa @ 1m.

Nedwell *et al*. (*op. cit.*) reported that trenching noise was a mixture of broadband noise, tonal machinery noise and transient noises (probably associated with rock breakage). It was noted that noise levels and character were variable and depended greatly on the type of seabed being cut at the time. After being run through a dBht filter (to relate noise levels to the hearing thresholds of various marine organisms), all but one measurement was below the 70dBht threshold that would be expected to induce a behavioural reaction from fish or marine mammals.

The above measurements are comparable to the stated source noise levels for dredging activity in Richardson *et al*. (1995) of between 172 and 185 dB re 1 µPa @ 1m.

No specific measurements of noise levels produced by rock cutting equipment used during cable laying have been found; however, a relatively large number of impact assessments have stated that noise associated with cable installation works is significantly lower than that created by hammer piling of monopile foundations (e.g. Npower Renewables, 2005) and recent reviews of wind farm construction-related noise effects have focused solely on hammer piling with little or no mention of cable laying as an important source of underwater noise (Gill *et al*., 2012; Gill and Bartlett, 2010; Nedwell *et al*., 2007; Thomsen *et al*., 2006). The latter has then been focused upon as the 'worst-case' scenario in terms of noise generation with relatively lower levels of noise expected from activities such as cable installations.

4.2.2 Rock Placement

Limited information is available on noise levels associated with rock placement. SVT Engineering Consultants (2010) provide a relatively recent assessment for this activity. They determined that it was unlikely to induce physical injury or damage to marine mammals but could induce behavioural disturbance. Source noise levels were expected to be in the region of 120 dB re 1 µPa @ 1m and behavioural disturbance to be limited to within 450m. This absolute source level may be an underestimate; Nedwell and Howell (2004) for example discuss expected noise levels for rock placement and similar activities and suggest that source noise levels of around 177 dB re 1 μPa @ 1m could be anticipated. This is broadly comparable to cable laying procedures.

4.2.3 Dynamic Positioning (DP) Systems

Vessels operating under DP maintain position using thrusters. These can create cavitating bubbles which can implode causing high acoustic energy levels in the water. Cavitation can cause damage to impeller and tunnel materials and also lead to propagation of underwater noise in the marine environment. Propeller cavitation is typically the largest component of vessel noise from larger vessels (Erbe *et al*., 2013).

Relatively little information is available on the environmental noise levels produced by DP systems but the following summarises information found by a literature search. The source noise levels and sound characteristics will depend on the exact vessels used but quoted levels associated with DP systems range between 177 and 197 dB re 1 μPa @ 1m and frequencies lie towards the lower end of the spectrum, up to around 3 kHz.

- Talisman Energy (2004) report source noise levels of 177 dB re 1 μPa @ 1m;
- Lawson *et al*. (2001) reported source levels for dynamic positioning thrusters to be 162 to 180 dB re 1μ Pa @ 1 m;
- McCauley (1998) reported sound generated by DP rig supply vessels was significantly greater than that arising from drilling operations. When rigs were operating, the effects of noise on cetaceans was reported to be confined to behavioural changes within a few hundred metres; and,
- AT&T (2008) reported source noise levels between 121 – 197 dB re1 μPa @ 1 m (and that these were relatively low frequency, between 50 and 3,200 Hz).

4.2.4 Support Vessels

Richardson *et al*. (1995) provide typical figures for source noise levels from vessels underway. Broadband noise for vessels of the type proposed for cable installation works range between 171 dB re 1 μPa @ 1 m (tug/barge, assumed equivalent to Guard Vessel) to 181 dB re 1 μPa @ 1 m (supply ship, assumed equivalent to Installation Vessel). These are believed to represent approximations of the noise levels expected as vessels transit to site but during operations engine-derived noises are anticipated to be below these levels as speeds will be low.

5. Anticipated Marine Environmental Effects of Cable Installation Noise

A review of the environmental impacts of cable laying by OSPAR (2009) included the following in relation to underwater noise:

> There are no clear indications that underwater noise caused by the installation of sub-sea cables poses a high risk of harming marine fauna. Richardson *et al*. (1995) provide an overview of investigations into behavioural responses of cetaceans to dredging, an activity emitting comparatively higher underwater noise levels (than cable installation). However, it is not clear if behavioural responses were due to sound or the increased presence of ships.

The above is consistent with information summarised in Section 4 and cable laying itself, together with related activities including rock placement, are not expected to generate sound levels sufficient to cause physical harm to marine fauna. There may be some disturbance leading to temporary displacement of mobile species (e.g. fish) but the works will not lead to any long term displacements and individuals would be expected to be able to return once the operation had passed through. The available evidence suggests that the range of behavioural effects is likely to be not more than hundreds of metres to low kilometres for the most sensitive species such as herring and cetaceans and rather lower for less acoustically sensitive species such as salmonids and eels. It should be noted that the ability of small fish to take avoiding action may be limited, and temporary displacement may not therefore occur.

Most noise is expected to be generated at relatively low frequency levels. In the relatively noisy coastal environment animals are habituated to, the predominant low frequency noises arise from sources such as wave action as well as certain anthropogenic inputs. In busy areas such as the Irish Sea, activities such as shipping, dredging and land-based sources contribute to existing lower frequency background noise and the relatively short period of time required for activities such as cable laying is not expected to contribute significantly to this. Remedial burial works in places where ploughing or trenching is not possible may take longer but the spatial impact of these activities is expected to be trivial.

Due to the existing high levels of vessel activity associated with local ports such as Belfast, Glasgow, Barrow, Fleetwood and Liverpool together with wider traffic throughout the Irish Sea, the relatively small number of installation and support vessels are not expected to contribute significantly to any increase in background noise levels through routine engine noise.

The highest levels of noise anticipated from the cable installation are expected to be produced by vessels using dynamic positioning systems. Such systems are relatively routine for highly specified installation vessels but are associated with quite high levels of underwater noise. Much of the noise is directed vertically downwards but some lateral spreading and reflection off seabed sediments will occur. Temporary displacement of marine mammals for distances of the order of some hundreds of metres to low kilometres is expected when DP is used, but noise levels are anticipated to lie below those believed to cause physical harm (Southall *et al.*, 2007) and no physiological effects are expected. It should also be noted that the marine mammal species most susceptible to disturbance by lower frequency sound are the baleen whales, which are adapted to communicate using such frequencies.

These species are rare in the Irish Sea and smaller cetaceans, dolphins and porpoise are more likely to encounter the works. Harbour porpoise are the cetacean species most likely to be encountered (CMACS, 2014) and this animal is more sensitive to higher frequencies than are expected to be generated by the project (functional hearing range approximately 250Hz to 160kHz with peak sensitivity between 100 and 140kHz (Kastelein *et al*., 2002).

The above levels of disturbance (temporary displacement of marine mammals, and it is anticipated fish (except small specimens), for distances of not more than low kilometres, more likely hundreds of metres) by DP vessels is predicted to represent the greatest noise-related effect of the cable installation activity. Some, more limited, behavioural impacts can be anticipated from ploughing, trenching and rock cutting but due to the lower levels of noise expected from these activities effect ranges will be smaller (not more than low hundreds of metres is anticipated).

Temporary displacement of mobile species in the marine environment is not expected to result in significant adverse impacts for the individuals concerned unless it interferes with a critical activity such as reproduction (e.g. fish spawning). A wide number of species do spawn in the Irish Sea and although some, such as sole (*Solea solea*, spawning between March and May) have restricted spawning areas none are so limited that small scale displacements such as are anticipated from cable laying activities are likely to be ecologically significant. One of the most acoustically sensitive species, herring (*Clupea harengus)*, also relies on spatially restricted spawning grounds. The Isle of Man grounds, which are believed to be relatively important in the Irish Sea during autumn and winter as evidenced by high egg concentrations, are relatively distant from the Project Area (Figure 3; Coull *et al*., 1998) and it is not expected that disturbing levels of noise would propagate to this extent. There is a spawning ground off the Scottish coast near Ballantrae and Lendalfoot that partly overlaps with the eastern-most extent of the Interconnector, although only low egg concentrations are thought to occur (Figure 3). Nonetheless, herring spawning in this area could be disturbed by cable installation works and vessels using DP during spawning, which is understood to occur between August and October off Scotland.

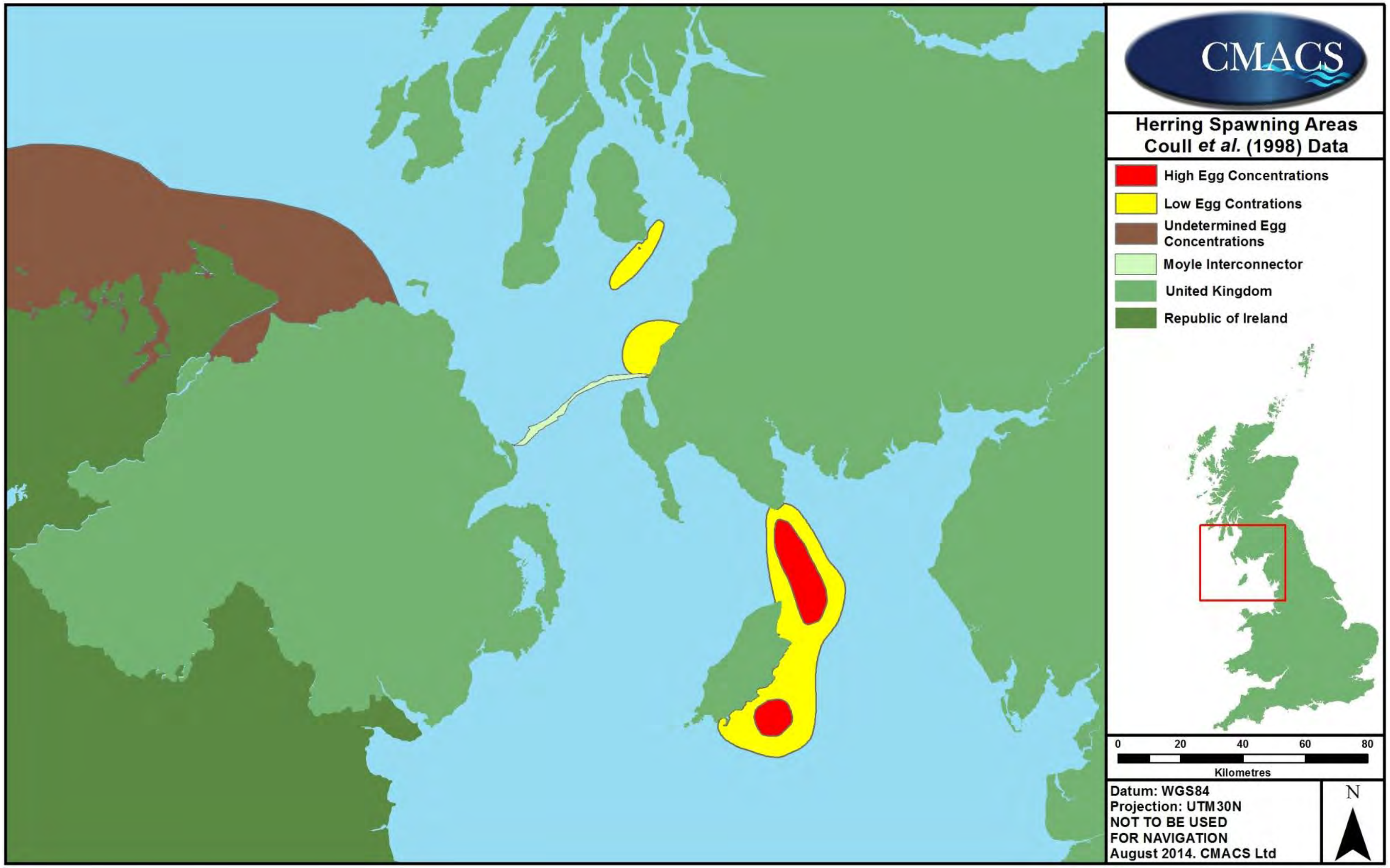

Figure 3: Herring spawning areas in the Irish Sea

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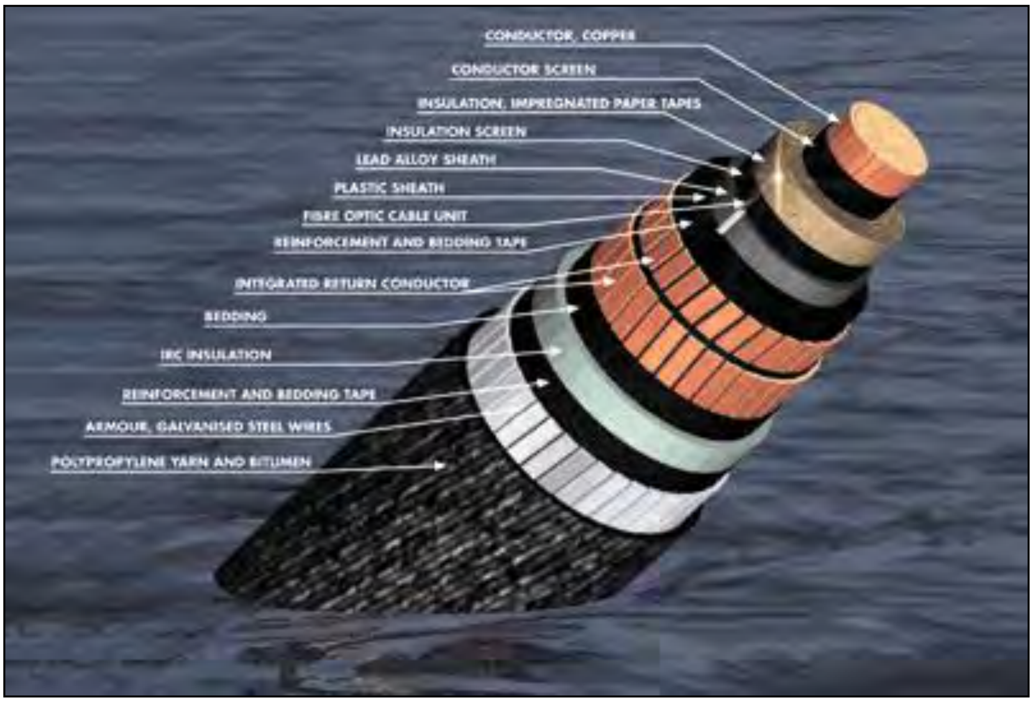
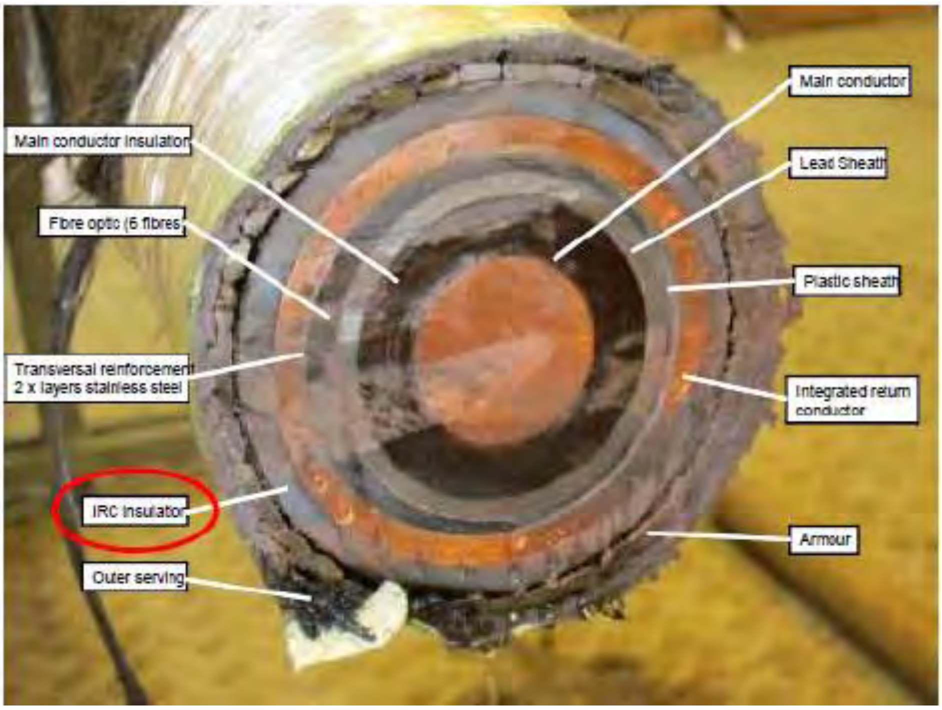
Appendices

Appendix 1. Moyle Integrated Return Conductor Cable



Appendix 2. Cross section of Moyle Interconnector IRC cable



A.2.5 – Heating Effects Assessment Technical Report (desk based study on subtidal marine ecology)

Centre for Marine and Coastal Studies Ltd

MOYLE INTERCONNECTOR LTD

Assessment of the likely effects of heat during operation of replacement metallic return conductors on sub tidal marine ecology

Client: Intertek Energy and Water Consultancy Services

Document: J3257 Moyle Interconnector Heat report v3

Version	Date	Description	Prepared by	Checked by	Approved by
1	Aug 2014	Issued Draft	IGP	JK	IGP
2	22-08-14	FINAL	IGP	JK	IGP
3	Dec 2014	Terminology update	JK	JK	IGP

Executive Summary

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland. It consists of two separate High Voltage Direct Current (HVDC) cables, each rated to transfer 250MW in either direction. The system has been operational since 2002. However, since 2010 there have been four system faults as a result of a failure in the low voltage polyethylene Integrated Return Conductor (IRC) insulation. The interconnector is currently running at half capacity and Moyle Interconnector Ltd (MIL) is investigating options for the restoration of the interconnector to full capacity. It is expected that this will involve the installation of two replacement metallic return conductor (MRC) cables.

Intertek has been appointed by MIL to undertake an environmental assessment of the proposed reconfiguration. Intertek have commissioned Centre for Marine and Coastal Studied Ltd (CMACS) to provide advice on the likely ecological effects of heating associated with the HVDC connection following its reinstatement to full capacity.

The replacement cables will be buried to approximately 1m depth, or, where this is not possible, protected by rock armour or matressing.

The replacement MRC cables are not expected to generate significant environmental heating effects. Such cables are expected to operate at below 45°C and evidence from cables operating at temperatures approximately twice as high or more suggests that burial deeper than approximately 1m serves to avoid significant elevation of temperature in overlying surficial sediments. This means that no adverse effects are expected to be experienced by animals living within seabed sediments (infauna), which are accustomed to very much more marked temperature fluctuations due to natural variation than are expected to result from cable heating.

Where the cable is protected by rock armour or mattressing instead of burial, it will be closer to the surface; however, the surrounding water has a relatively high heat capacity compared to sediments and any temperature change is expected to be trivial.

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1 INTRODUCTION

The Moyle Interconnector is a High Voltage Direct Current (HVDC) link between the electricity grids of Northern Ireland and Scotland. The system has been operational since 2002. However, since 2010, there have been three subsea system faults as a result of a failure in the low voltage (LV) polyethylene Integrated Return Conductor (IRC) insulation allowing water ingress (in addition to one land-based fault). The reason for failures is not confirmed. The interconnector is currently running at half capacity and Moyle Interconnector Ltd (MIL) is investigating options for the restoration of the interconnector to full capacity (500MW).

The preferred long-term option is the installation of two separated (as opposed to integrated), replacement MRC cables between the Northern Ireland and Scotland converter stations. The two existing High Voltage (HV) conductors would remain *in situ* and operational as originally installed. The desired monopole circuits would therefore each comprise the existing HV conductor (in the existing cable) and replacement MRC.

The proposed replacement MRC cables will be installed in a corridor between 50m to 100m south of the north cable, and in a corridor between 50m to 100m south of the south cable along the majority of the route. In near-shore areas, however, they will be installed as close as practically possible to the existing HV conductors (approximately 4m apart).

The replacement cables will be buried to a minimum target depth of 1m or protected by rock armour or matressing if this this not possible (see Section 2.1).

Each of the two existing corridors is approximately 5km long onshore in Scotland, 53km long submarine and 3km long onshore in Northern Ireland.

Finalisation of the cable routes will take into consideration environmental and technical constraints, the results of detailed surveys (if required following further review of existing seabed information) and the feedback from the consultation process. MIL intends to submit an application to MS-LOT for a Marine Licence under the Marine (Scotland) Act 2012 for the extent of the marine cable in Scottish territorial waters and under the Marine and Coastal Access Act (MCAA) 2009 for the extent of the marine cables in Northern Ireland territorial waters.

Centre for Marine and Coastal Studies Ltd (CMACS) has been contracted to provide advice on the likely environmental impacts of heat generated as a result of the operation of the new separated LV returns upon marine fauna. This advice will inform the environmental appraisal of the installation of the new cables in support the Marine Licence application.

2 PROJECT DESCRIPTION

2.1 Overview

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland, stretching 53km across the North Channel of the Irish Sea between landfalls at Portmuck South, County Antrim and Currarie Port, Ayrshire (Figure 1). From the landfalls, the interconnector then runs to converter stations at Ballycronan More in Island Magee, County Antrim and Auchencrosh in Ayrshire.

Figure 1. Moyle Interconnector Route

The existing cables are buried where possible to a depth of 1.5m within seabed sediments. Where this is not possible, for example over hard ground or cable/pipeline crossings, rock armour or matressing has been used to protect the cable.

2.2 Cable Specifications

The interconnector consists of two separate HVDC cables (north and south cable), each with integrated HV and LV conductors in a co-axial design (Figure 2 and Appendix 1). Both the north and south cables are rated to transfer up to 250MW in either direction.

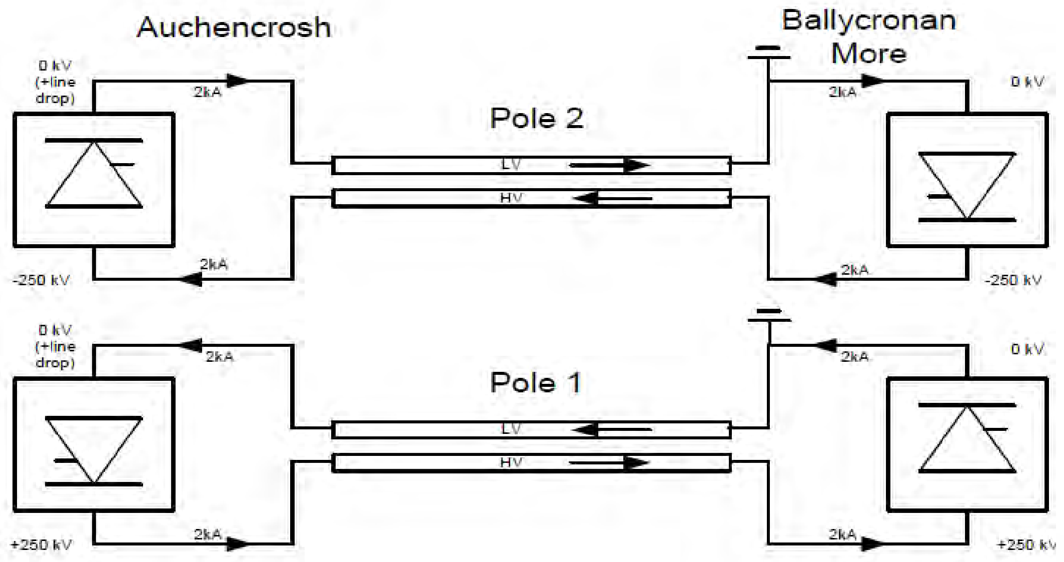

Figure 2. Moyle Interconnector general arrangement

The HV elements of the cables, which utilise conventional mass impregnated paper insulation, have never suffered a fault since commissioning and are expected to remain in good condition. All faults have occurred along the return, LV conductors, the initial three of which have been successfully repaired, but the most recent of which is still damaged (Table 1; Appendix 2).

Table 1. Moyle Interconnector cable fault history

Date	Location	Description	Status
09/09/10	Land-based, South cable	n/a	Repaired
26/06/11	Subsea, South cable	140m depth, partly buried & rock dumped	Repaired
24/08/11	Subsea, North cable	20m depth, buried in silt	Repaired
23/06/12	Subsea, North cable	20m depth, buried in silt	Unrepaired

There is now a lack of confidence in the LV elements of the system, which is currently running at half capacity via the south cable; any further faults along this cable would result in zero power transfer capability.

Proposals to revert to reliable maximum capacity have included:

1. A temporary change to the operational mode of the cables until delivery of Option 2. The station control would be redesigned such that full capacity could be transferred through the two HV conductors, with the currently functional south LV conductor operating as a metallic return. It is understood that this option is no longer being taken forward for consideration at this stage.

2. An enduring solution involving replacement of the integrated LV conductors by laying an additional two new MRC cables between 50 and 100m away from the existing HV conductors (which would remain *in situ* and operational) along the majority of the route and 4m from the HV conductors in near-shore regions.

There is also an emergency fall-back position (possible to be set up in just a few hours) using the integral HV conductors of both cables to serve the functions of one HV conductor and one LV conductor to restore half capacity.

This document provides advice on the likely environmental impacts of heat predicted to be generated from Option 2 upon marine fauna, which will feed into the environmental assessment and non-statutory environmental report being produced to support the Marine Licence applications. Heat associated with Option 2 is expected to be similar to that associated with the emergency fall-back position, and the latter is therefore not assessed separately.

3 ASSESSMENT METHODOLOGY

Intertek consulted with a wide range of organisations to seek their opinion on requirements for environmental assessment through issue of a Scoping Report. In relation to heating effects, Marine Scotland in their Scoping Opinion (dated 25 March 2014) requested further information relating to the predicted temperature rise described in the Scoping Report (Intertek, 2013):

> *There are no other significant emissions, apart from a small temperature effect, associated with the submarine cable in the marine environment.*

Marine Scotland and the Department of the Environment Northern Ireland (DOENI, Scoping Opinion dated 27 March 2013) both requested that the Developer should provide an assessment of the possible ecological effects of construction and operation of the proposed activity.

Heating effects, if present and of sufficient magnitude to have ecological consequences, would be expected to affect only sessile organisms present in or on sediments overlying the cable or motile organisms using such areas in a restricted manner. The focus of this report is therefore on groups such as benthic invertebrates, including commercial shellfish and crustaceans, and not wide-ranging species such as marine mammals or pelagic fish.

4 HEATING EFFECTS OF UNDERWATER POWER CABLES

4.1 Sensitivity of Marine Fauna to Heating

In a shallow, coastal waterbody such as the north eastern Irish Sea the temperature of the sea water varies markedly with the seasons. The Irish Sea Study Group (1990) reported that the water is at its coldest in February/March (5-8.5^{o}C) and warmest in August/September (13-17^{o}C). Although temperature variations are most pronounced in surface waters due to solar warming any marine organism living in the Irish Sea or in surficial sediments will experience annual temperature fluctuations of at least 4-5^{o}C. Somewhat more extreme temperature fluctuations can be expected for intertidal organisms both seasonally and diurnally.

In such an environment it would not be expected that organisms which are highly sensitive to small scale temperature fluctuations would thrive. The thermal tolerances of some invertebrates known to occur in the development area have been reviewed by MarLIN (website accessed 2014) and include the crinoid *Antedon bifida* and the brittle star *Ophiothrix fragilis*. *A. bifida* is distributed between Scotland and Portugal and is likely to be tolerant of long-term increases in temperature (~2°C). As the species is subtidal it is likely to be sensitive to short-term changes although such changes of less than around 5°C are not thought likely to be important. Similarly, long-term changes in temperature are unlikely to have any significant effect on the brittle star and although acute short-term changes in temperature are noted to cause a reduction in the loading of sub-cutaneous symbiotic bacteria in echinoderms such as *O. fragilis* the temperature fluctuations necessary to induce such effects are marked and intolerance is associated with short-term changes in excess of around 5°C.

MarLIN (accessed 2014) provides an assessment of the temperature sensitivity of certain burrowing organisms likely to be present where the cable is installed. Two examples of deeper burrowing organisms are the sand gaper (*Mya arenaria,* a bivalve mollusc) and Norway lobster (*Nephrops norvegicus*). The sand gaper is a large, long-lived and deep burrowing bivalve and has been recorded at up to 50cm depth in sand, mud and sandy gravels from intertidal to fully subtidal areas up to nearly 200m water depth. The southern distribution of the sand gaper may be restricted by a limit of 28°C (Nedwell & Hidu, 1986; Strasser, 1999: both cited in MarLIN, accessed 2014) whilst over-wintering individuals in Alaska tolerate temperatures as low as -2°C (Strasser, 1999: cited in MarLIN, accessed 2014). *N. norvegicus* burrows in soft sediments but to a more shallow depth than *Mya,* typically to around 20—30cm, and might therefore be expected to experience more pronounced temperature changes. The species is recorded as far south as the Mediterranean and Adriatic and therefore adapted to temperatures well in excess of those occurring in the Irish Sea. Both these species, which represent examples of the deepest burrowing members of the invertebrate infauna are regarded as having low intolerance of temperature increases (i.e. they are not sensitive).

In light of the dynamic nature of the Irish Sea in terms of temperature fluctuations, and the inherent tolerance of marine fauna to fluctuations in temperature, it is suggested that any heating effect of the cable would have to be marked, i.e. in excess of around 5°C in surrounding waters or sediment to use the MarLIN benchmark, to represent a potential impact to mobile fauna. Sessile organisms could potentially be affected by smaller variations in temperature but small changes of the order of 1-2°C (2°C is the MarLIN benchmark for long term chronic changes) are thought very unlikely to be significant in the context of an environment that fluctuates naturally by at least twice this amount on an annual basis.

4.2 Anticipated Heating Effects

The existing Moyle integrated return conductor cable and proposed replacement MRC cables utilise impregnated paper tape insulation (Appendix 1). Such cables have maximum design operating conductor temperatures of up to around 80°C; however, the actual operating temperature when passing 1000A (maximum current load) will be approximately 45°C.

CMACS has been provided with information on the heat losses to be expected from the cable system (L. Trim, Cable Consulting International, pers. comm.). The two existing cables currently have thermal losses of up to 37.5W per metre of cable when operating with HV and LV returns together. This will reduce to 20W/m when only the HV element is operational with separate MRC cables. The latter will have thermal losses of approximately 17W/m. The result is therefore to spread the same overall heating effect (around 37W/m) between four as opposed to two cables, with the replacement MRC cables having rather lower thermal losses than the existing HV cables.

These thermal losses will result in a small and localised heating of the environment surrounding the cables (i.e. sediment for buried cable or water in the interstitial spaces of rock armouring or mattress protection). The rate of heat dissipation, and magnitude of environmental heating, will be determined by a number of factors, most notably the amount of power passing through the cables and the thermal properties of the surrounding media.

There is some empirical evidence of resultant heating effects from AC cable systems which have been the subject of interest in recent years due to their use by the rapidly expanding offshore wind farm industry. AC wind farm connections (intra-array and export to shore) generally utilise XLPE (cross-linked polyethylene) insulated cables that have a higher maximum conductor operating temperature of around 90°C. Because of interest in potential heating effects of AC systems, and a lack of direct evidence, CMACS commissioned and supported an undergraduate research project to measure sediment temperature in the intertidal area in relation to the electricity export cable for North Hoyle offshore wind farm in North Wales. The work was undertaken by a final year student under the supervision of Dr Ian Gloyne-Phillips (CMACS) and Dr Rick Leah (University of Liverpool). The main aim of the work was to measure sediment temperature at various depths above one of the two export cables[1] buried at around 2m depth. A related aim was to sample intertidal infauna to

[1] 50Hz AC, rated up to 36kV with three conductor cores per cable totalling 600mm^2 and carrying up to 745A. The normal maximum conductor temperature was 90°C.

investigate for any community level response to the presence of the buried cable. The work is not published but temperature measurements (temperature probe accuracy ±0.1°C) during near-maximum power generation revealed no detectable heating of sediments approximately 1m above the cable (i.e. at 1m depth) compared to reference locations.

Meißner *et al.*, 2007 (cited in OSPAR, 2009) provide the only known published work to measure heating in relation to a buried submarine power cable (intertidally). The rise in temperature did not exceed 1.4°C 20 cm depth above the cable, although the capacity of the cable was only 166 MW.

A report by OSPAR (2009) notes that in Germany, the conservation authorities have agreed a threshold of a maximum tolerable temperature increase of 2°C at 20cm sediment depth. The authors state that to achieve this requires (AC) cables to be buried to at least 1m.

Because of the higher maximum operating temperature of AC systems compared to HVDC it is believed reasonable to suggest that heating effects of AC systems should represent more than worst-case for HVDC. In particular, the German mitigation requirements reported in OSPAR (2009) suggest that no infaunal organisms should be exposed to temperature increases in excess of 2°C in the upper 20cm of sediment when cables are buried to 1m depth. Where cables are in contact with water within the interstices of rock armouring it would be expected that heating effects would be smaller because of the high heat capacity of water compared to sediments.

The relatively high heat capacity of water also means that irrespective of cable burial depth only infauna (subtidal or intertidal) could potentially be exposed to more than trivial temperature changes. Demersal fish species or surface dwelling invertebrates, whether mobile or sessile, would be protected from heating effects by the ability of the surrounding water to dissipate heat.

4.3 Anticipated Marine Environmental Effects of Heating

Since the surrounding water column will rapidly dissipate any heat from the cable the only organisms likely to experience elevated temperatures are those burrowing into surrounding sediments. The deepest burrowing organisms likely to be present, such as *Nephrops norvegicus* and *Mya arenaria*, are expected to burrow to around 0.5m depth and could come within approximately 0.5m of the cable if it is buried to 1m (the assumed minimum depth of the new LV cables when buried). There is not expected to be a significant effect at this distance; certainly, heating effects would be expected to result in less than a 2°C temperature rise as evidenced in Section 4.2.

For the vast majority of infauna which are restricted to upper sediments less than 20cm deep heating effects are expected to be even smaller, due to the increased distance from the cable and the increasing influence of the overlying water in controlling sediment temperature.

No significant effects are anticipated for marine fauna.

Where the Moyle Interconnector crosses the Western HVDC Link (which connects the West Coast of Scotland to the Wirral), it is assumed surface-laying with protective rock mattressing and dumping will be utilised. Any cumulative heating effects are therefore expected to be trivial owing to the high heat capacity of water in the interstitial spaces.

5 REFERENCES

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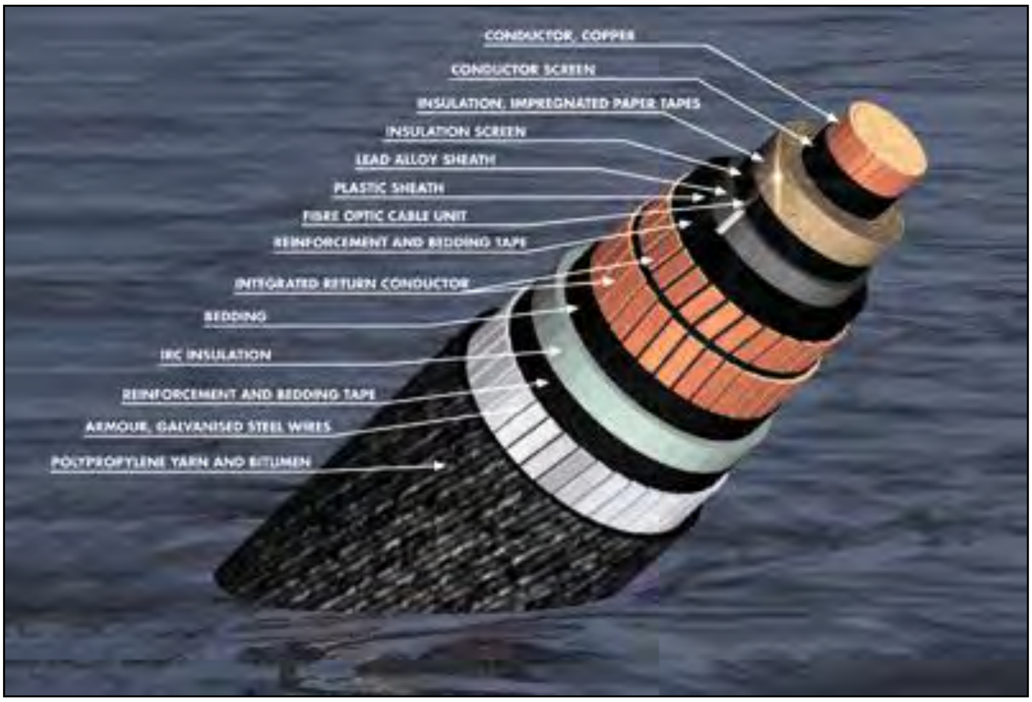
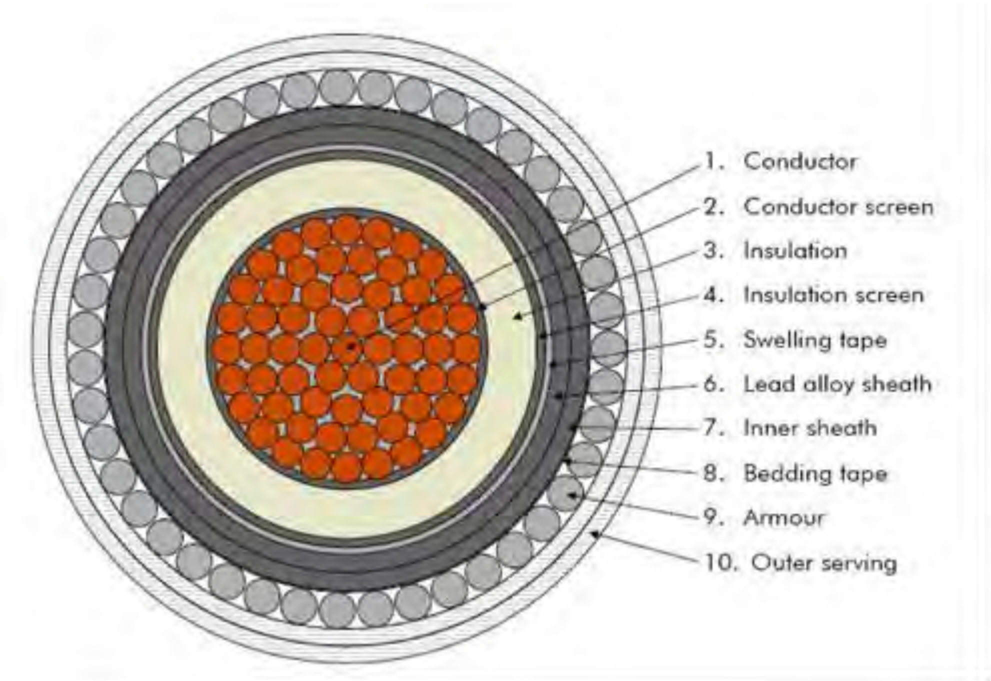
APPENDICES

Appendix 1. Moyle Integrated Return Conductor Cable



Appendix 2. Example Cable Construction



A.2.6 – Marine Mammal Baseline Report (desk study to collate information on marine mammal use of the Project Area)

Centre for Marine and Coastal Studies Ltd

MOYLE INTERCONNECTOR:
MARINE MAMMAL BACKGROUND REPORT

Review of occurrence, distribution and abundance of marine mammal species in relation to the Project Area

Client: Moyle Interconnector Limited

REPORT STATUS: CONFIDENTIAL

Document: J3257 Moyle Interconnector Marine Mammal Background Report v4

Version	Date	Description	Prepared by	Checked by	Approved by
1	Aug 2014	Submitted draft	KLS	JK	IGP
2	Sept 2014	Minor edits	KLS	JK	IGP
3	Oct 2014	Updated following consultee comments	KLS	JK	EH
4	Dec 2014	Terminology update	JK	JK	IGP

Contents

Figures

1 Introduction

1.1 Project Summary

The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland, stretching 63km across the North Channel of the Irish Sea between landfalls at Portmuck South, County Antrim and Currarie Port, Ayrshire. From the landfalls, the Interconnector then runs to converter stations at Ballycronan More in Island Magee, County Antrim and Auchencrosh in Ayrshire.

The system has been operational since 2002, however, since 2010, there have been three subsea system faults as a result of a failure in the low voltage (LV) polyethylene Integrated Return Conductor (IRC) insulation allowing water ingress (in addition to one land-based fault). The reason for failures is not confirmed. The interconnector is currently running at half capacity to restore the Moyle Interconnector to its full operating capacity of 500MW and to remove the dependence on the integrated LV conductors, Moyle Interconnector Ltd plans to install two separated, replacement metallic return conductor (MRC) cables between the Northern Ireland and Scotland converter stations.

The proposed replacement MRC cables will be installed in a corridor between 50m to 100m south of the north cable, and in a corridor between 50m to 100m south of the south cable along the majority of the route. In near-shore areas, however, they will be installed as close as practically possible to the existing HV conductors (approximately 4m apart).

Centre for Marine and Coastal Studies Ltd (CMACS) has been contracted to review the occurrence, distribution and abundance of marine mammals (cetaceans and pinnipeds) in relation to the Project Area by collating and summarising existing baseline data. Consideration will also be given to marine turtles (chelonians).

The Project Area is defined as the northern and southern limits of the existing and new cable locations i.e. the existing north cable represents the northern limit and 100m south of the existing south cable represents the southern limit of the Project Area (Figure 1).

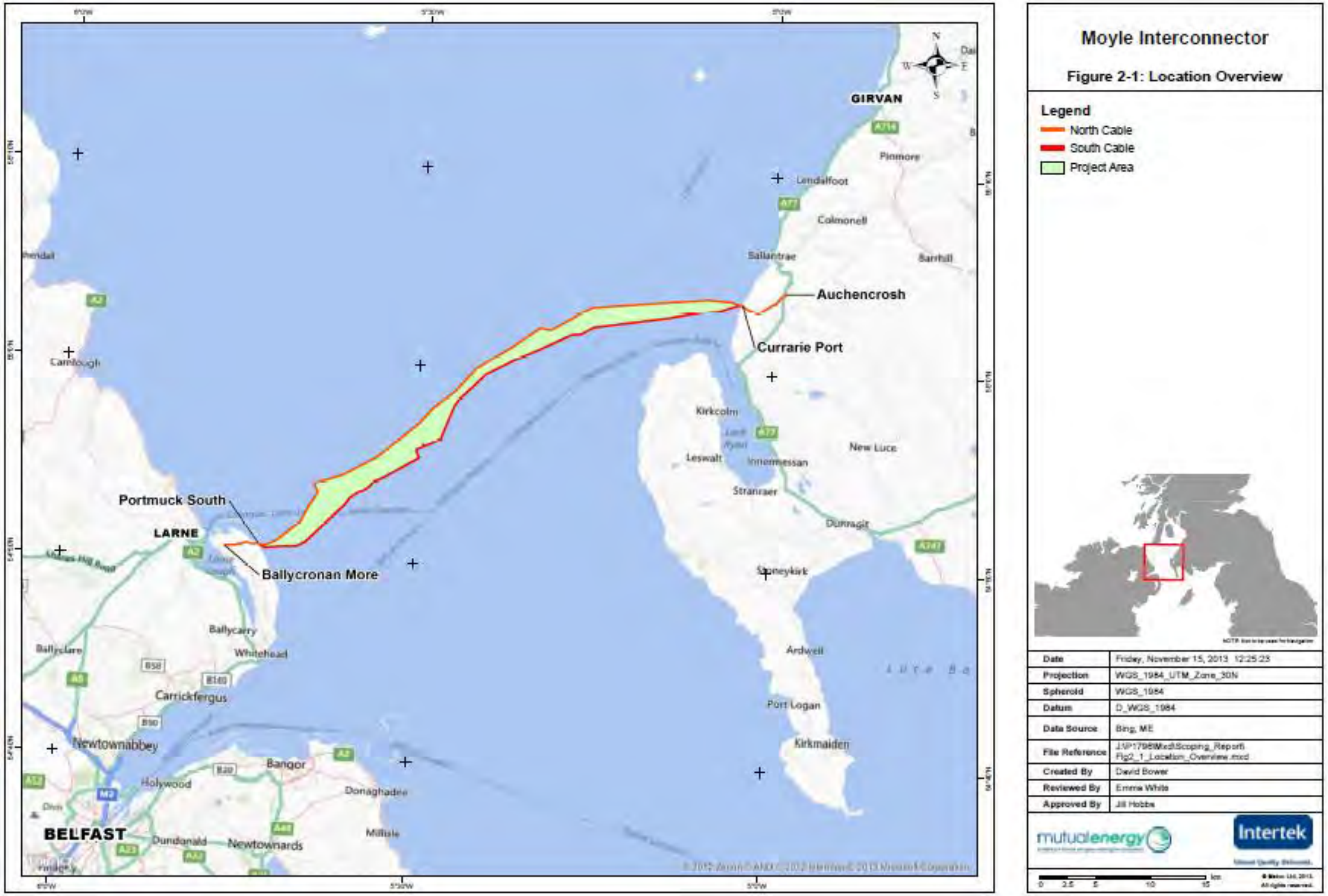


Figure 1. Moyle Interconnector Route and Project Area

1.2 Legislation Protecting Marine Mammals and Marine Turtles

Marine mammals and marine turtles are legally protected throughout Europe under the Habitats Directive (92/43/EEC) and in UK waters (0-12 nautical miles) under the Wildlife and Countryside Act 1981 and Nature Conservation (Scotland) Act 2004 and the Wildlife (Northern Ireland) Order 1985 (as amended).

All cetaceans and five species of marine turtles are listed in Annex IV of the Habitats Directive as European Protected Species (EPS). Some activities in the marine environment may kill, injure or disturb marine mammals. Offences relating to the protection of marine EPS are provided for under Article 12 of the Habitats Directive and transposed into domestic legislation under the Conservation of Habitats and Species Regulations 2010 and Offshore Marine Conservation (Natural Habitats, and c.) Regulations 2007, collectively known as the Habitat Regulations and prohibits the deliberate and reckless capture, injury, killing and disturbance of marine EPS. In Scotland the Habitats Directive is transposed through a combination of The Conservation of Habitats and Species Regulations 2010 and the Conservation (Natural Habitats, &c.) Regulations 1994. The Conservation (Natural Habitats, &c) Regulations (Northern Ireland) 1995 (as amended) transpose the Habitats Directive in relation to Northern Ireland (http://jncc.defra.gov.uk/page-1379).

Annex II of the Habitats Directive lists species of European Community interest whose conservation requires the designation of Special Areas of Conservation (SAC). Although grey and harbour seals are not listed Annex IV species, their inclusion in Annex II of the directive means that they may qualify as designated features of Special Areas of Conservation (SAC).

There are four marine mammal species listed on Annex II of the Directive that are known to occur in significant numbers in UK waters:

- Grey seal (*Halichoerus grypus*)
- Harbour (common) seal (*Phoca vitulina*)
- Bottlenose dolphin (*Tursiops truncatus*)
- Harbour porpoise (*Phocoena phocoena*)

Some marine turtles listed on Annex II also occur in UK waters but are unlikely to qualify as interest features of SACs. Further protection of pinniped species is provided under the Conservation of Seals Act 1970, the Marine (Scotland) Act 2010 and The Wildlife (Northern Ireland) Order 1985 (as amended).

Additionally, the UK has signed up to the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS). This agreement aims to restore and maintain populations of small cetaceans through the co-ordination and implementation of conservation measures. The Agreement identifies disturbance, especially of an acoustic nature, as a factor that may adversely affect small cetaceans. A number of Resolutions have been adopted to address this and reduce acoustic disturbance on cetacean species. (https://www.gov.uk/dangers-to-marine-species-and-measures-to-protect-them).

2 Methods

2.1 Overview

A number of data sources were used to provide information on the spatial and temporal distribution and abundance of marine mammals and turtles in relation to the Project Area. Because of the wide-ranging nature of marine mammals it was necessary to consider a wider geographical area than the limited Project Area; the Study Area is described in Section 2.2.

The primary data sources are detailed in Sections 2.3.2 to 2.3.8. Results are presented in Section 3. Where available and appropriate, other publications, papers and reports were used to inform this review. These have been referenced throughout the report and are listed in Section 5.

2.2 Study Area

This review considers the distribution and abundance of marine mammals and turtles known to occur within or adjacent to the Project Area located within the Northern Channel of the north Irish Sea geographical region. Due to the wide ranging migratory nature of marine mammals, consideration is given to populations occurring not only within this area, but within the Irish Sea wider region, north east Atlantic and the waters of the European Atlantic Continental Shelf.

The Project Area is located in other geographically defined areas, which are useful to understand when reviewing marine mammal data for this region:

- The Department of Energy and Climate Change Strategic Environmental Assessment (SEA) is the process of appraisal through which environmental protection and sustainable development may be considered in relation to national plans. The SEA Process subdivides the UK Continental shelf (UKCS) into eight areas based on variations in factors such as temperature, depth and currents. The Project Area occurs within Strategic Environmental Assessment Area 6 (SEA 6) (Figure 2).

- The Small Cetacean Abundance in the North Sea (SCANS) survey(s), which significantly informs the understanding of marine mammals in the region of interest, sub-divided European Atlantic waters into survey blocks (Figure 3).

The Data related to marine mammal species occurrence and abundance in the Project Area and immediately adjacent regions is not comprehensive, but there are numerous data sources available that, when considered in combination, can help to inform on species abundance and distribution in this region.

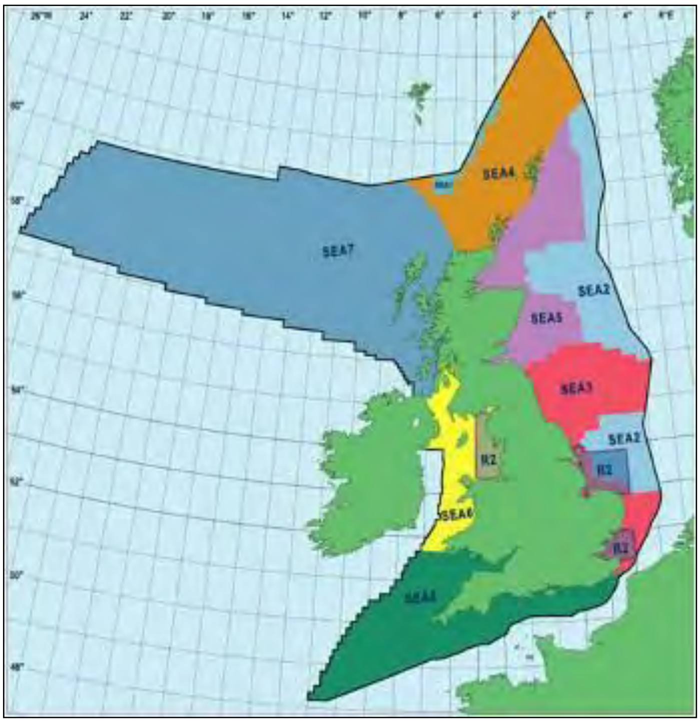


Figure 2. Map to show location of Strategic Environmental Assessment Area 6

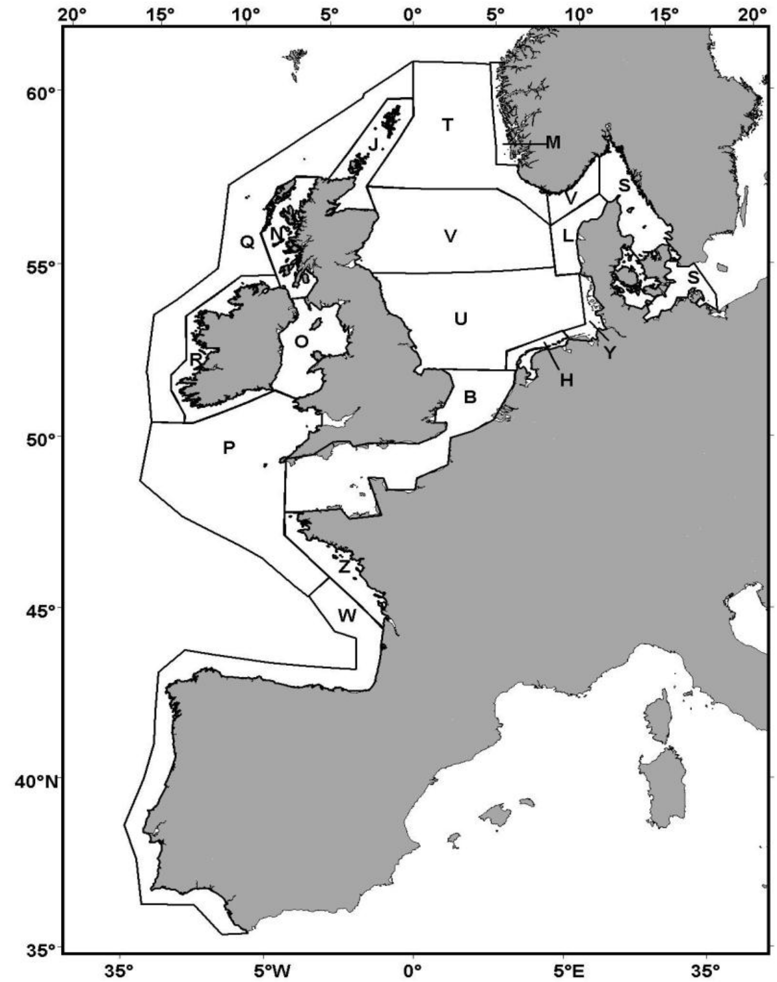


Figure 3. Survey blocks defined for the SCANS-II surveys

2.3 Data Sources

2.3.1 Small Cetaceans in the European Atlantic and North Sea (SCANS)

The first SCANS project survey took place in the July 1994 and was conducted by teams of observers on research ships and small aircraft across different survey blocks in north-west European waters. Line transect methods were used to collect distance sampling data to estimate the number of animals in the areas. This survey generated the first large-scale, robust, abundance estimates for many cetacean species in the North Sea and European Atlantic continental shelf waters; however, the 1994 SCANS survey only marginally entered the southern boundary of the Irish Sea and did not cover all waters to the west of Britain and Ireland. A further survey (SCANS II) took place in July 2005, which extended survey coverage to include the Irish Sea and north-east Atlantic. Using the survey data collected, it was possible to calculate animal density and abundance for the different survey blocks and where possible, surface density maps were produced for the areas surveyed. The project was co-ordinated by the University of St Andrews Sea Mammal Research Unit (SMRU).

2.3.2 Cetacean Atlas (Atlas of Cetacean distribution in north-west European waters (2003) Reid, J.B., Evans, P.G.H., & Northridge, S.P.)

A number of organisations associated with cetacean research in Europe contributed cetacean sightings data to a co-operative venture called the Joint Cetacean Database (JCD), and it is the data from this resource that are depicted in this Atlas. Data used to inform this Atlas primarily came from three main sources, European Seabirds at Sea (ESAS) data, Sea Watch Foundation data and the original SCANS survey and is used to provide an account of the distribution of all 28 cetacean species that are known certainly to have occurred in the waters off north-west Europe in the last 25 years. It should be noted that maps in the Atlas hide temporal and to some extent spatial variation.

2.3.3 The Joint Cetacean Protocol (JCP)

EU Member States have a legal obligation under Article 11 of the Habitats Directive to undertake surveillance of all cetacean species occurring in their waters to determine their conservation status, and to report on this every 6 years. The Joint Cetacean Protocol (JCP) has been established by the Joint Nature Conservation Committee (JNCC), to facilitate the reporting requirements of the Habitats Directive and is the successor of the Joint Cetacean Database and JNCC Cetacean Atlas.

The aim of the JCP is to integrate effort related data on cetacean abundance, characterise cetacean abundance and distribution in European waters, and detect trends in abundance at large scales.

Advice from JNCC (Pers. Comms., August 2014) is that outputs from Phase III of JCP (including the production of species specific density surface data) are expected to be published in autumn 2014 and are therefore not available at time of writing.

2.3.4 UK Department of Trade and Industry offshore energy Strategic Environmental Assessment programme

In order to inform the SEA process a report on background information of marine mammals in SEA 6 was produced (Hammond *et al.*, 2005).

2.3.5 Joint Nature Conservation Committee Reports by the UK under Article 17 on the implementation of the Habitats Directive

Under Article 17 of the Habitats Directive all EU Member States are required to report on the implementation of the Directive. In the UK, these reports are compiled by the JNCC with the support of the relevant statutory nature conservation bodies (SNCB) and government administrations. The most recent report, including marine mammal species reports, was submitted to the European Commission in 2013 (3rd Report by the UK under Article 17 on the implementation of the Habitats Directive).

2.3.6 Seal usage maps, produced by the Sea Mammal Research Unit, University of St Andrews as a deliverable of Scottish Government Marine Mammal Scientific Support Research Programme

Marine Scotland commissioned the Sea Mammal Research Unit (SMRU) at the University of St Andrews to investigate the biology of marine mammals in areas likely to be used for renewable energy generation and to provide maps showing the distribution of grey and harbour seals around the UK. Maps were produced by looking at movement patterns from electronically tagged seals (Grey and harbour seal usage maps, Sea Mammal Research Unit).

2.3.7 Special Committee on Seals (SCOS) Reports

The Special Committee on Seals (SCOS) was appointed by the Natural Environment Research Council (NERC) to assist in fulfilling its duty to provide scientific advice to government on matters related to the management of seal populations as required under the Conservation of Seals Act 1970 and the Marine (Scotland) Act 2010. Formal advice is given annually based on the latest scientific information provided to SCOS by the Sea Mammal Research Unit.

2.3.8 TURTLE: A Database of Marine Turtle Records for the United Kingdom & Eire

Historically, records on marine turtles in British waters have been held at various locations by many different institutions, organisations and individuals. The TURTLE database was set up to help collate and provide information on marine turtles in the British Isles.

3 Results

3.1 Marine Mammals

Twenty eight species of cetacean are known to occur in the waters of north-west Europe, eighteen of which have been recorded in the Irish Sea (Reid *et al.*, 2003). However, only five species of cetacean and two species of pinniped are known to regularly occur in this region:

- Bottlenose dolphin (*Tursiops truncatus*)
- Harbour porpoise *(Phocoena phocena)*
- Risso's dolphin (*Grampus griseus*)
- Short-beaked common dolphin (*Delphinus delphis*)
- Minke whale (*Balaenoptera acutorostrata*)
- Grey seal (*Halichoerus grypus*)
- Harbour seals *(Halichoerus grypus)*

The abundance and distribution of the above species are the main focus of this report; however, it should be noted that there have also been occasional recordings of the following cetacean species in the wider Irish Sea region (Hammond *et al.*, 2005):

- Fin whale (*Balaenoptera physalus)*
- Sei whale (*Balaenoptera borealis)*
- Humpback whale (*Megaptera novaeangliae)*
- Sperm whale (*Physeter macrocephalus)*
- Northern bottlenose whale *(Hyperoodon ampullatus)*
- Killer whale *(Orcinus orca)*
- Long-finned pilot whale *(Globicephala melas)*
- Striped dolphin (*Stenella coeruleoalba)*
- Atlantic white-sided dolphin (*Lagenorhynchus acutus)*
- White-beaked dolphin (*Lagenorhynchus albirostris)*

3.2 Marine Turtles

Of the seven known marine turtle species, five have been recorded in British waters:

- Leatherback turtle (*Dermochelys coriacea*)
- Loggerhead turtle (*Caretta caretta*)
- Green turtle (*Chelonia mydas*)
- Hawksbill turtle (*Eretmochelys imbricata*)
- Kemp's Ridley turtle (*Lepidochelys kempii*)

The most commonly occurring species is the leatherback turtle. This species can regularly occur during the summer months in British and Irish coastal waters (Langton, 1996).

3.3 Species Accounts

3.3.1 Cetaceans

3.3.1.1 Toothed Whales (*Odontoceti*)

3.3.1.1.1 Harbour porpoise (*Phocoena phocoena)*

The harbour or common porpoise primarily occurs in cold temperate and sub-arctic waters of the northern hemisphere, typically occupying continental shelf waters between depths of 20-200 m and commonly inhabiting shallow coastal bays, estuaries and tidal channels (Hammond *et al.*, 2005). It is the smallest and most abundant cetacean in north-west Europe usually occurring in small groups of one to three individuals (Hoek, 1992, Reid *et al.*, 2003, Shirihai, 2007).

This species is present year round in coastal UK waters and may be a permanent resident in some areas, with peak numbers typically observed March to April and July to November. The observed peaks in these months may however be related to undercounting in the winter months due to reduced observational effort and the difficulty in observing this species in adverse weather conditions (Baines, 2009).

In British waters this species is most abundant around north-west and north-east Scotland, western and southern Ireland, most of the coast of Wales and off south-west England (Hammond *et al.*, 2005). Figure 4 presents the distribution of harbour porpoise in north-west European waters (Reid *et al.*, 2003). It should be noted that the Northern Ireland Cetacean Monitoring programme has recorded porpoise nearby the Interconnector at Portmuck and Black Head (www.iwge.ie).

When comparing the results of the SCANS I (1994) and SCANS II (2005) surveys, there appears to be little change in the abundance of harbour porpoise in the wider north-west European region although a general shift in distribution from north to south was observed in the North Sea, possibly related to changes in prey availability. Additionally, there was an observed increase in animal density in the Celtic Sea (Hammond *et al.*, 2013). However, as the 1994 SCANS I survey did not cover all waters to the west of the UK, including the majority of the Irish Sea and North Channel, it is not possible to provide a similar comparison from this data for the western UK harbour porpoise population (JNCC, 2013).

It is understood that this species is not evenly distributed within the Irish Sea (Baines, 2009) with population densities being higher in the southern sector and into the Celtic Sea (Hammond *et al.*, 2005). Figure 5 presents the predicted surface density of harbour porpoise from the SCANS II survey (Hammond *et al.*, 2013).

Most recent population density/abundance estimates from SCANS II surveys provide the following information (SMRU, 2006; Hammond *et al.*, 2013):

European Atlantic estimated abundance:	375,358
Irish Sea zone estimated abundance:	15,230
Irish Sea zone estimated density:	0.34/km^2

Based on the information available it would not be unreasonable to expect regular year round occurrence of this species within the vicinity of the Project Area; however the SCANS II data (Figure 5) suggests that animal abundance is relatively lower in this region than in other parts of the UK.

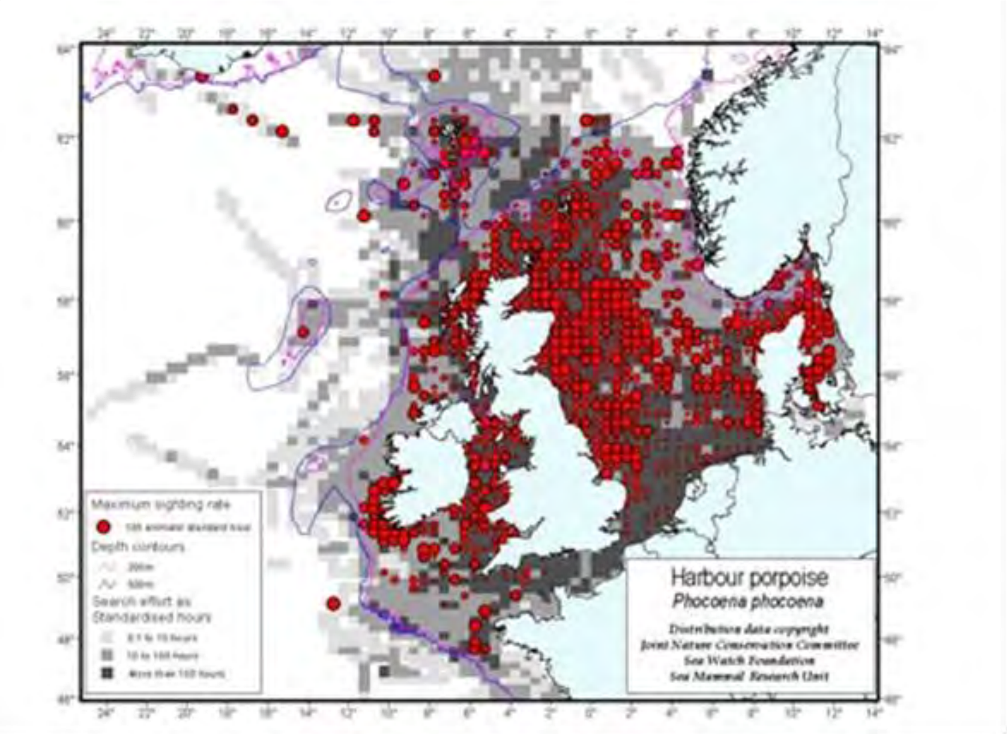


Figure 4. Distribution of harbour porpoise in north-west European waters (Reid *et al.*, 2003)

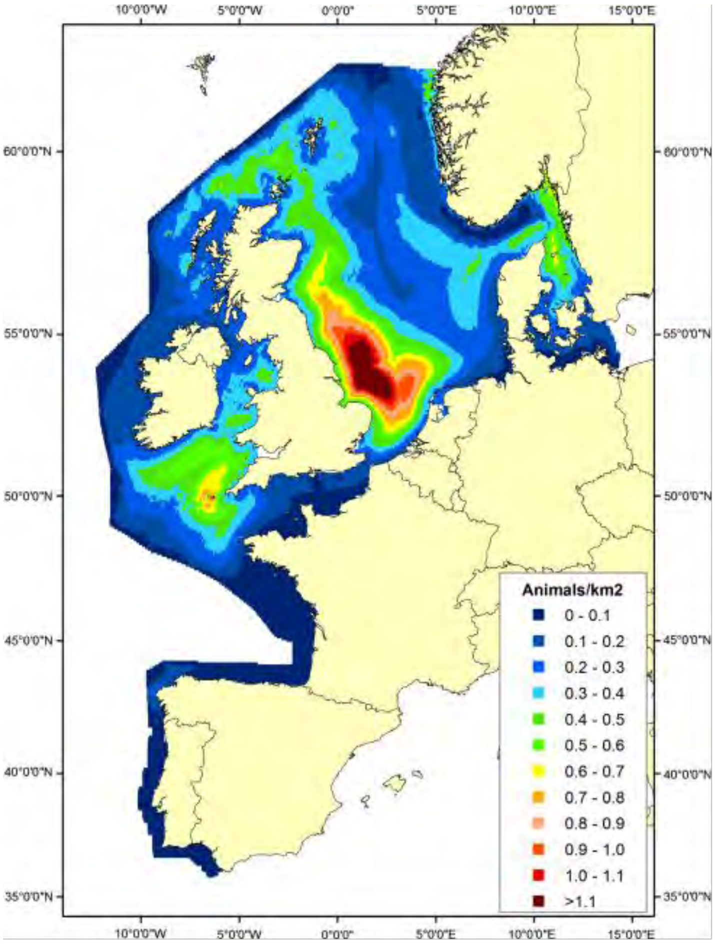


Figure 5. Predicted density surface for harbour porpoise in 2005 (Hammond 2012)

3.3.1.1.2 Bottlenose dolphin (*Tursiops truncates*)

Bottlenose dolphins are found in temperate and tropical seas of the southern and northern hemispheres (Reid *et al.*, 2003) and are both a coastal and oceanic species. This species occupies diverse habitats, ranging from rocky reefs to calm lagoons and open waters (Jefferson, 1993). In coastal waters they often favour habitats where there are strong currents and uneven topography such as estuaries, headlands and sandbanks (Lewis, 2003, Reid *et al.*, 2003).

Bottlenose dolphins are large animals and can measure up to 4 m in North Atlantic waters. Although this species has been reported occurring individually they can be found in groups of between 10-100 inshore and units of several hundred in deeper offshore waters (Shirihai, 2007, Reid *et al.*, 2003). Typically, animals occur in small groups near the coast in the summer dispersing more widely and generally northwards in the winter forming large groups (Baines, 2009).

In UK waters this species is most abundant in the Irish Sea and north-east Scotland with observed peaks in May to September but with some near shore coastal individuals present year round (Hammond *et al.*, 2005). Although there are limited quantitative effort-related observations for the Irish Sea, this species is regularly sighted and recorded and is one of the most abundant cetaceans in this region (Baines, 2009).

Figure 6 shows bottlenose dolphin distribution in north-west European waters (Reid *et al.*, 2003) which indicates a predominantly coastal distribution with concentrations around north-east Scotland, south-west Ireland and the southern Irish Sea off the coast of Wales. There are regular sightings in summer months off the Galloway coast of south-west Scotland, around the Isle of Man and north Anglesey (Hammond *et al.*, 2005).

Most recent population density/abundance estimates from SCANS II surveys provide the following information (SMRU, 2006; Hammond *et al.*, 2013):

European Atlantic estimated abundance:	16,485
Irish Sea zone estimated abundance:	235
Irish Sea zone estimate density:	0.0052/km^2

Based on the information available it would not be unreasonable to expect year round occurrence of this species within the vicinity of the Project Area; however, high concentrations of animals are not known to regularly occur in this region relative to other locations in the UK.

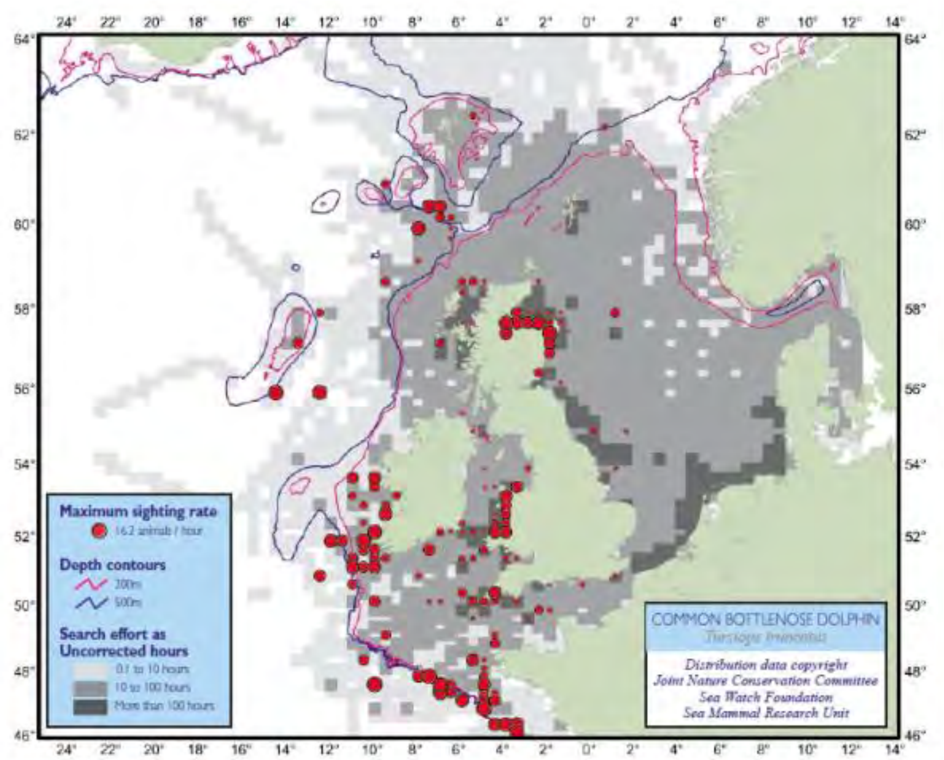


Figure 6. Distribution of bottlenose dolphin in north-west European waters (Reid *et. al.,* 2003)

3.3.1.1.3 Short-beaked common dolphin (*Delphinus delphis*)

Common dolphins are found in all seas throughout the world and are one of the most abundant species in temperate and tropical waters of both the northern and southern hemispheres (Hammond *et al.*, 2005, Reid *et al.*, 2003). They are typically an oceanic dolphin, but are known to also occur regularly in coastal waters with the short beaked species favouring temperate deeper waters and the long beaked common dolphin occurring in mainly warm temperate and tropical waters. (Evans, 1994, Reid *et al.*, 2003).

This species is usually easy to identify at sea due to its distinctive pattern and colouring and the short-beaked common dolphin is the most abundant offshore cetacean in the north-east Atlantic. Common dolphins have been reported individually but are usually found in groups that range in size from several dozen to several thousand, occupying diverse habitats, ranging from rocky reefs to calm lagoons and open waters (Jefferson, 1993).

Around the coast of the British Isles, the short-beaked common dolphin mainly occurs in the western English Channel, Celtic Sea and off the coast of southern and western Ireland and is predominantly present during the summer when it is one of the most abundant cetacean species within the Irish Sea, although it may remain in Celtic waters into November (Hammond *et al.*, 2005; Baines, 2009).

Figure 7 shows short-beaked common dolphin distribution in north-west European waters (Reid *et al.*, 2003) indicating a predominantly offshore distribution and with concentrations in the south west of the region, but numbers inhabiting particular areas may vary considerably between seasons and years. In summer months this species also occurs further north in the Sea of Hebrides, around the Shetlands and Orkneys (Reid *et al.*, 2003).

Most recent population density/abundance estimates from SCANS II surveys provide the following information (SMRU, 2006; Hammond *et al.*, 2013):

European Atlantic estimated abundance:	56,221
Irish Sea zone estimated abundance:	826
Irish Sea zone estimate density:	0.018/km^2

Based on the information available it would not be unreasonable to expect occurrence of this species within the vicinity of the Project Area, especially in the summer months; however, this region supports relatively fewer animals than other locations to the south and west of the UK and Ireland where abundance and occurrence rates are significantly higher.

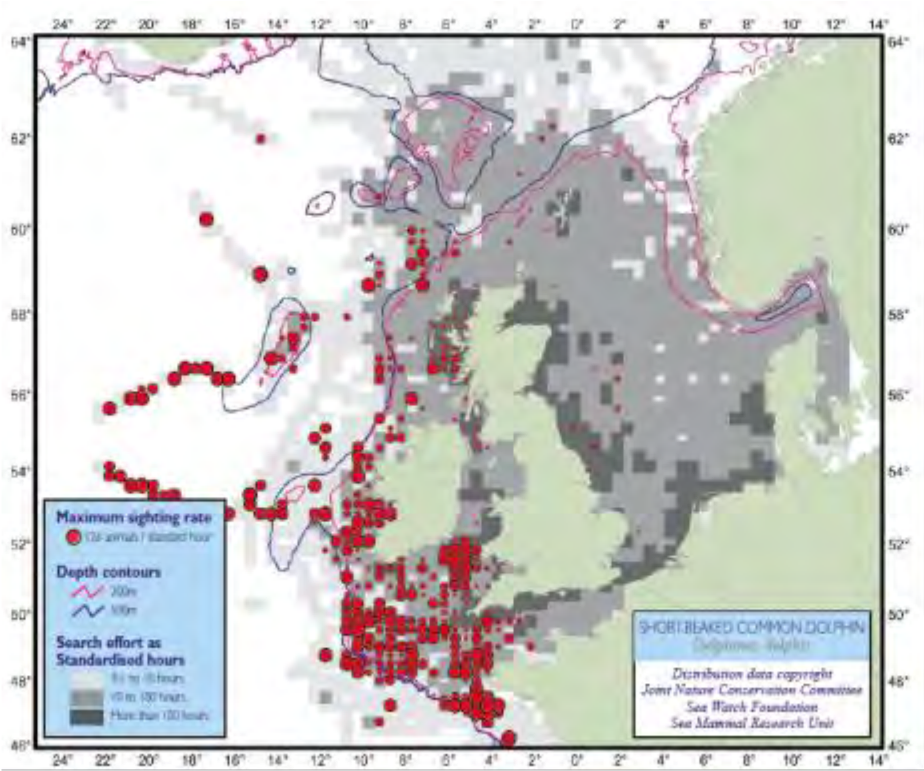


Figure 7. Distribution of short-beaked common dolphin in north-west European waters (Reid *et. al.,* 2003)

3.3.1.1.4 Risso's dolphin (*Grampus griseus*)

Risso's dolphins are widely distributed throughout temperate and tropical deep oceanic and continental shelf waters of both hemispheres. Group sizes tend to be small to moderate, although groups constituting several thousand individuals have been recorded (Jefferson, 1993) and this species will often associate with other species of cetacean. Within northern European waters concentrations occur off the Hebrides; however, animals are regularly seen in the Irish Sea and off southwest Ireland. In the UK continental shelf waters animals have been observed mainly in areas of 50–100 m depth (Reid *et al.*, 2003; Baines, 2009). Within the Irish Sea animals are typically observed in the southern part of the region within 10 km of the coast and predominantly occur off north Wales and around the Isle of Man (Kruse, 1999; Evans, 2003; Reid *et al.*, 2003).

Animals occur mainly in the summer and autumn with the highest sighting rates in the period July to September (Reid *et al.*, 2003; Hammond *et al.*, 2005; Hammond *et al.*, 2013). Due to small numbers and sporadic distribution there is limited data available for this species in UK waters and therefore, due to a deficiency of robust data, no population estimate exists for Risso's dolphin in this region (Reid *et al.*, 2003); however, Figure 8 shows distribution in north-west European waters based on the data available. The SCANS II survey was also not able to provide accurate estimates for Risso's dolphins as there were too few observations during surveys, however, a study identified at least 142 individuals over two summers in the north-western Minch off western Scotland (Atkinson, 1999).

Based on the information available it would not be unreasonable to expect occasional occurrence of this species within the vicinity of the Project Area; however, it would appear that occurrence of this species is more likely in the waters further north and west of Scotland than in the Northern Channel.

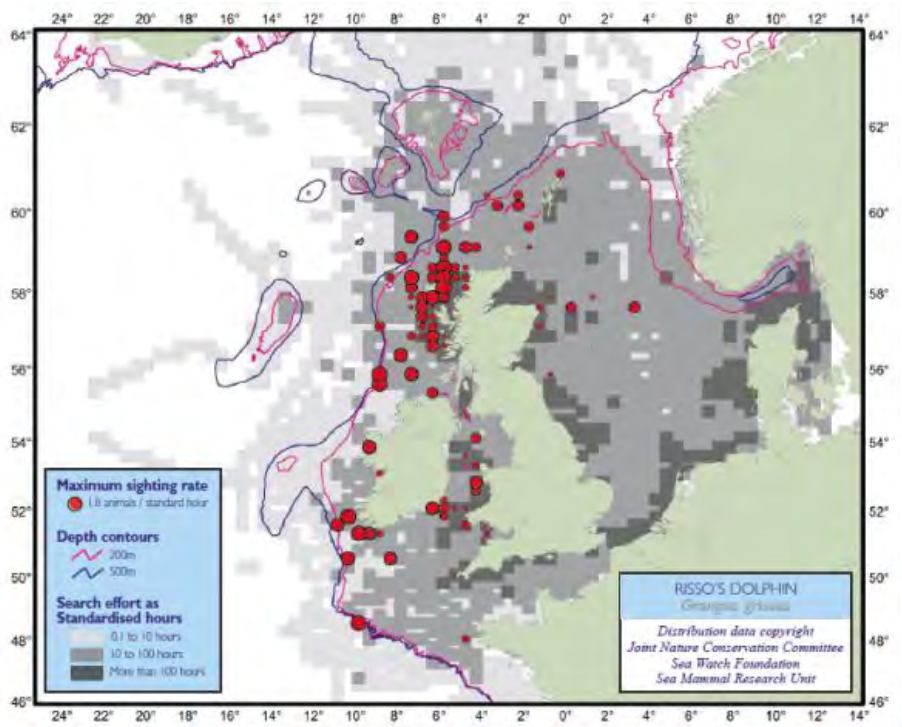


Figure 8. Distribution of Risso's dolphin in north-west European waters (Reid *et. al.,* 2003)

3.3.1.2 Baleen Whales (*Mysticeti*)

3.3.1.2.1 Minke whale (*Balaenoptera acutorostrata)*

Minke whales are the smallest and most abundant baleen whale and are widely distributed from the tropics and temperate waters to polar seas, with individuals reaching a maximum length of 10.7 m (Jefferson, 1993). The species seasonally migrates from polar feeding grounds to warm temperate or tropical breeding grounds although animals in temperate regions may remain year round (Haug, 1995; Evans, 2003). Animals are typically seen individually or in pairs but larger groups of 10 to 15 animals can occur with whales mainly occurring in continental shelf water depths of 200m or less (Reid *et al.*, 2003; Hammond *et al.*, 2005). This species is frequently seen in inshore northern and western coastal waters of the UK, occurring year round but with most sightings between May and September. In the Irish Sea, animals occur mainly in the summer in the deeper central region and are rarely recorded north of the Isle of Man (Reid *et al.*, 2003; Hammond *et al.*, 2005).

Figure 9 shows the distribution of minke whale in north-west European waters and Figure 10 shows the SCANS II surface density map for minke whale.

Most recent population density/abundance estimates from SCANS II surveys provide the following information (SMRU, 2006; Hammond *et al.*, 2013):

European Atlantic estimated abundance: 18,958

Irish Sea zone estimated abundance: 1073
Irish Sea zone estimate density: 0.024/km^2

Based on the information available it would not be unreasonable to expect occasional occurrence of this species within the vicinity of the Project Area; however, occurrence and abundance of this species in this area is significantly lower than in other waters off the UK.

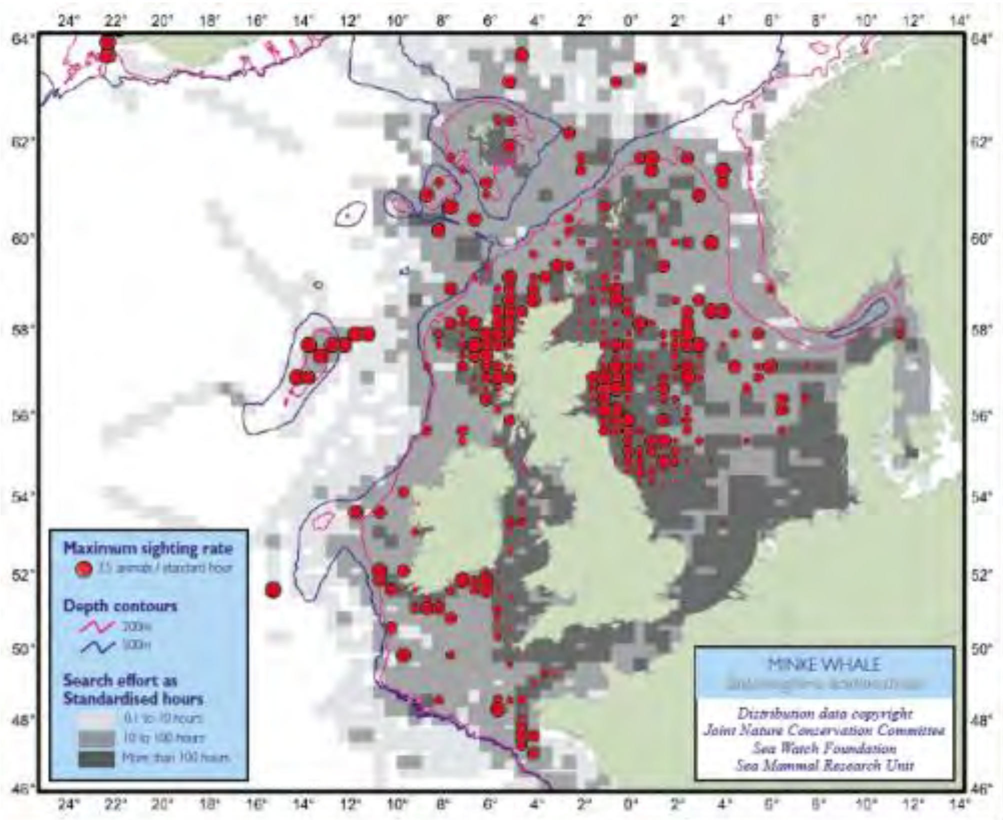


Figure 9. Distribution of minke whale in north-west European waters (Reid *et al.*, 2003)

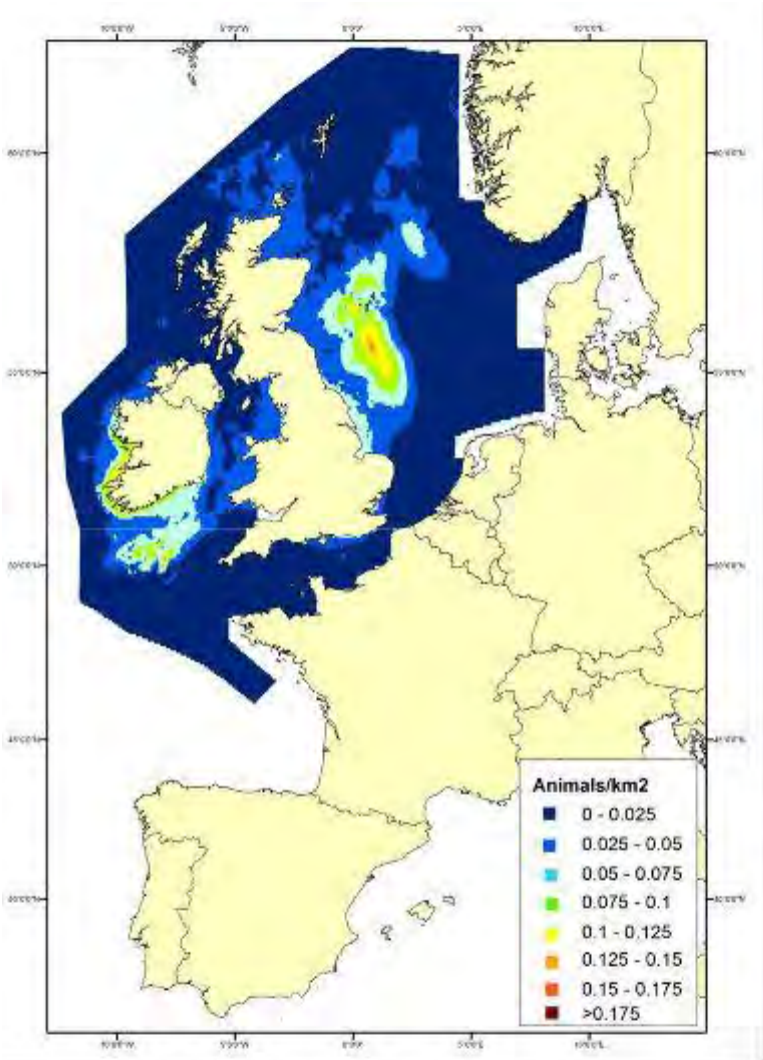


Figure 10. Predicted density surface for minke whale in 2005 (Hammond *et al.*, 2013)

3.3.1.3 Other species

Of the less commonly occurring cetacean species that have been recorded in the region (as listed in Section 3.1) only the fin whale, long-finned pilot whale, killer whale and white-beaked dolphin have been recorded more than casually (Hammond, 2012).

3.3.1.3.1 Fin whale (*Balaenoptera physalus*)

The fin whale occurs in all oceans of the world but mainly in temperate and polar seas of both the northern and southern hemispheres. Animals migrate to polar waters in summer for feeding and return to warmer seas in winter for breeding. The species is one of the largest of the baleen whales, second only in size to the blue whale (*Balaenoptera musculus*). Animals may occur individually or in groups of 6 to 10 individuals typically in deeper waters (200-4,000m). This species is relatively uncommon in the eastern Atlantic and only occasionally sighted in the Irish Sea when it may occasionally migrate through the region from Iceland and Norway to the Mediterranean (Shirihai, 2007, Hammond, 2012). Figure 11 shows the locations of opportunistic sightings of fin whales around the UK.

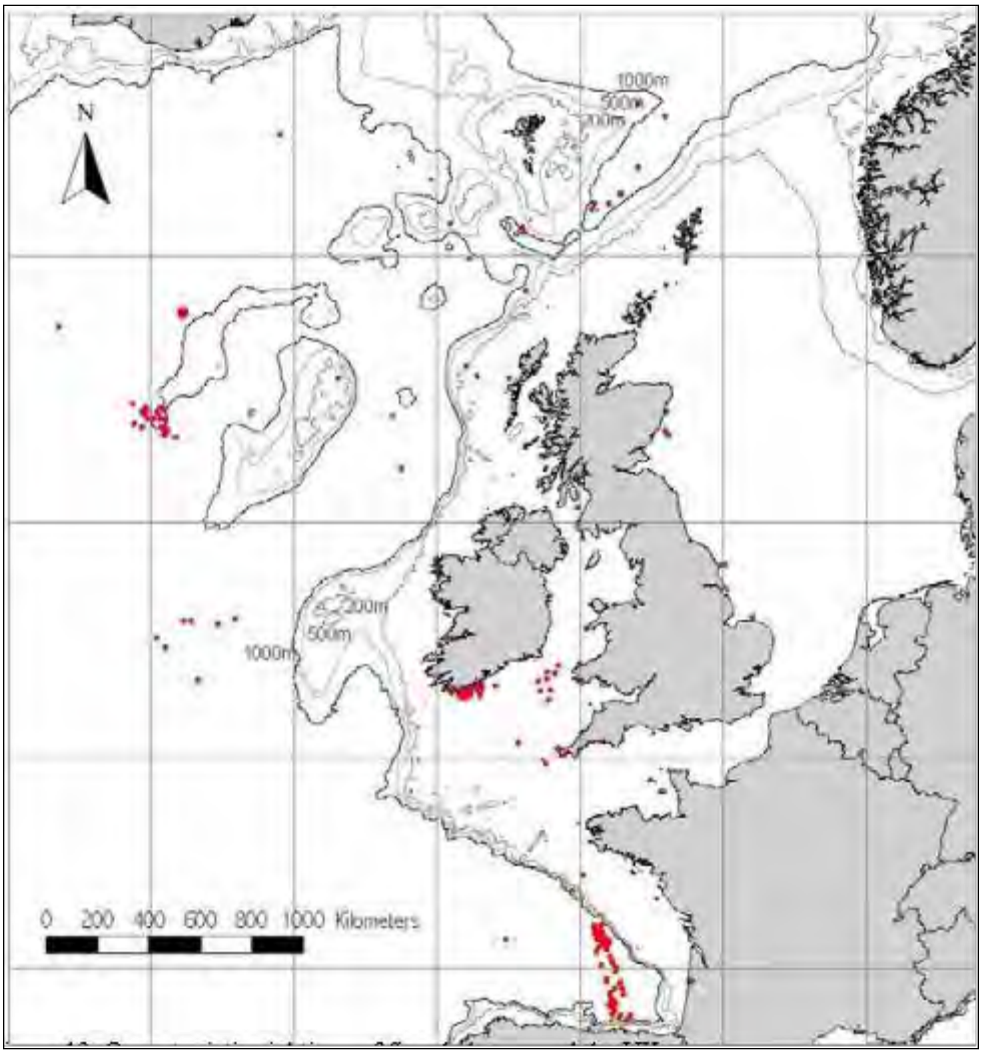


Figure 11. Opportunistic sightings of fin whales around the UK (Hammond *et al.*, 2005)

3.3.1.3.2 Long-finned pilot whale *(Globicephala melas)*

Long-finned pilot whales occur in temperate and sub-polar waters, with the northern hemisphere population isolated from those in the southern hemisphere. The species has a wide distribution in the deep waters of the North Atlantic. In the waters around the British Isles animals mainly occur along the continental shelf slope and are rare in the Irish Sea; however sightings have been recorded in the eastern part of this region (Hammond, 2012). Figure 12 shows the locations of opportunistic sightings of long-finned pilot whales around the UK.

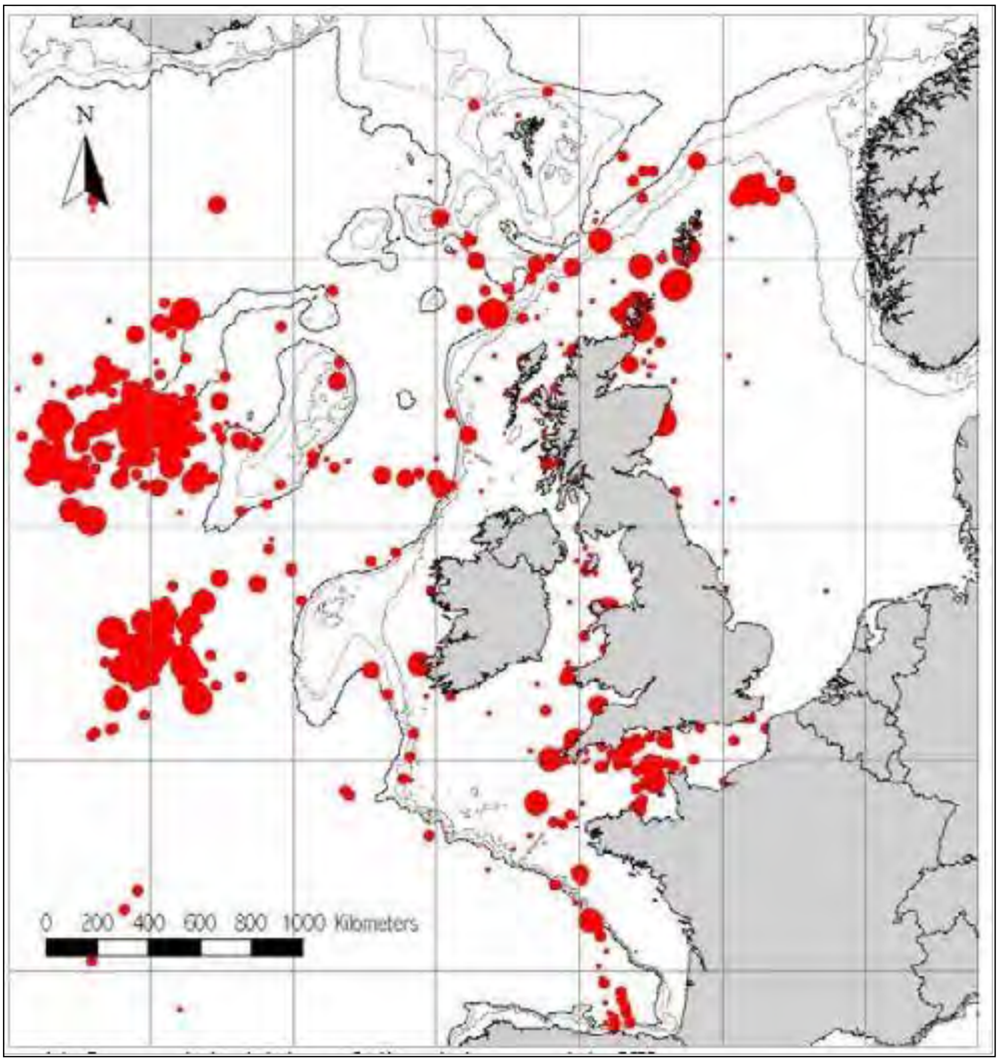


Figure 12. Opportunistic sightings of pilot whales around the UK (Hammond *et al.*, 2005)

3.3.1.3.3 Killer whale *(Orcinus orca)*

The killer whale occurs in almost every marine region in both hemispheres of the world, although they are more abundant in coastal, cold temperate to sub-polar waters. This species is known to regularly occur around Iceland, Norway and northern Scotland but can occasionally be seen further south in the Irish Sea (Hammond, 2012). Figure 13 shows the locations of opportunistic sightings of killer whales around the UK.

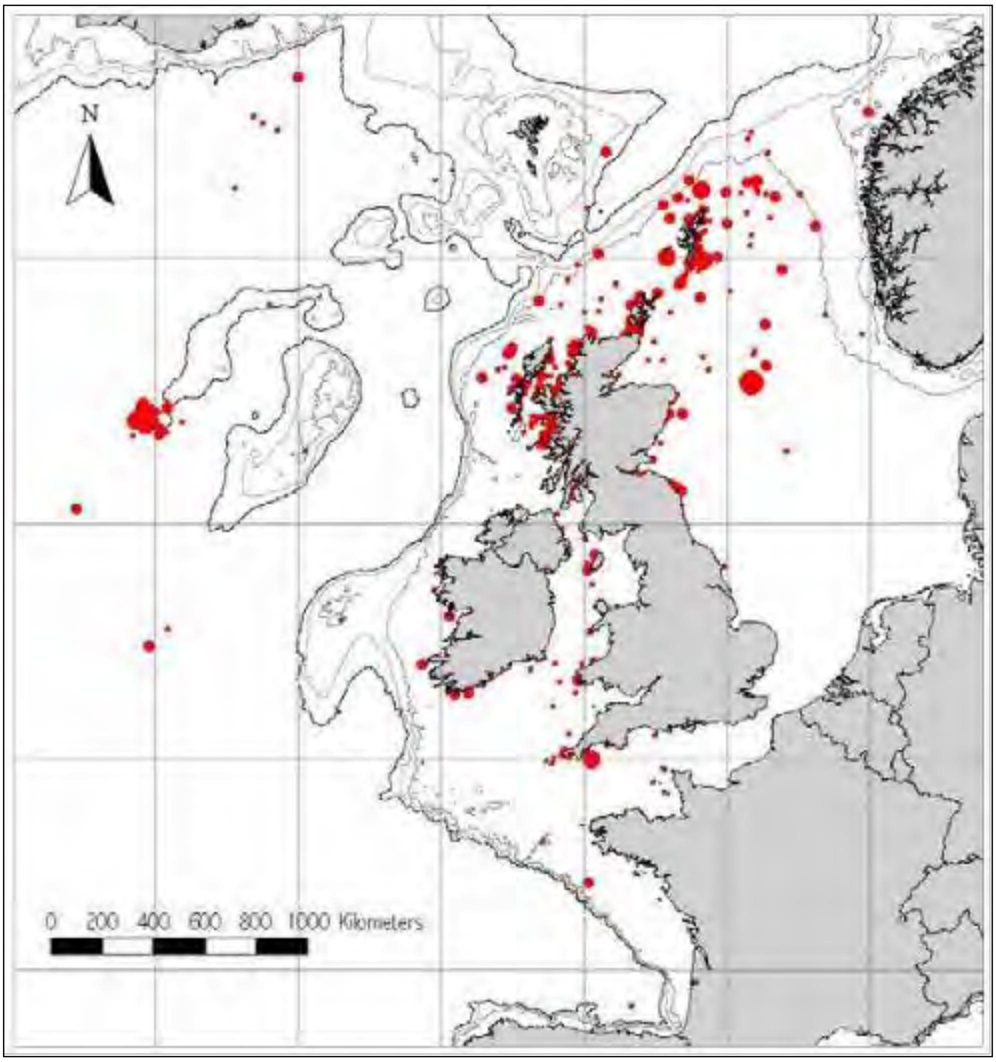


Figure 13. Opportunistic sightings of killer whales around the UK (Hammond *et al.*, 2005)

3.3.1.3.4 White-beaked dolphin (*Lagenorhynchus albirostris)*

White-beaked dolphins are found in cold temperate to sub-polar waters of the North Atlantic and typically occupy the waters of the continental shelf in depths of 50 – 100m. They are considered only occasional visitors in the Irish Sea, although animals are more common around north and west Scotland, where they can occur year round but are seen most frequently between June and October (Reid, 2003).

Of the other cetacean species that have been recorded, but occur only very occasionally or rarely in the region, there is limited data currently available and it would not be unreasonable to anticipate the likelihood of encountering these species in the vicinity of the Project Area to be low.

3.3.1.4 Marine protected areas and cetacean species

Due to the highly mobile and wide-ranging nature of cetaceans, the effectiveness of Marine Protected Areas (MPA) in conserving these species is frequently brought into question. However, where critical habitat can be identified, MPA designation is considered appropriate.

In the UK there are three SAC's designated for the conservation of bottlenose dolphin; Cardigan Bay SAC and Lleyn Peninsula and the Sarnau SAC, located in the Irish Sea off the west coast of Wales, and the Moray Firth SAC. None of these sites are in close proximity to the Project Area (>100nm).

There is one MPA for which harbour porpoise is a qualifying feature, the Skerries and Causeway Site of Community Importance (SCI/SAC), located in Northern Ireland and covering an area of 136.86km^2. This is the closest MPA with cetacean qualifying features to the Project Area (71.5km). Evidence to support designation showed that harbour porpoise is present year round at this site and calves and juveniles are regularly recorded.

3.3.2 Pinnipeds

3.3.2.1 Grey seal (*Halichoerus grypus*)

Grey seals occur in the North Atlantic Ocean where there are three recognised populations; the eastern Atlantic, western Atlantic and the Baltic Sea. Animals found around the British Isles are from the eastern Atlantic population whose range extends from Iceland and Norway to northern France with the majority of animals breeding around Great Britain and Ireland (SCOS, 2011; 2012).

When not foraging, grey seals haul out on land to rest, moult and breed, forming large colonies on rocky shores, beaches, sandbanks and on primarily uninhabited offshore islands around the UK. Approximately 38% of the world's grey seals breed in the UK and 88% of these breed at colonies in Scotland (SCOS, 2011; 2012). Pupping occurs at different times throughout the geographical range, with animals in northern Britain pupping from October to November whereas individuals around the Welsh coast are known to pup year round with peaks in September. Moulting typically occurs from February to April (Hammond *et al.*, 2005).

Around the UK there are breeding colonies on the north and east coasts of Britain, Shetland, south west England and Wales, but the highest concentrations are found in the Inner and Outer Hebrides, in Orkney and in the Firth of Forth (SCOS, 2011; 2012). Grey seals are the larger and more abundant of the two UK resident seal species. They are generalists that can feed in waters of up to 100m depth and therefore when at sea can be found in most of the UK continental shelf waters. Foraging trips and ranges can be long and wide ranging with animals potentially travelling large distances (>100km) between haul out sites. During pupping and moulting, animals spend most of their time on land resulting in lower densities at sea during these periods (Hammond *et al.*, 2005).

The current best estimate of the UK grey seal population size is 111,300 individuals (SCOS, 2012) with an estimated 5,198-6,976 individuals in the Irish Sea (Kiely, 2000). Tracking studies provide information on animal movement within the region and results indicate that the Irish Sea is an important foraging habitat for seals that haul out in England and Wales, with the southern sector of the Irish Sea, northern St George's Channel and Liverpool Bay being the most heavily used areas (Hammond *et al.*, 2005; SCOS, 2012). Data suggest little movement of animals from this area north through the north Irish Sea and Northern Channel and additional tracking studies on individuals breeding in north west Scotland do not show significant movement southwards into the Irish Sea (SMRU, 2004). Figure 14 shows the modelled at sea usage for grey seals and Figure 15 and Figure 16 indicate the distribution and abundance of grey seals in the UK (SCOS, 2011) and Scotland (SCOS, 2012; Duck, 2013) respectively.

Based on the information available it would not be unreasonable to expect regular, year round occurrence of this species within the vicinity of the Project Area; however, encounter rates may be reduced during times of moulting (February to April) and pupping (September to November).

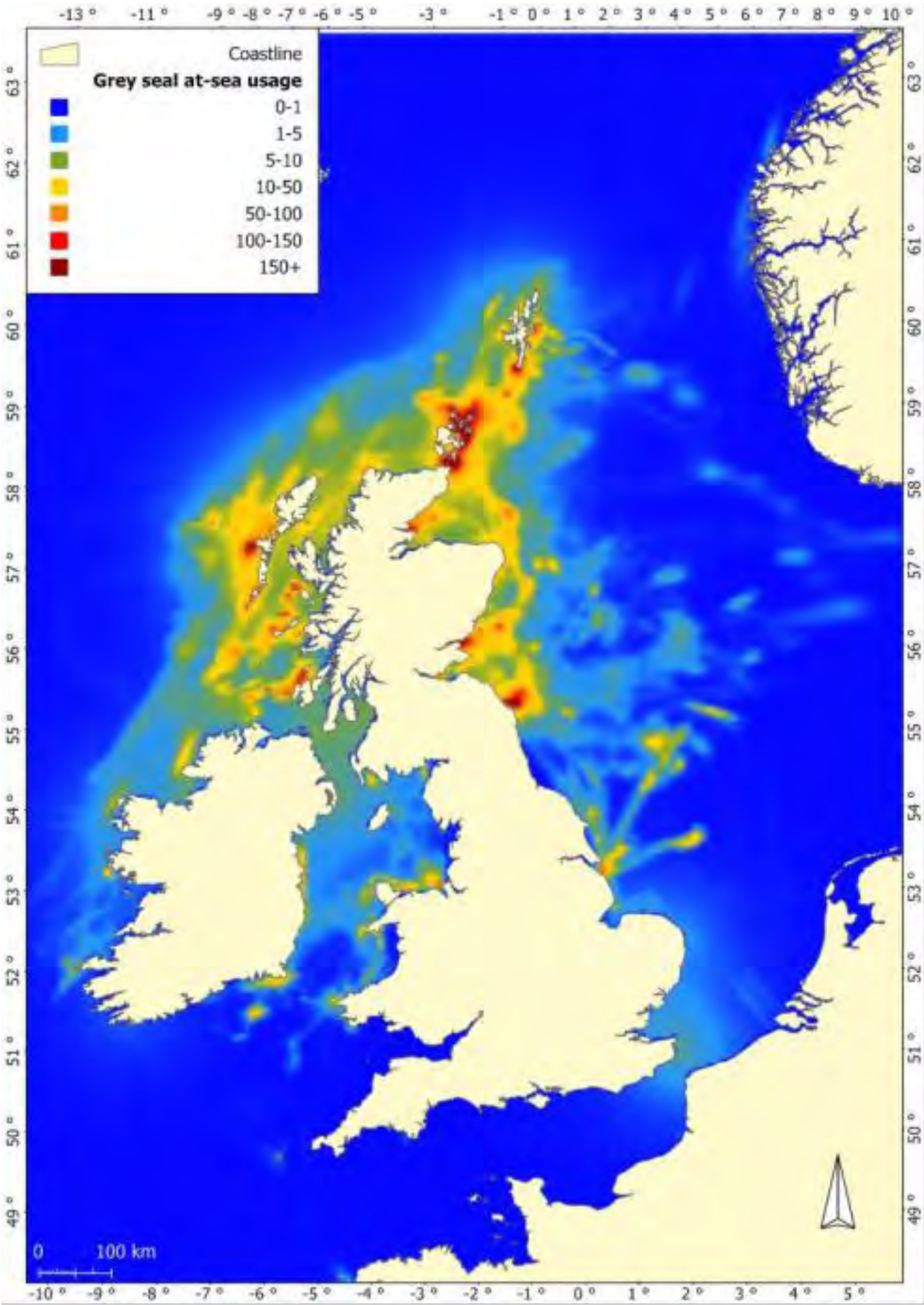


Figure 14. **Estimated at-sea usage of grey seals around the UK (SMRU, 2013)**

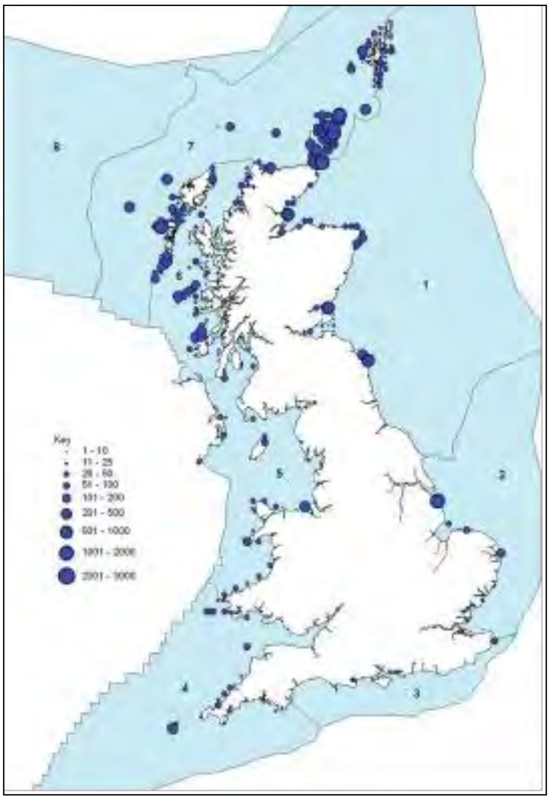


Figure 15. The distribution and number of grey seals in Great Britain and Northern Ireland in August, by 10 km squares, from surveys carried out between 2000 and 2006 (Duck, 2010).

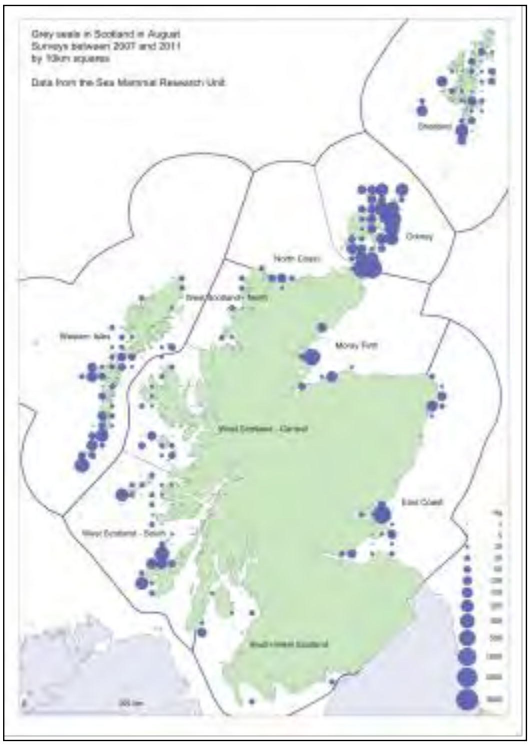


Figure 16. The number and distribution of grey seals in Management Areas around the coast of Scotland, from surveys carried out between August 2007 and 2011 (SCOS, 2012)

3.3.2.2 Common or harbour Seal (*Phoca vitulina)*

The common seal is one of the most widespread of all the pinnipeds. They occur in the northern hemisphere from temperate to Polar regions (Jefferson, 1993). There are five sub species of harbour seal with the European species (*Phoca vitulina vitulina*) ranging from northern France to Iceland, Svalbard and to the Baltic Sea in the east with 30% of European harbour seals found in the UK (SCOS, 2012). Harbour seals occupy more sheltered waters than grey seals and haul out on sandbanks and in estuaries, returning to land to rest, moult and breed. Unlike grey seals, females give birth on their own or in very small groups between late May and early July with moulting typically occurring in August (SMRU, 2004; SCOS, 2012). Harbour seal foraging ranges are not as extensive as that of grey seals with most foraging trips only a few tens of kilometres from their favoured haul-out sites.

This species is widespread around the west coast of Scotland and throughout the Hebrides and Northern Isles with Scotland supporting approximately 79% of the UK harbour seal population (SCOS, 2012). The current estimated population of harbour seals in the UK is 36,500 with main concentrations in south-east Northern Ireland, along the west coast of Scotland, the Inner Hebrides, the east coast of the Outer Hebrides the Shetlands and Orkneys (SCOS, 2012).

Figure 17 shows the modelled at sea usage for harbour seals and Figure 18 and Figure 19 indicate the distribution and abundance of harbour seals in the UK (SCOS, 2011) and Scotland (SCOS, 2012; Duck, 2013) respectively.

Based on the information available it would not be unreasonable to expect regular, year round occurrence of this species within the vicinity of the Project Area; however encounter rates may be reduced during times of moulting (August) and pupping (May to July).

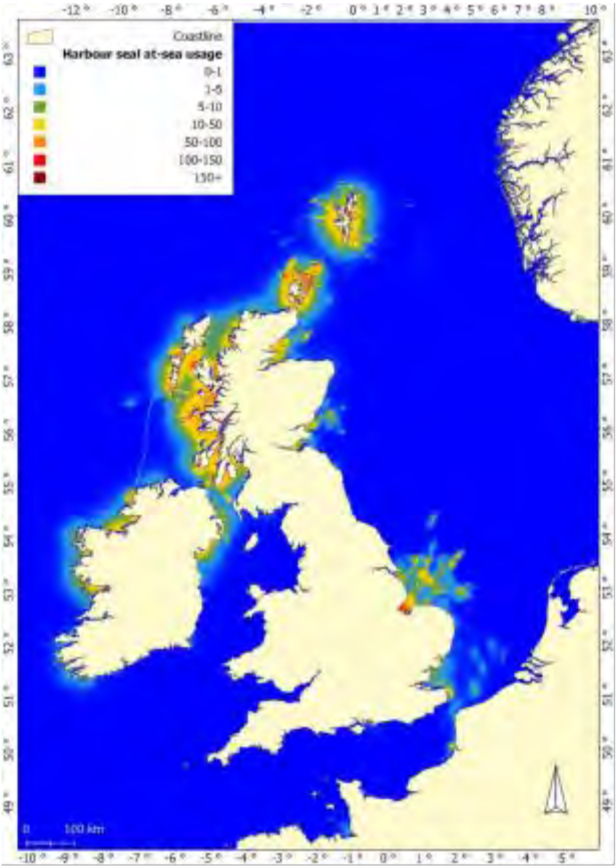


Figure 17. Estimated at-sea usage of harbour seals around the UK (SMRU, 2013)

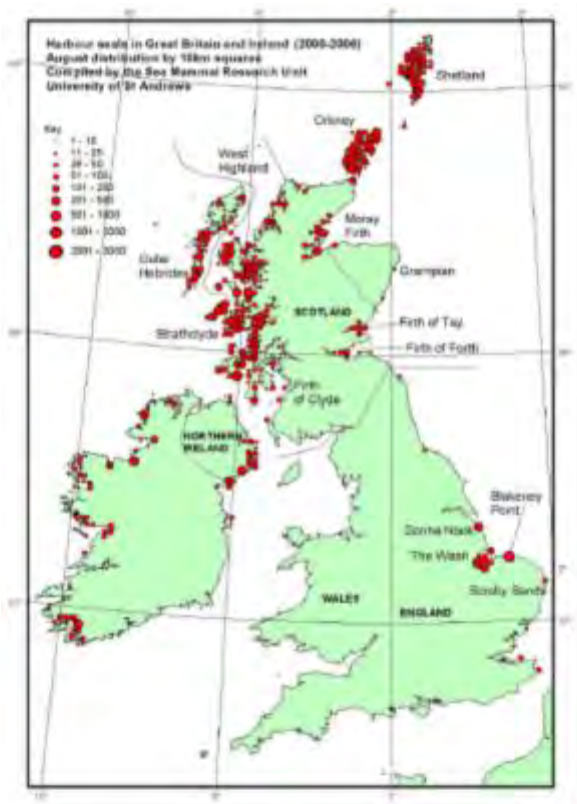


Figure 18. The August distribution of harbour seals in Great Britain and Ireland, by 10km squares (SCOS, 2011)

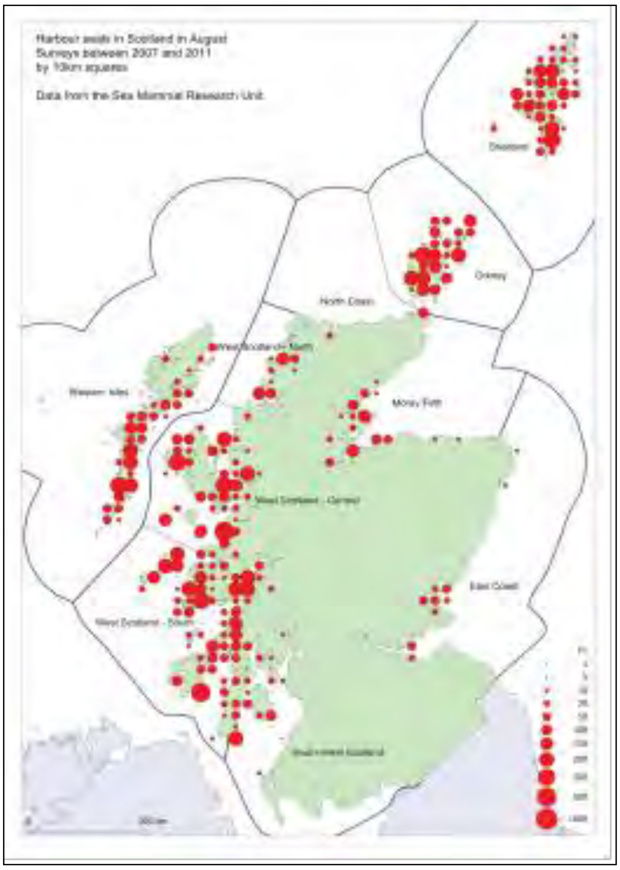


Figure 19. The number and distribution of harbour seals in Management Areas around the coast of Scotland, from surveys carried out between August 2007 and 2011 (SCOS, 2012).

3.3.2.3 Marine protected areas and pinniped species

Coastal SACs have been designated in the UK to protect breeding colonies, moulting and haul out sites for grey and harbour seals. These are shown in Figure 20 and Figure 21 respectively **(N.B. The Maidens SAC is not currently shown on these maps due to recent designation. See Figure 22 for location of this site).**

The sites designated for seals in the proximity of the Project Area are the Maidens SAC (within 4nm - grey seal), Strangford Lough (>30nm - harbour seal), Murlough (>30nm – harbour seal) and South east Islay Skerries (>30nm – harbour seal).

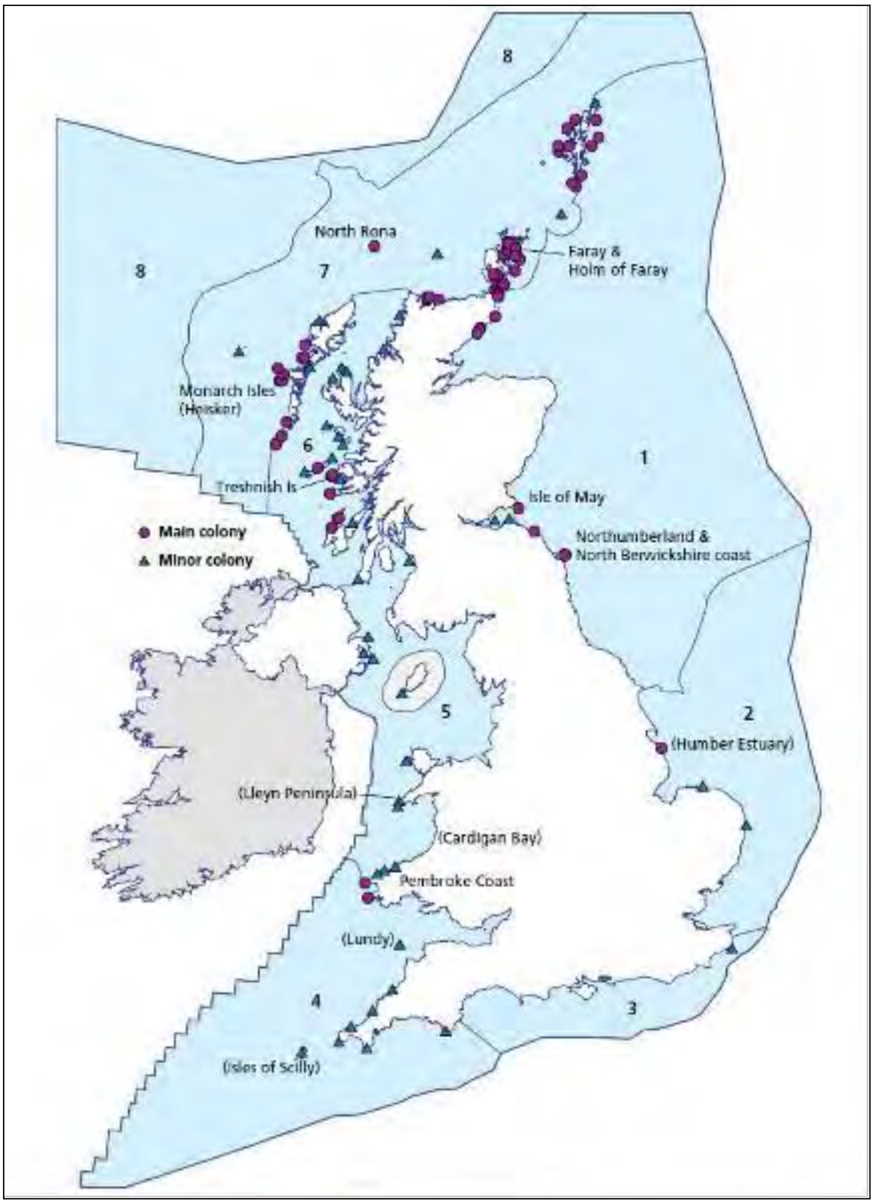


Figure 20. Map to show the location of grey seal breeding colonies in Great Britain and Northern Ireland. Text labels identify the Special Areas of Conservation (SACs) where grey seals are one of the main reasons for the creation of the protected site. Site names in brackets are SACs where grey seals have only contributed to the reasons for designation and are not the main reason for the creation of a SAC (Duck, 2013).

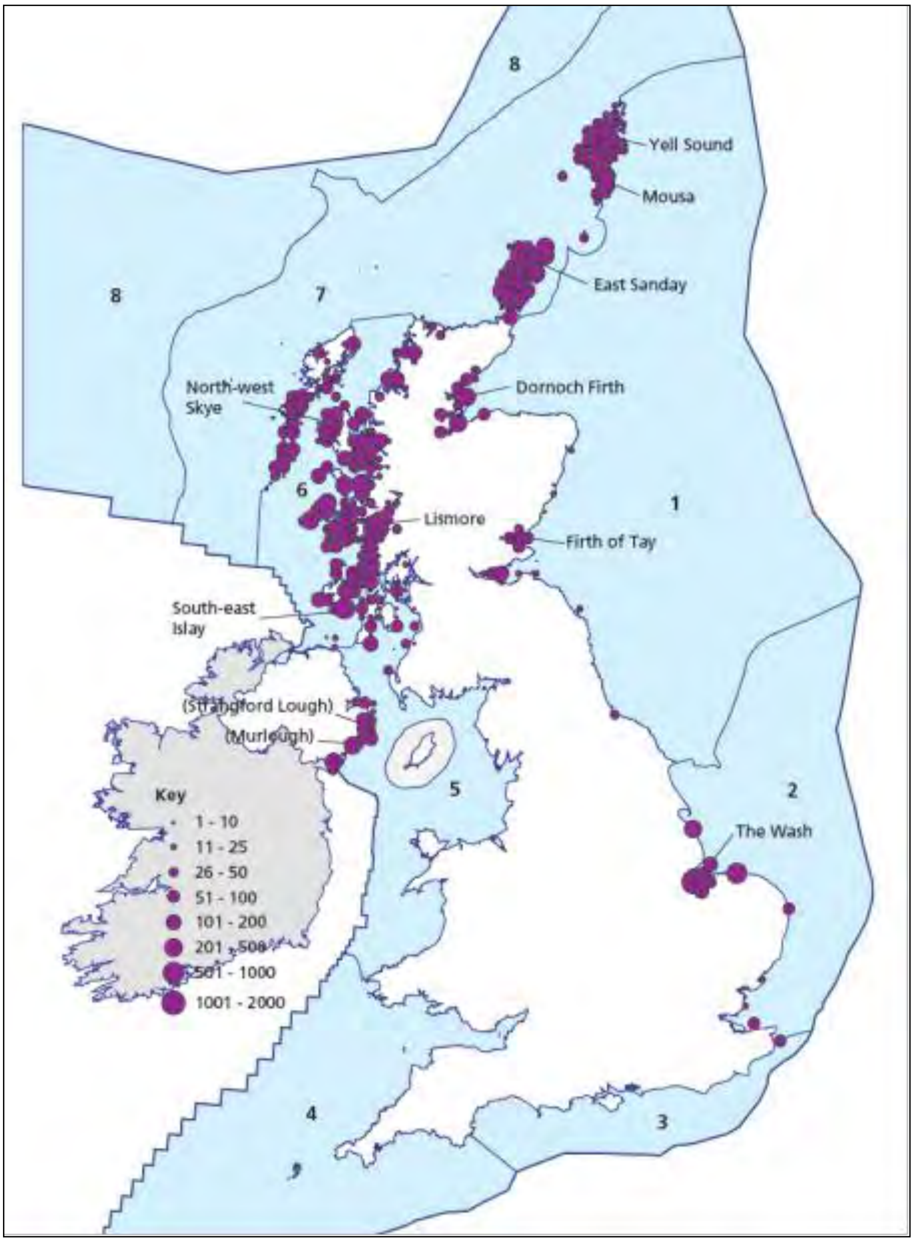


Figure 21. Map to show the distribution of harbour seals in Great Britain and Northern Ireland. Text labels identify the Special Areas of Conservation (SACs) where harbour seals are one of the main reasons for the creation of the protected site. Site names in brackets are SACs where harbour seals have only contributed to the reasons for designation and are not the main reason for the creation of a SAC (Duck, 2013).

Figure 22. Map to show location of The Maidens SAC (http://jncc.defra.gov.uk)

3.3.3 Chelonians

Sightings and strandings of marine turtles in British waters show that by far the most commonly reported species in this region is the leatherback turtle (*Dermochelys coriacea)* with the second most recorded species being the loggerhead turtle (*Caretta caretta)*. In order to help increase the knowledge and understanding of marine turtle occurrence in British waters a survey was conducted in Irish waters between April and August 2006. The results showed that of the 65 new turtle records acquired during this survey 37% were from Northern Ireland, 29% from the Republic of Ireland and 34% from Scotland, Wales and England with nearly 80% of all records being of leatherback turtle and 78% of records from July to September, supporting the existing understanding and findings of previous surveys and data analysis (King, 2006).

Records of Kemp's ridley turtles (*Lepidochelys kempii)* are infrequent and records of green turtles (*Chelonia mydas)* and hawksbill turtles (*Eretmochelys imbricate)* are rare (JNCC, 2007; Penrose R.S., 2007). The leatherback turtle is considered to be a regular and established species in British waters due to its ability to adapt to temperate waters. Studies conducted in Atlantic waters have shown that female leatherback turtles may migrate northwards after nesting to feed in the more abundant cooler, temperate waters (Doyle, 2007). All other species of marine turtle that are sighted in the region are considered to have arrived after being accidentally displaced from their normal range by currents (JNCC, 2007).

3.3.3.1 Leatherback turtle (*Dermochelys coriacea*)

The leatherback turtle is a large and wide-ranging species migrating throughout the Atlantic Ocean. British waters are believed to be a small part of its summer foraging range with UK waters representing the northern most limit of routine seasonal leatherback foraging migrations. However, individuals have been recorded as far north as Iceland and Norway (Marubini, 2010).

This species is considered a regular visitor to the north eastern Atlantic waters (Langton, 1996) and it was estimated that on average there are 33 records per year for leatherback turtles in UK waters (Marubini, 2010). However, it is believed that up to 180 leatherback turtles may visit UK waters each year (Langton, 1993). The majority of sightings have been recorded in the Western Channel, Celtic Sea and Irish Sea with a peak in abundance in the late summer months (Marubini, 2010).

The current population of leatherback turtles in British waters is unknown (JNCC, 2007). Figure 23 shows the locations of leatherback turtle recordings from around the UK (Pierpoint C., 2002).

There is the potential for marine turtles to occur in the Project Area, however occurrence rates are very low and likely restricted to the summer months.

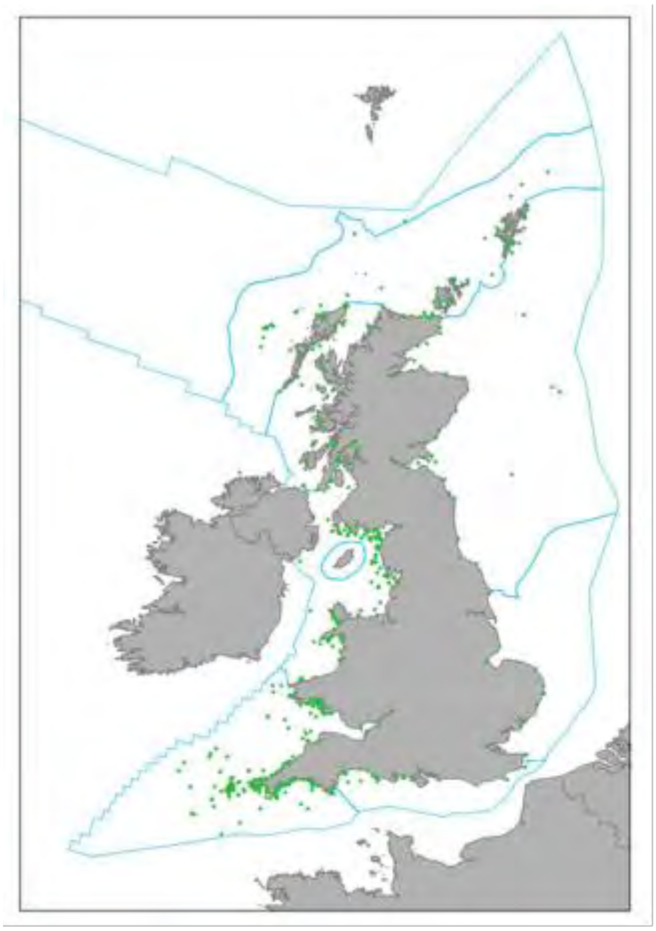


Figure 23. Records of leatherback turtles (*Dermochelys coriacea*) collated in the 'TURTLE' database since 1998 (Marubini, 2010).

4 Summary

Of the five cetacean species that are known to regularly occur in the waters off western Britain, the species most likely to be encountered within the Project Area would be harbour porpoise, with animals being present year round. Common dolphins are likely to be present in the region with the possibility of occurrence being higher further offshore and in the summer months. Bottlenose dolphins, Risso's dolphin and minke whales can also occur in the region, but abundance and encounter rates would be expected to be higher in the summer months for all three of these species and in more coastal locations with regards to the bottlenose dolphin.

Figure 24 and Figure 25 present a summary of the presence of the five most abundant cetacean species and other less frequently occurring cetacean species present in relation to the Project Area respectively (Source data: Reid et al., 2003).

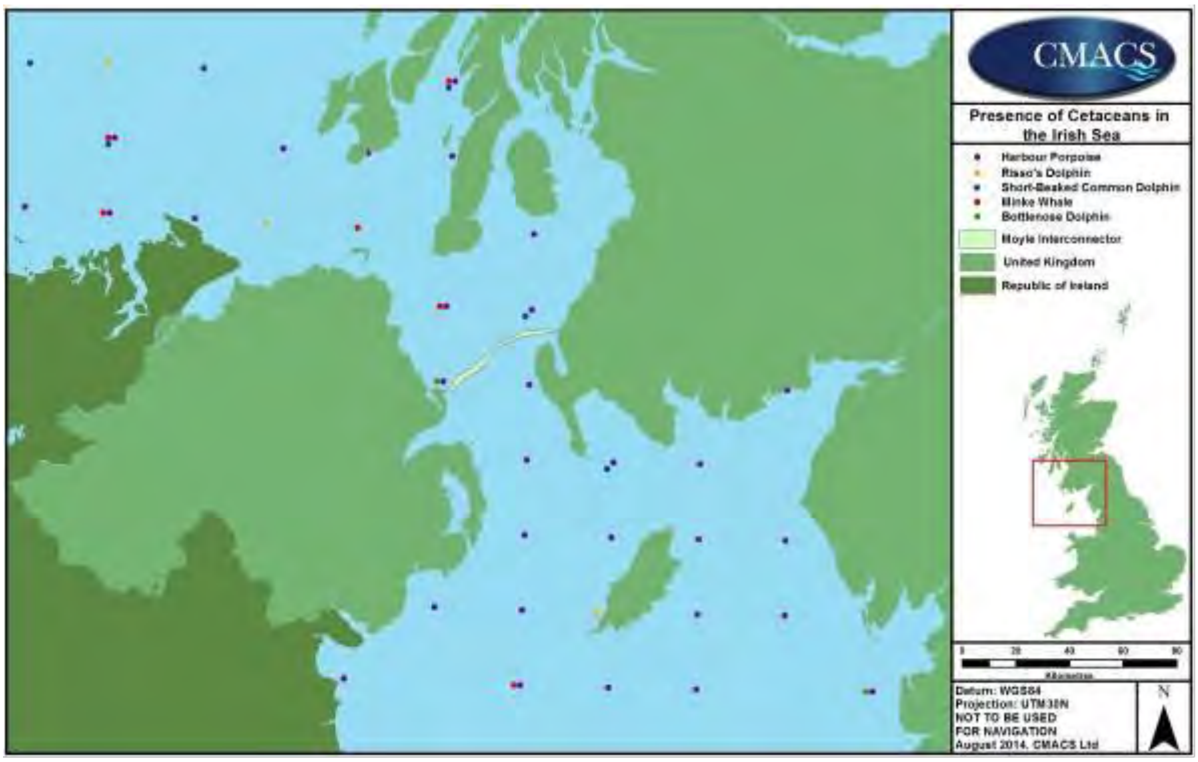


Figure 24. Summary of presence of the five most abundant and regularly occurring cetacean species in relation to the Project Area

Figure 25. Summary of the presence of other species of less frequently occurring cetacean in relation to the Project Area

Both species of seals are likely to be encountered year round in the Project Area although encounter rates at sea are likely to be lower during times of moulting and pupping, typically from February to April and September to November respectively for grey seals and May to August for harbour seals.

There is the potential for occurrence of marine turtles in the Project Area, in particular the leatherback turtle during summer months, therefore consideration should be given to these species; however encounter rates would be expected to be very low.

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A.2.7 – Diadromous Fish Baseline Report (desk study to collate information on migratory fish use of the project area)

Centre for Marine and Coastal Studies Ltd

MOYLE INTERCONNECTOR LTD

Review of occurrence and migration routes of diadromous fish species in relation to the Project Area

Client: Intertek Energy and Water Consultancy Services

Document: J3257 Moyle Interconnector Diadromous Fish report v3

Version	Date	Description	Prepared by	Checked by	Approved by
1	Aug 2014	Working Draft	MC/IGP	JAK/EH	-
2	Sept 2014	Final	KS	JAK	JAK
3	Dec 2014	Terminology update	JK	JK	IGP

Contents

Figures

Tables

1 Introduction

1.1 Project Overview

The Moyle Interconnector is a High Voltage Direct Current (HVDC) link between the electricity grids of Northern Ireland and Scotland (Figure 1). The system has been operational since 2002. However, since 2010, there have been three subsea system faults as a result of a failure in the low voltage (LV) polyethylene Integrated Return Conductor (IRC) insulation allowing water ingress (in addition to one land-based fault). The reason for failures is not confirmed. The interconnector is currently running at half capacity and Moyle Interconnector Ltd (MIL) is investigating options for the restoration of the interconnector to full capacity (500MW).

The preferred long-term option is the installation of two replacement metallic return conductors (MRC) between the Northern Ireland and Scotland converter stations. The two existing HV conductors will remain *in situ* and operational as originally installed. The desired monopole circuits will therefore comprise the existing HV conductors (in the existing cable) and newly laid MRCs.

Along the majority of the route, the proposed two new MRC cables will be installed in a corridor between 50m to 100m south of the north cable, and in a corridor between 50m to 100m south of the south cable. In near-shore regions, the MRC cables will be installed as close as practically possible to the HV conductors (approximately 4m).

Each of the two existing corridors is approximately 5km long onshore in Scotland, 53km long submarine and 3km long onshore in Northern Ireland.

Figure 1. Moyle Interconnector Route

1.2 Scope of Work

Finalisation of the cable routes will take into consideration environmental and technical constraints, the results of detailed surveys (if required following further review of existing seabed information) and the feedback from the consultation process. MIL intends to submit an application to MS-LOT for a Marine Licence under the Marine (Scotland) Act 2010 for the extent of the marine cable in Scottish territorial waters and under the Marine and Coastal Access Act (MCAA) 2009 for the extent of the marine cables in Northern Ireland territorial waters.

Intertek consulted with a wide range of organisations to seek their opinion on requirements for environmental assessment through issue of a Scoping Report (Intertek, 2013). The Marine Nature Conservation Team (Department of the Environment Northern Ireland, Scoping Opinion dated 27th March 2014) and Marine Scotland Science (Scoping Opinion dated 25th March 2014) both requested that the developer should record and consider potential effects upon diadromous fish species.

Species highlighted for particular focus were salmon, trout, eels and river and sea lampreys with rivers highlighted including the River Bladnoch in south west Scotland, Rivers Eden, Derwent and Ehen in North West England, River Dee in North Wales and any relevant rivers in Northern Ireland and the Republic of Ireland.

Marine Scotland included specific advice concerning information they considered important to collate should there be potential for diadromous fish to be affected by the planned development. Notwithstanding the outcome of separate work to assess such impacts, this advice is summarised as follows:

- Identify likely use of the Project Area by diadromous fish
    - species occurring (feeding or migration)
    - seasonality of use
    - origin of fish (local rivers or from further afield)
- Behaviour during use of the area
    - swimming depths
    - proximity to coast

Centre for Marine and Coastal Studies Ltd (CMACS) has been contracted to collate available information on diadromous fish (salmonids, eel and lampreys) in relation to the Project Area. This report therefore reviews all available literature and data, with particular reference to the following review highlighted by Marine Scotland:

- Malcolm *et al*., (2010) Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables.

A more recent publication (Malcolm *et al*., 2013) provides updated information to Malcolm *et al*. (2010), although the focus is on Scottish north, north west and east coast rivers.

The collated information is intended to help inform Environmental Impact Assessment and any Habitat Regulations Appraisal work.

1.3 Diadromous fish

Diadromous is the term used to describe fishes that migrate between fresh and salt water. These movements are a characteristic element of the lifecycle of certain species of fish (McDowall, 1997). They either spawn in freshwater and feed at sea (anadromous fish), such as Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*) and lamprey (sea lamprey, *Petromyzon marinus* and river lamprey, *Lampetra fluviatilis*), or feed in freshwater and spawn at sea (catadromous fish), such as European eel (*Anguilla anguilla*). All of the species mentioned are present within the Irish Sea and certain rivers in the general proximity of the landfall sites of the Moyle Interconnector. The Moyle Interconnector crosses one of the narrowest stretches of the Irish Sea (known as the North Channel), linking Islandmagee in Northern Ireland to Auchencrosh, Scotland. The North Channel is likely to be an important migration route for any diadromous fish passing to the east of Ireland on their way to or from marine feeding grounds and rivers along the Scottish, English, Welsh and Irish coasts.

Fish species that adopt a diadromous lifecycle may be more vulnerable to fisheries and environmental impacts along their migratory routes (McDowall, 1999). The increased vulnerability may be in the form of fish not usually targeted by fisheries being caught as by-catch en-route to their spawning grounds, or fisheries species being caught at a crucial stage in their reproductive cycle. This can have a negative knock-on effect for later population abundance as the spawning population becomes reduced.

Figure 2 presents the main salmon and sea trout rivers in the region of the Project Area. Lampreys are also understood to utilise many of the same rivers. Eels are also thought to be widespread throughout the Irish Sea and the surrounding rivers, but numbers are low and population studies have proved challenging as a result. A large number of other rivers are present to the north and south of this area, including rivers such as the Dee in North Wales where salmon are present as an interest feature of the SAC. Because of the distance and number of rivers involved all rivers are considered here generally as ‘north of the Project Area’ (Scottish west coast and NW Northern Ireland Rivers) and ‘south of the Project Area’ (Scottish south-west coast, English, Welsh and Irish rivers).

Further information on each group is provided in subsequent sections (Atlantic salmon, Section 2; sea trout, Section 3; lamprey, Section 4; and European eel, Section 5).

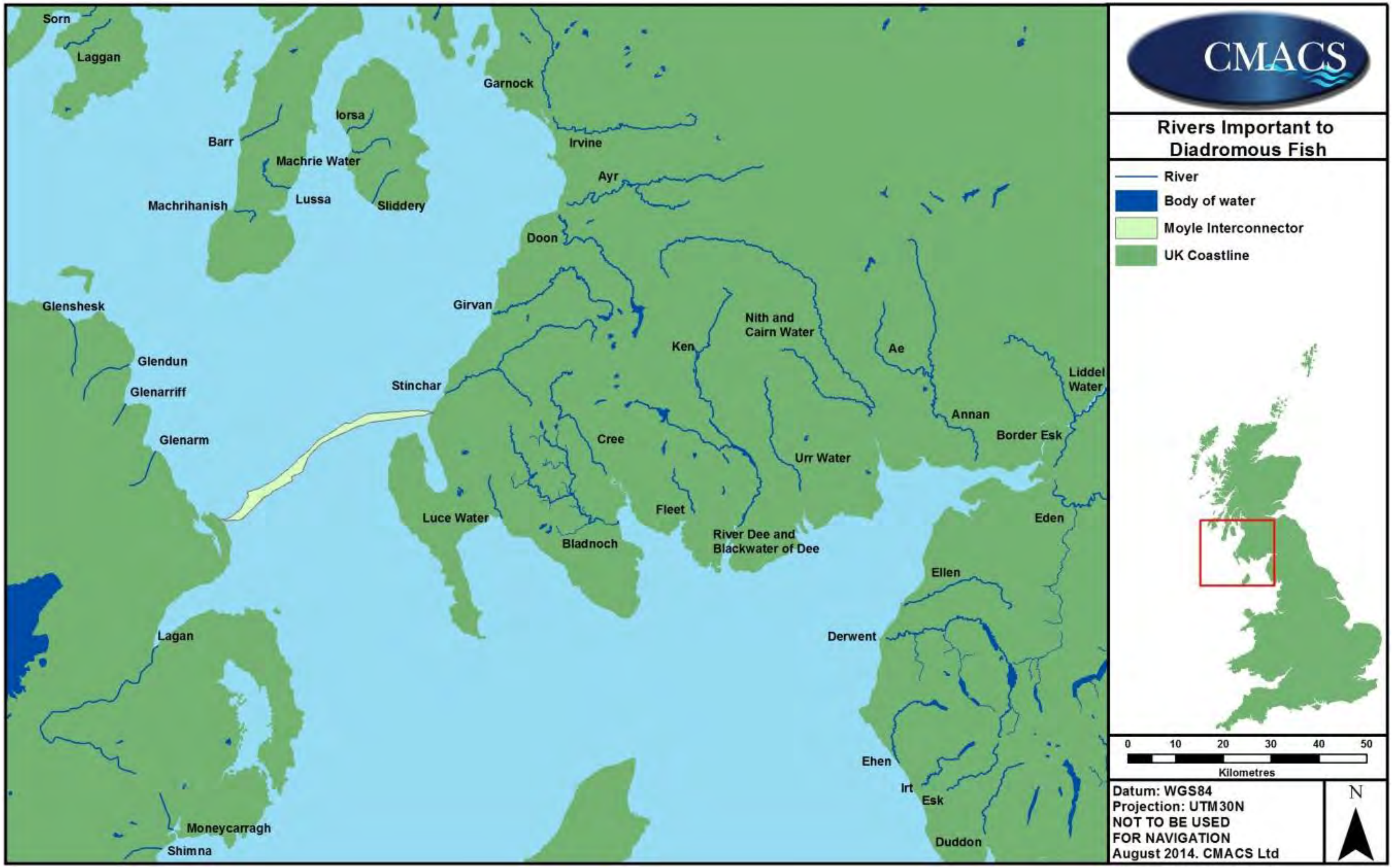

Figure 2: Salmon and Trout Rivers in relation to Moyle Interconnector. Lamprey spp. are also present in these water bodies (data source: www.salmonatlas.com).

2 Atlantic salmon (*Salmo salar*)

2.1 Conservation Status

There are a number of European and national legislation regarding Atlantic salmon which aim to promote the conservation of this species and its habitats. Atlantic salmon are listed on Annex II and V of the Habitats Directive (92/43/EEC) as a species of community interest whose conservation requires the designation of special areas of conservation and/or a species of community interest whose taking in the wild and exploitation may be subject to management measures. This species is also listed on Appendix III of the Bern Convention (The Convention on the Conservation of European Wildlife and Natural Habitats) the obligations of which are transposed into UK law by means of the Wildlife and Countryside Act (1981 as amended), Nature Conservation (Scotland) Act 2004 (as amended), Wildlife (Northern Ireland) Order 1985, and the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985, regulating the exploitation this species. The protection given to salmon through the Habitats Directive is restricted to freshwater habitats only and the Bern Convention does not relate to salmon at sea. However, In order to deliver Scotland's Marine Nature Conservation Strategy a list of Priority Marine Features considered to be of conservation importance in Scotland's seas was announced in July 2014, including the marine part of life cycle of the Atlantic salmon.

As a signatory to the Convention on Biological Diversity, the UK developed a Biodiversity Action Plan (UK BAP) with Atlantic salmon being listed as a priority species. This plan has since been succeeded by the UK post-2010 Biodiversity Framework (covering the period 2011-2020). This framework focuses work on a country level with each component nation developing its own biodiversity strategy in order to comply with EU commitments. However, the priority species and habitats identified under the UK BAP continue to be regarded as conservation priorities and still form the basis of much of this work. Additionally, through the creation of The Convention for the Conservation of Salmon in the North Atlantic Ocean, the UK is also a member of an inter-governmental organization, the North Atlantic Salmon Conservation Organization (NASCO) whose objective is to conserve, restore, enhance and rationally manage wild Atlantic salmon. This species also appears on OSPAR's list of threatened and/or declining species and habitats.

2.2 Overview of Life History

Atlantic salmon utilise rivers for the nursery and reproductive phases of their lifecycle and migrate to the Atlantic Ocean to feed and grow (Hendry & Cragg-Hine, 2003). The UK has a significant proportion of the stock of EU waters and there are over 300 rivers in the UK with annual runs commonly exceeding 1,000 fish (JNCC, 2010).

The lifespan of Atlantic salmon is six to ten years, with individuals reaching maturity between three and five years (McCormick *et al*, 1998). Juvenile fish (smolt) generally migrate to sea from their natal rivers after two to four years, usually returning to spawn after one year or more at sea, or less commonly, after multiple (up to four) winters at sea (Hendry & Cragg-Hine, 2003). Spawning occurs in late autumn and winter although fish return over a relatively wide number of months and run timing in adult Atlantic salmon is highly variable.

Different sea-age classes of salmon have different patterns of run timing and these vary on a geographic scale, but also between stocks in a region and within stocks over time. In the UK, 1 sea-winter (SW) (fish that have spent a single winter at sea) salmon mainly enter rivers from June to August, though some rivers have strong autumn runs, 2SW fish enter throughout the year, but sometimes with spring, summer or later peaks, while 3SW fish generally enter rivers early in the year, with few entering after about May (Cefas & Environment Agency, 2013). Where fish return in spring and early summer, they will hold up in the estuary and adjacent coastal waters. Most of the fish will be present in rivers in the months up to October (Jones & McCubbing, 1993).

Atlantic salmon are magnetically sensitive and many authorities have suggested that this capability might be used to aid orientation during oceanic migration whilst olfactory cues are believed to become increasingly important during the final phases of migration as adult fish return to their natal watercourse (McCormick *et al*, 1998; Hendry & Cragg-Hine, 2003; Malcolm *et al*, 2010; Hansen *et al*., 1993). Fish may also use other cues such as sight, hearing and hydrographic information during migrations (Stabell, 1984).

The seaward migration of salmonid smolts is a dynamic, active process that follows the physiological transformation of the juvenile fish (parr) to enable them to survive a saline environment. This transformation combined with favourable environmental conditions (namely, river flow and temperature) motivates the fish to move away from the freshwater environment. The active movement through an estuary and then out to the coastal waters is considered to be a critical stage, when both salmon and sea trout may be particularly vulnerable to predation and adverse environmental conditions (Hendry & Cragg-Hine, 2003).

Smolts leave rivers in cohorts in early spring/summer, usually between April and June (Holm *et al*, 2000; Hendry & Cragg-Hine, 2003). This is triggered by combinations of environmental stimuli such as water temperatures greater than 10°C and rates of high flow in river. When they have reached the estuary, they will generally enter the sea during ebb-tide and follow the direction of tidal streams (Hendry & Cragg-Hine, 2003; Malcolm *et al*, 2010).

Smolt emigration through estuarine waters is rapid and there is no period of acclimation required, because of the naturally increasing salinity, as the fish are already pre-adapted to the marine environment. Smolts tend to follow the fastest currents and will move to the surface waters at night. The factors regulating the survival and movement of the fish are not fully understood although sea surface temperature, availability of suitable prey and favourable coastal currents may all play an important role (e.g. Moore *et al*., 1995). Once beyond the limits of the estuary there is much less known about smolt emigration and it is uncertain whether they remain in shoals or undertake the migration individually (see also Section 2.4).

2.3 Local Populations

The broad, national, context is that Atlantic salmon stocks have decreased quite substantially around the UK over the last 15-20 years (Holm *et al*, 2000; CEFAS & Environment Agency, 2012). Stocks are thought to be in decline as a result of a combination of pressures, potentially including: commercial fishing, reduced food sources at sea, changes in water quality in natal rivers, barriers to migration, upstream perturbations to the river flow and alterations in water temperature (McCormick *et al*, 1998; Hendry & Cragg-Hine, 2003).

Rivers in Ayrshire, such as the Ayr, Doon, Girvan, Stinchar, Garnock and Irvine support salmon populations in close proximity to the area in which the Moyle Interconnector is present. The River Stinchar is the closest main river to the Moyle interconnector on the Scottish side of the Irish Sea. The Stinchar is situated to the north of where the cable reaches Auchencrosh. The river has a catchment area of approximately 253km^2; included in this are the main tributaries of the Muck Water, River Duisk, Water of Tig and the Assel. It is known for its salmon, trout, eel and lamprey populations amongst others (Ayrshire Rivers Trust, 2014a). Catch data is limited for the Ayrshire rivers but there is enough information available to show general trends over the last seven decades, until 2008. The River Stinchar rod and line catch records illustrate that there has not been significant variation in the salmon population present in this river. This is also the overall trend for the major rivers in Ayrshire; in this respect the area is an exception to the majority of the UK. The reason for this is thought to be attributed to effective management of the fishery by the Ayrshire Rivers Trust and the lack of urban development on the rivers meaning lower pollution risk, although the trends differ for other species in the same rivers (FRS, 2003). Rivers in north west England, such as the Eden, Border Esk, Ellen and Derwent which drain into the Solway include some where fisheries management objectives[1] are understood likely to be met (e.g. Derwent and Border Esk) and others, such as the Eden, where there is risk of the objectives not being met because of low stock levels.

At the Northern Ireland landfall of the Moyle interconnector the closest river is the Inver which is approximately six miles in length and enters the sea at Larne harbour. The river is controlled by Larne & District Game Angling Association and is not a major contributor in terms of catch statistics for Northern Ireland (not shown in Figure 2). Historically, there were salmon present in this river; however after two serious pollution incidents in 1996 and 2001, there is no longer a record of a salmon population here. Attempts were made to restock the river and improvements were made to the habitat, for example, gravel laid for spawning beds and removing overhanging trees, but this was unsuccessful for this species (Larne & District Game Angling Association, 2014). The coastal area surrounding the landfall of the Moyle Interconnector has rivers both north and south or the Project Area, e.g. River Lagan and Glenarm. In general, the number of salmon returning to many Northern Ireland rivers are below conservation targets and subject to intervention measures to try to support fisheries. The Lagan, for example, has been subject to various re-fish introduction and conservation work to attempt to establish self-supporting stocks (DCALNI, 2010).

2.4 Migration routes and behaviour

Atlantic salmon from UK and other European waters migrate to the North Atlantic Ocean to take advantage of rich feeding grounds for a year or more before returning to spawn; however, knowledge of the location of offshore feeding grounds, the routes taken by both emigrating juveniles/kelts and returning adult fish is incomplete. Malcolm *et al*. (2010 and 2013) conducted an extensive review of available information and identified gaps in

[1] For any river the target is to meet a Conservation Limit (the minimum spawning stock level below which stocks should not be allowed to fall) in four out of five years (Cefas & Environment Agency, 2013).

understanding relating to all stages of migration. Current understanding of the broad pattern of migration for returning adult salmon is summarised in the paragraph below.

Known feeding areas for adult salmon (from evidence provided by commercial fisheries) occur around West and (to a lesser extent) East Greenland, at least for multi-sea winter (MSW) salmon from Scottish rivers, with fish also occurring off the Faroes. The fish caught off the Faroes include MSW which may be heading to or from Greenland or utilising waters around the Faroes and, potentially, 1SW fish which likely do not venture beyond this area. From this the authors inferred, albeit with the caveat that explicit evidence was lacking, that fish are likely to approach the Scottish coast from a predominantly north-westerly direction. However, there is considerable uncertainty about the offshore feeding areas of 1SW fish and it is possible that they, and perhaps other MSW fish, utilise broad areas of open ocean by making use of large scale ocean currents. If this is the case it would mean that fish could approach from a number of directions. On balance, a direction of return from the north (entering the Irish Sea via the North Channel for those fish heading for rivers south of the Project Area) appears more likely if fish approach from a predominantly northerly or westerly direction, but this is tentative.

Malcolm *et al.* (2010) examined historical studies involving both marked release and recapture of adult fish in coastal waters and of smolt recaptured as adults after tagging in their home rivers. The focus of this effort was Scottish east, north and far north west coast rivers and the authors do not comment on the relevance of their conclusions to Scottish southwest or NW England and Wales rivers. However, their broad interpretation is that both MSW and 1SW salmon may return to Scottish waters from either the north or the west, reaching the north or west coast and then moving along the coast to their natal river. This is consistent with the conclusion above.

There is some evidence to support the hypothesis that salmon return to at least more northerly and central rivers in the Study Area (Figure 2) from the north. The Lune is one of the few remaining rivers where licensed drift net fishing still occurs. Salmon netters fish the Lune estuary and drift out to sea (over Lune Deep). There are reports of salmon returning to rivers south of the Lune being caught around the Lune estuary (Jones & McCubbing, 1993). This suggests that adult fish are moving in a southerly direction at that point on their return from oceanic feeding grounds. For the Lancashire rivers, a general southwards movement of fish parallel to the coastline in this area is expected. A similar pattern is expected for the Cumbrian and Scottish rivers and there is some information from the Cumbrian drift net fishery, now closed, that nets were generally set 1-2nm from shore, suggesting that fish were moving relatively close to the coast (K. Nash, Environment Agency, pers. comm.).

On the North Wales coast, commercial fishermen take the view that salmon approach from the west, through the Menai Strait, moving on the flood tide over intertidal areas rather than further offshore (Npower Renewables, 2005). It is unknown whether these fish have entered the Irish Sea from the north or south, and therefore whether fish making for rivers such as the Welsh Dee (SAC for salmon) will cross the Project Area.

It is assumed that fish returning to rivers in Northern Ireland would be more likely to follow the pattern predicted for Scottish and Lancashire fish and return from the north. Again, this suggestion can only be tentative.

Malcolm *et al*. (2010) point out that very little is known about the phase of migration between return to the home land-mass and identification of the home river. Thus it is uncertain to what extent magnetic fields may be important in orientation within coastal areas, although these are understood to play a key role at least in the first phase of oceanic migration which is described as rapid and highly directed.

Adult salmon entering rivers are believed to swim predominantly in surface waters at night and to follow coastal tidal streams (Holm *et al*., 2000; Gill & Bartlett, 2010), although they may dive to greater depths (Malcolm *et al*, 2010). Likewise, smolt leaving rivers are understood to do so at night and in surface waters; however, beyond these stages the swimming depths of both adult and juvenile fish are uncertain. It is perhaps noteworthy that drifting gill nets used to target adult salmon at sea are fished with success near the surface and that reduced by-catch of salmon in coastal areas has been achieved by setting nets for other species (e.g. bass, mullet and flounder) parallel to the shoreline or in deeper water (Potter & Pawson, 1991).

For juvenile fish (smolts) and kelts leaving rivers to the south of the Project Area it would be logical for their route to the open ocean to take them via the Project Area, making use of prevailing currents (Figure 3). Conversely, it would be surprising if fish leaving rivers to the north crossed the Project Area since to do so would add substantially to their energy costs. However, there is no direct evidence for such behaviour and Malcolm *et al*. (2010) point out that for kelts leaving Scottish rivers there is almost no information on migratory routes or behaviour although data from other countries suggest rapid migration to the open sea at shallow depths (<15m).

Once in coastal waters, salmon smolts have been shown to continue to migrate in a directed manner with continual swimming within tidal currents ensuring that the fish quickly move to their first offshore feeding grounds. Malcolm *et a*l. (2010) cite Thorstad *et al*. (2007), who reported that smolts in Norwegian fjords covered several kilometres in their first day at sea and tens of kilometres over two days, and Lacroix *et al*. (2005), who found that 71% of smolts in Canada (Bay of Fundy) moved 5-10km within the first 12hrs, 94% within 24hrs. All fish were within a few hundred metres to a few kilometres of the coast. In Scottish rivers, it has been reported that smolts do not necessarily follow the coast as closely as returning adult fish (Malcolm *et al*., 2010; Genesis, 2012), potentially reflecting differences in the coastal environment between fjordic systems and many UK rivers. Malcolm *et al*. (2010) state that for the few studies where swimming depth was reported, it appears that post-smolts generally utilise shallow depths (typically 1-3m, but up to 6m) and suggest that wider evidence supports the concept of these fish swimming in near-surface waters.

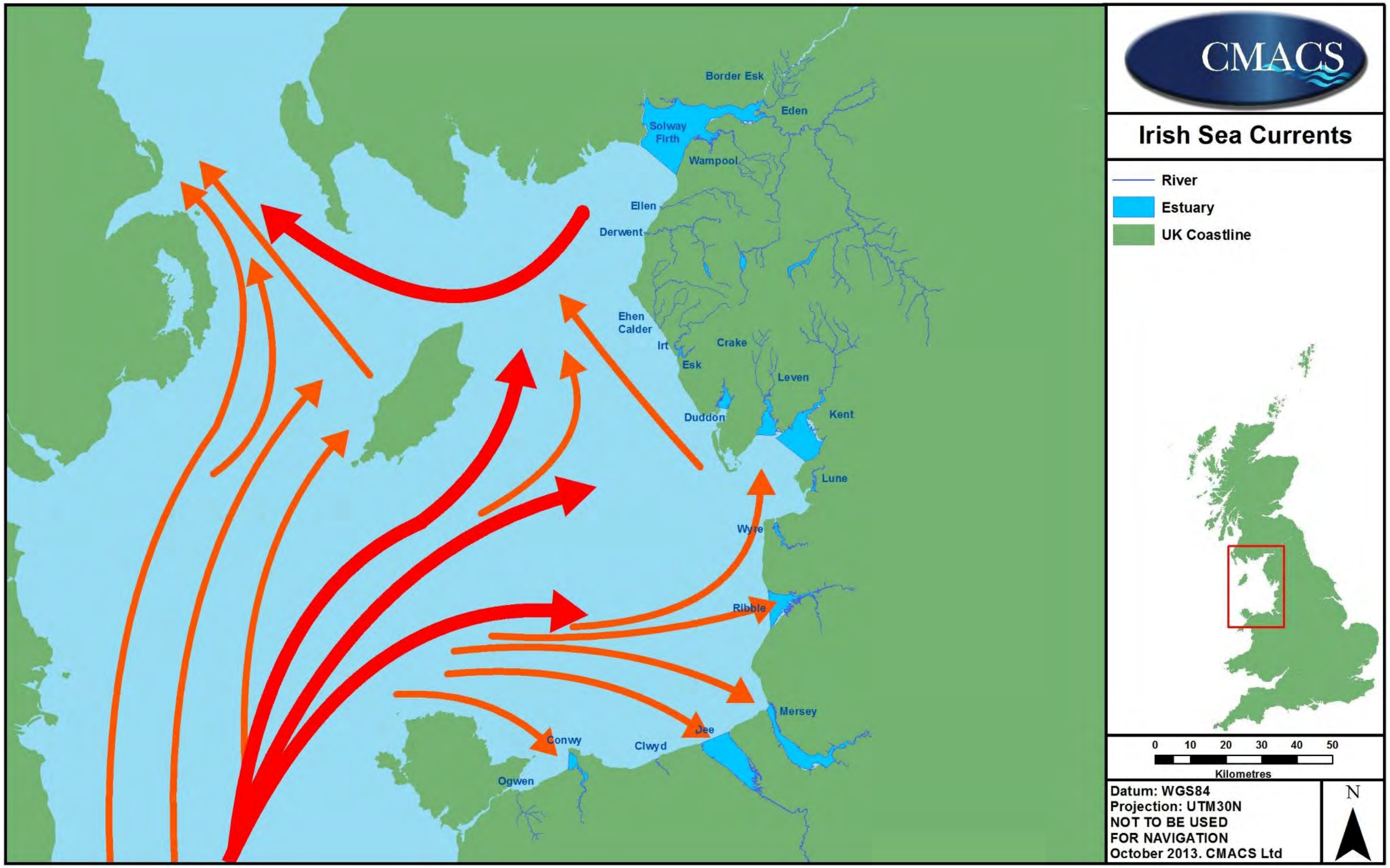

Figure 3: Broad scale Irish Sea net flow pattern (adapted from ABPmer, 2008).

3 Sea trout (*Salmo trutta*)

3.1 Conservation status

Sea trout is not afforded the same level of protection as Atlantic salmon, however it was also listed as a UK priority species under the original UK BAP and, as such, should be given consideration where appropriate in the succeeding country level biodiversity strategies. It has also been identified as a Priority Marine Feature in Scottish seas (marine part of life cycle).

Some further protection comes from existing fisheries legislation and in Scotland, it is protected at the same level as Atlantic salmon due to the definition of the term salmon in Scottish legislation as "all migratory fish of the species *Salmo salar* and *Salmo trutta*".

3.2 Overview of Life History

The sea trout lifecycle is superficially similar to that of the Atlantic salmon in that fish spawn in freshwater and mature at sea although in practice there are marked differences; for example, immature sea trout may return to freshwater during winter and fish are relatively likely to spawn more than once (Jonsson, 1985; Maitland & Campbell, 1992). It is also worth noting that brown trout, despite being the same species as sea trout, do not migrate to sea but spend their entire lives in freshwater. Those fish which do exhibit anadromy are believed to do so as a result of genetic and environmental factors (Malcolm *et al*., 2010). Like salmon, sea trout generally return to their natal river to spawn.

The timing of sea trout emigration is variable between rivers and likely influenced by environmental conditions but is essentially an event which occurs between spring and summer. Some rivers, such as the Welsh Dee, see adult fish returning from late winter through summer but with a peak from spring to around August (BODSA, 2014). Most rivers of the Study Area see peak runs of adult fish through summer months.

3.3 Local Populations

The trout population in the River Stinchar, the closest river on the Scottish side of the Project Area, and all other Ayrshire rivers, has decreased markedly since the 1960s. There is still an active rod fishery which is carefully monitored by the Ayrshire Rivers Trust. Very few trout are caught in comparison to previous years and in recent years most of the fish caught have been released back into the river under a catch and release scheme (Ayrshire Rivers Trust, 2014a). As there is a relatively healthy salmon population in the rivers, the cause of the dramatic reduction in the sea trout population is unknown.

Inver River in Northern Ireland historically had a thriving brown and sea trout population, a mixture of indigenous stock and hatchery fish which were introduced by Larne and District Angling Association (Larne & District Game Angling Association, 2014). The river supported an unmanaged fishery, meaning that many of the larger fish returning to spawn were removed from the river by poachers using nets. The impact poachers were having on the population became apparent throughout the 1980s and '90s as rod fishermen reported lower catch figures and smaller fish caught. A major pollution incident occurred in 1996 when cyanide entered the water system and killed the trout population present in the river. Subsequently, a group of local sports fishermen formed the Larne and District Game Angling Association to manage the fishery. They have since implemented and maintain river restoration projects and have restocked the river with trout. Other known sea trout rivers in the area include the Lagan, Bann and Glenarm and Six Mile Water.

Many other rivers both north and south of the Project Area support sea trout stocks; however, in the Irish Sea region, as in many other areas, there is concern about declining stocks.

3.4 Migration Routes and Behaviour

Unlike salmon, sea trout do not undertake consistent long distance migrations. Malcolm *et al*. (2010) summarise available evidence which suggests that many fish, especially from Scottish west coast rivers, remain in coastal waters relatively close to their natal river after initially entering the sea (typically up to a few tens of miles). There is evidence of more extensive movements, however, notably for adult fish that have spent a winter or more at sea. Understanding of this topic is restricted by the practical difficulties of tracking fish in the open sea, a task made more difficult even than it is for salmon by the relatively small size of the fish and absence of pronounced migratory routes.

There is an ongoing study into sea trout in the Irish Sea region, the Celtic Sea Trout Project (CSTP). This project has not yet published its outputs but an interim report (CTSP, 2013) provides some preliminary findings, including the suggestion of clear regional differentiation of Irish Sea sea trout into nine principal regional groups based on the location of marine feeding areas inferred from genetic and chemical analyses. Although these groups were concluded to have distinct foraging areas there was also evidence of considerable exchange between groups. A further early result of this study is the observation of high growth rates for fish which overwinter at sea.

In summary, it can be concluded that sea trout clearly have a much less pronounced migratory behaviour than salmon, typically remaining relatively close to their natal river system. This is not to say that individual fish do not range widely (there are examples of movements of at least hundreds of miles cited in Malcolm *et al*., 2010 and such movement can be inferred from initial results of the CSTP Project) and when returning to their native river sea trout must use specific cues (e.g. olfactory) to locate their target. The function of magnetic fields is unknown although like salmon the species is known to be magnetically sensitive (Gill *et al*., 2005).

There have been limited studies of sea trout swimming depths. Rikardsen *et al.* (2007, cited in Malcolm *et al.*, 2010) conducted a survey off the coast of Norway where eight trout were tagged with data storage tags. The fish were tagged during their migration to the sea and re-caught up to 40 days later. The data obtained showed that the fish spent 93% of their time near the surface at depths of less than 3m, also diving up to 28m depth. Malcolm *et al*. (op. cit.) also cite work by Johnstone *et al*. (1995) who reported that post-smolt sea trout mostly swam in near surface waters (within 10m in 50m of water) but with frequent dives to greater depths (to 20m). As adult trout have relatively smaller body sizes in comparison to those of salmon, it is more difficult to deploy larger tags, such as satellite tags, to collect data (Malcolm *et al*. 2013).

4 Sea and River Lamprey (*Petromyzon marinus* and *Lampetra fluviatilis*)

4.1 Conservation Status

River lamprey are listed on Annex II and V of the Habitats Directive (92/43/EEC) as a species of community interest whose conservation requires the designation of special areas of conservation and/or a species of community interest whose taking in the wild and exploitation may be subject to management measures. This species is also listed on Appendix III of the Bern Convention (The Convention on the Conservation of European Wildlife and Natural Habitats). Sea lamprey are listed on Annex II of the Habitats Directive and Appendix III of the Bern convention. Both river and sea lamprey were listed as UK BAP priority species and have been identified as a Priority Marine Feature in Scottish seas (marine part of life cycle). Additionally, sea lamprey appear on OSPAR's list of threatened and/or declining species and habitats.

4.2 Overview of Life History

Both species of lamprey are parasitic on other fish species and both spawn in rivers. River lampreys lay eggs in gravelly sediment and once hatched the larvae, known as ammocoetes, drift downstream with the current and settle in suitable habitat. Juveniles move downstream after two to three years, often between July and September, and develop into adults for one to two years in estuaries. They migrate back up rivers between October and December, spawning when water temperatures reach >10°C, around March/April time, or when environmental parameters allow (Maitland, 2003; Goodwin *et al,* 2009).

Sea lampreys have similar lifecycles to river lamprey but venture into the open sea. They typically spawn between May and June, when water temperatures reach >15°C and remain in river systems for approximately five years before migrating downstream between July and September. Little is known about their migration when they reach the open sea but they have been found in both coastal and deep sea environments (Maitland, 2003; Goodwin *et al*, 2009). Once adult lampreys have spawned, regardless of species, all individuals die (Maitland, 2003). Since they do not leave the estuary of their natal river system river lampreys are not considered likely to encounter the Project Area. For completeness they are however considered further in this report. There is no evidence that lampreys return to their natal river to spawn (Waldman *et al*., 2008)

4.3 Local populations

Lampreys are considered an endangered species in Europe and all EU member states are required to take steps to ensure they are protected (Goodwin *et al*., 2009) with good water and substrate quality required for lamprey to be present in rivers.

River lampreys are widespread throughout southwest Scotland and sea lampreys are known to spawn in these rivers also. Monitoring surveys are undertaken as part of a national survey programme which is funded by Scottish Natural Heritage (Ayrshire Rivers Trust, 2014b). The rivers Eden and Derwent and the Solway Firth in Cumbria are within a Special Area of Conservation (SAC) and contain healthy populations of river lamprey (JNCC, 2011a).

There are healthy populations of sea lampreys in the lower and middle reaches of Cumbrian rivers Eden and Derwent. The Eden is a designated cSAC for this species. The Solway Firth is a migratory passage for sea lamprey both to and from spawning grounds (JNCC, 2011b).

River and sea lamprey are found in many of the rivers in Northern Ireland. Lamprey share similar spawning habitat to that of salmon and trout, creating nests (redds) in gravel beds. Fishermen in Lough Neagh often report lamprey attached to pollan (*Coregonus autumnalis*) and trout (Goodwin, *et al*., 2006).

4.4 Migration routes and behaviour

Sea lampreys spawn in the lower reaches of rivers (potentially because they are relatively poor at overcoming obstacles such as weirs, etc.) before returning to sea in early summer. As mentioned previously, it is not believed that sea lamprey return to their native river. There is evidence that lamprey detect a pheromone produced by larval lamprey to aid their spawning migration (Bergstedt & Seelye, 1995 cited in Vrieze, 2008), thus increasing the likelihood that they will migrate up a 'suitable' river.

Lamprey are electrically sensitive and therefore also have the capability to detect magnetic fields (Gill *et al*., 2005). No information has been found in relation to the potential use of this sense to aid migration but the lack of strong homing behaviour suggests that it is unlikely it is used beyond returning to a coastal environment before other senses are used to identify larval conspecifics.

5 European Eel (*Anguilla anguilla*)

5.1 Conservation Status

Due to the observed decline in this species, the European Commission developed an Eel Recovery Plan (Council Regulation 1100/2007) with the aim to restore eel stocks to a sustainable level with each member state required to establish an Eel Management Plan.

The European eel was also added to the UK BAP priority species list, has been identified as a Priority Marine Feature in Scottish seas and appears on OSPAR's list of threatened and/or declining species and habitats.

5.2 Overview of Life History

European eel is a widespread species which is distributed as far north as the Arctic Circle to North Africa in the south and Baltic coasts to the east.

European eels spawn in an area of the west-central Atlantic, east of the Caribbean known as the Sargasso Sea (see, for example, Maitland & Campbell, 1992 and Moriarty, 2000). Larvae then travel approximately 6,000km to reach coastal waters with some individuals remaining in the marine environment, others travelling far up into catchments and others moving between marine, estuarine and freshwater as adults. By the time the eels arrive at the European continental shelf they have metamorphosed into glass eels (unpigmented eels approximately 5cm in length).

Eels begin their migration upriver between February and April. The timing of return migration is dependent on environmental factors, such as temperature, flow levels, etc., but usually occurs in the UK during late-summer to autumn (Bruijs & Durif, 2009).

The entire population is regarded as one single stock (ICES, 2009), reflecting that eels do not return to native river systems or even continent but arrive perhaps randomly, carried by ocean currents (see also Section 5.4).

5.3 Local populations

Ayrshire Rivers Trust reports an 'abundant' eel population in rivers in the region (Ayrshire Rivers Trust, 2014b).

NIEA (2010) have taken data available from sampling carried out on intake screens at Ballylumford power station, Larne. This shows that between 1989 and 2009, eels were present in Larne Lough. There have been no surveys completed since but it is assumed that the eel remain present.

European eel populations, in general, are in decline. Dekker *et al.* (2006) show the extent of this by stating that the recruitment of glass eels in the Atlantic Ocean, in the 1980s, reduced to approximately 10% of former levels and have fallen by a further 1-5% since 2000. Lough Neagh in Northern Ireland is the largest freshwater lake in the British Isles and is home to a prominent eel fishery. As Lough Neagh has a catchment area of approximately 5,750km^2 with many of the rivers in Northern Ireland feeding into it, it can be assumed that migrating eels will travel through many of these waterways (Dekker *et al*, 2006) and may therefore be present along the east coast of Northern Ireland near the Moyle Interconnector.

5.4 Migration Routes and Behaviour

The eggs and larvae (leptocephali) of eels which were spawned around the Sargasso Sea drift with the North Atlantic Drift and arrive in European coastal waters one to four years after spawning. Once in coastal waters, the leptocephali undergo metamorphosis to become elvers or 'glass' eels and these young fish enter the estuaries of most UK rivers. The main elver run occurs each spring, between February and April, it is reasonable to assume that elvers will potentially run up all rivers draining into the Irish Sea. Some eels do not enter rivers and remain instead in coastal waters.

Eels typically mature over a number of years (sometimes many decades), feeding and growing as 'yellow eels'. When they are ready to return to the spawning grounds those eels that have lived in freshwaters or estuaries move downstream on high water flow events on dark/moonless nights as they are phototactic and avoid light. They can travel short distances across land in order to overcome barriers to migration. Either prior to or on re-entering an estuary in late summer to early autumn they undergo a process of pigment change to become 'silver eels' ready for the return sea migration.

There is very little data available on the swimming depths and distance offshore that adult European eels use when migrating. Likewise, there are stages in the lifecycle of the eel which are still unknown, for example, neither spawning adults or eggs have been observed in the wild (Dekker *et al.*, 2006).

Juvenile eels are likely to arrive in the Irish Sea and Project Area from the south, since to do so some from the north would require the small eels to move against prevailing currents. It is believed that the oceanic phase of their migration is passive; the animals relying on the direction of prevailing currents to deliver them to coastal areas. However, once in coastal waters, there is evidence of eels actively moving up in the water column to take advantage of tidal flow towards the shore, whilst remaining near the seabed during the ebb to avoid being taken back away from the shore (Creutzberg, 1961 and Tesch, 2003, cited in Malcolm *et al*., 2010). This behaviour is evident only in darkness (De Casamajor *et al*., 1999, cited in Malcolm *et al*., 2010).

Very little is known about the marine phase of adult migration back to their southern spawning area. Eels leaving rivers of the Project Area could potentially pass around either to the west or east of Ireland; it is simply unknown which, if either, route is preferred.

Eels are both electrically and magnetically sensitive and magnetic sense is believed to be important in the migration of adult seals towards the Sargasso Sea; however, whether eels begin to use magnetic sense in the early coast phase of their migration is unknown. It seems less likely that magnetic sense is important for the migration of juvenile eels into freshwater given their reliance on largely passing drifting and phototaxis.

6 Summary

Information in the sections above is summarised in (Table 1), below, together with an assessment of the level of confidence. This information should not be used without reference to the supporting text in preceding sections in order to understand the tentative and incomplete nature of much of our knowledge of the behaviour and ecology of diadromous fish.

Table 1: Summary in relation to report objectives (see Section 1.2)

Species	Use of Project Area (PA) for feeding or migration [confidence of information]	Origin of fish (local rivers or other) and migration routes in relation to Project Area (PA) [confidence of information]	Coastal swimming depth [confidence of information]	Proximity to Coast [confidence of information]	Seasonality (period when fish could be present in/around Project Area (PA) [confidence of information]
Salmon	Juvenile fish (smolts) and mature fish (kelts) will pass across the Project Area during their migration to oceanic feeding grounds. [HIGH] Returning adult salmon will cross the Project Area as they return to their natal rivers to spawn. [HIGH]	Juvenile fish (smolts) and mature fish (kelts) leaving rivers to the south of the Project Area are expected to cross the Project Area whilst those from rivers to the north are not. [MEDIUM] Adult salmon returning to rivers north of the Project Area are not expected to cross the Project Area. [MEDIUM] Adult salmon returning to rivers south of the Project Area (SW Scotland, NW England rivers) are likely to cross the Project Area. [HIGH that some fish will do this, LOW that it applies to all rivers] There is no information as to whether fish returning to North Wales rivers are likely to cross the Project Area.	Smolts: predominantly surface waters [MEDIUM-HIGH] Kelts: unknown Returning adults: predominantly surface waters. [MEDIUM]	Smolts: fish leaving local rivers are likely to be present in coastal areas [HIGH], it is unknown whether fish from other rivers will keep towards the coast in the PA. Kelts: unknown. Adults: fish returning to rivers local to the PA are likely to be present within a few km of the coast [MEDIUM]. It is believed that fish returning to more distant	Smolts: migrate to sea early spring/summer; generally peaking between April and June. [MEDIUM-HIGH] Adults: most fish return to rivers between June and August. There is a strong autumn run of grilse (1SW fish) in many rivers and some rivers see small numbers of larger MSW fish earlier in the year. [HIGH] Kelts: after spawning in winter to early spring [HIGH]

Species	Use of Project Area (PA) for feeding or migration [confidence of information]	Origin of fish (local rivers or other) and migration routes in relation to Project Area (PA) [confidence of information]	Coastal swimming depth [confidence of information]	Proximity to Coast [confidence of information]	Seasonality (period when fish could be present in/around Project Area (PA) [confidence of information]
				rivers are also likely to prefer coastal waters. [LOW]	Note: timing of migration is variable between rivers at a local scale.
Sea trout	It is unknown whether the PA is important for sea trout feeding. Lower intertidal sediments at both landfalls are coarse (cobbles and bolders), and therefore shallow waters at either extent of the Interconnector could, therefore, potentially be used for feeding by trout. Some passage of fish across the PA, especially from local rivers, is likely [HIGH] but more widespread movement of fish is considered unlikely	It is believed that most fish in the PA are likely to originate primarily from local rivers (within some tens of km of the PA) but with occasional fish from more distant rivers [LOW-MEDIUM]. There are not believed to be definite migration routes [LOW]	Adults and smolt: surface waters (LOW-MEDIUM)	Adults: predominantly coastal [MEDIUM] Smolts: predominantly coastal [LOW-MEDIUM]	Adults: runs peak in summer months [HIGH] Smolts: generally peaking between spring and summer [HIGH] Note: as with salmon, migration is variable on a local scale between rivers.

Species	Use of Project Area (PA) for feeding or migration [confidence of information]	Origin of fish (local rivers or other) and migration routes in relation to Project Area (PA) [confidence of information]	Coastal swimming depth [confidence of information]	Proximity to Coast [confidence of information]	Seasonality (period when fish could be present in/around Project Area (PA) [confidence of information]
	[MEDIUM]				
European eel	Some adults likely forage in or around the PA [HIGH] although numbers are unknown. Adults from some rivers/coastal areas probably cross the PA during their spawning migration [HIGH] and juveniles likewise when arriving in the area on their way to coastal or freshwater feeding grounds. [HIGH]	Adults: it is unknown whether fish travel around the west or east coast of Ireland by preference and it is therefore not possible to say whether it is likely or not that fish from certain rivers or coastal areas will cross the PA. Juveniles: it is believed that only fish travelling to rivers or coastal areas north of the PA are likely to cross the PA [HIGH]	Adults: unknown. Juveniles: variable (surface waters on flooding tides and deeper on the ebb if entering local rivers [LOW], otherwise unknown).	Adults: unknown Juveniles: unlikely that they will actively be coastal or otherwise as travel is facilitated by currents and so could be present at any distance offshore [MEDIUM]	Adults: late summer-early autumn [MEDIUM-HIGH] Juveniles: February-April [HIGH]
Sea lamprey*	Adults seeking freshwater to spawn may cross PA. [HIGH] Whether adults forage in the PA depends on the movements of the host organism but it is unlikely that there is any strong preference to utilise the PA [HIGH]	Adults: fish could be present from any river system. [HIGH]	As parasitic adults: dependent on host species and therefore variable. As free-swimming adults searching for freshwater	As parasitic adults: dependent on host species and therefore variable. As free-swimming adults searching for freshwater	Adult emigration: July-September. [HIGH] Spawning adults: spring-early summer [MEDIUM]

Species	Use of Project Area (PA) for feeding or migration [confidence of information]	Origin of fish (local rivers or other) and migration routes in relation to Project Area (PA) [confidence of information]	Coastal swimming depth [confidence of information]	Proximity to Coast [confidence of information]	Seasonality (period when fish could be present in/around Project Area (PA) [confidence of information]
			spawning habitat: unknown.	spawning habitat: unknown, but if entering local rivers likely coastal to detect larval pheromones.	

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A.2.8 – Marine Archaeology Desk Based Assessment

MICC14

SCOTLAND-NORTHERN IRELAND MOYLE INTERCONNECTOR

Marine archaeology desk-based assessment

August 2014

HEADLAND ARCHAEOLOGY

SCOTLAND-NORTHERN IRELAND MOYLE INTERCONNECTOR

Marine archaeology desk-based assessment

August 2014

HA Job no.: MICC14

Project Manager: Michael Walsh
Authors: Michael Walsh & Scott Timpany
Graphics: Sam Fox
Approved by: Michael Walsh – Project Manager

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SECTION ONE EXECUTIVE SUMMARY

1.1 This document presents a maritime cultural heritage baseline report, incorporating an archaeological desk-based assessment of marine and coastal cultural assets including analysis of geophysical data collected for routine monitoring of the existing Moyle Interconnector cables to identify assets potentially affected by the proposed installation of replacement low voltage (LV) cables ('the Project'). The current assessment was undertaken by Headland Archaeology (UK) Limited on behalf of Intertek Energy and Water Consultancy Services.

1.2 The purpose of this report is to provide a baseline characterisation by identifying any sites and features of cultural heritage significance within and in proximity to the cable installation corridors, within which the replacement LV interconnector cables will be installed. This baseline assessment will be used to:

- Assess the nature of the cultural resource in this area;
- To outline the archaeological potential of the marine environment;
- To aid in the identification of seabed anomalies that might be discovered during the proposed geophysical survey; and
- Inform and propose mitigation for sites that may be impacted by the proposed geotechnical survey.

1.3 In due course a project-specific Written Scheme of Investigation (WSI) will be prepared and submitted, detailing the staged programme of works that will be undertaken by Headland Archaeology to identify and protect the marine cultural heritage resource.

1.4 This assessment has examined the cable installation corridors within which the replacement LV cables will be installed, to identify sites in close proximity that could be directly affected by the development. For the purposes of this baseline assessment a cable study corridor has been assessed that extends 1 km either side of the existing Moyle Interconnector cables and a Wider Study Area (WSA) with a 5km buffer to inform the archaeological potential of the area.

1.5 This assessment has established that there are no designated wrecks or other designated cultural heritage assets with legal designations within the cable corridors or the WSA. However, there is one potential Protected Place under the PMRA 1986, as an aircraft is reported to have crashed in this vicinity during WW2 although the precise location of the wreckage remains unknown.

1.6 This report has identified seventeen cultural heritage assets within the cable study corridor, nine of which are live. There are two nineteenth century wrecks, four casualties from WW1, one aircraft from WW2, one inter-war wreck, and one modern wreck. The identities and dates of the remaining six wrecks and the nature of two obstructions remain unknown.

1.7 A further forty-six wrecks and obstructions have been identified within the WSA including twenty five known wrecks, nine unidentified wrecks and twelve obstructions. Thirty eight of the forty-six sites are live. Nine of the wrecks date from the nineteenth century, one dates from the early twentieth century, eight were sunk in WW1, one in WW2, two wrecks date from the inter-war years, one from just after WW2 and five are modern wrecks dating from 1975 onwards.

1.8 Desk-based analysis of the intertidal zones in the vicinity of the proposed landfall sites in both Scotland and Northern Ireland have shown that there are no recorded cultural heritage assets in either location.

1.9 Analysis of the geophysical survey data collected under the inspection and maintenance regime for the existing cables has shown that the ability to identify sites on the seabed in the vicinity of the existing cables is good, and that the distribution of wrecks in the vicinity is fairly sparse. This assessment identified seven sites of high potential, five of which appear to be associated with the cables and two which seem to indicate wreck sites. Six further sites are of medium potential as they seem to indicate the characteristics of man-made objects on the seabed.

1.10 Previous studies have shown that there is high potential for organic deposits, such as peats to be present in the marine and intertidal areas at Portmuck which would be of palaeoenvironmental and archaeological significance. The rich archaeological history of Larne, including the finds of log boat fragments at Larne Lough near to Portmuck indicates that there is also high potential for the recovery of artefacts from the Mesolithic period onwards.

1.11 The rate of isostatic uplift combined with the nature of the coastline at Currarie Port, Ayrshire suggests there is low potential for intertidal and shoreline deposits of palaeoenvironmental interest. The absence of archaeological features and peats within the onshore area at Currarie Port also suggests that there is low potential for the presence of organic deposits of palaeoenvironmental and archaeological interest and for the presence of archaeological finds.

1.12 Recommended mitigation for cultural heritage and potential cultural heritage sites should include:

- Exclusion zones around the known extent of any wreck sites and sites of high archaeological potential identified in the pre-installation geophysical and geotechnical surveys;
- Further investigation of sites considered to be of medium archaeological potential that could potentially be impacted by the development; and
- Further examination of potential offshore prehistoric deposits.

1 Glossary of Terms

AD	*Anno Domini*
Anomaly	Possible manmade target identified in the geophysical survey data
Assets	Parts of the historic environment that has local, regional and national significance, such as listed buildings and war memorials
Bathymetry	The measurement of the depth of the seabed from the water surface
BGS	British Geological Survey
BC	Before Christ
BP	Before Present
COWRIE	Collaborative Offshore Wind Research into the Environment
CSC	Cable Study Corridor
DEAD Wreck	Wreck reported to be in a certain location but has not been detected by repeated or most recent surveys
Designated Wreck	A protection placed on historic wrecks so they are not put at risk from unauthorised access, undisciplined activities or investigation, in accordance with the Protection of Wrecks Act 1973
EIA	Environmental Impact Assessment
Fauna	Animals both invertebrates and vertebrates
Findspot	A known location of a previously recorded archaeological find
Flint	Form of quartz mineral (chert) used to make tools in prehistoric societies
Geophysical Survey	A non-intrusive investigative survey with example methods including sidescan sonar, magnetometer, echo-sounding and sub-bottom profiling, to detect or measure features on and below the seabed
Geotechnical Survey	An intrusive survey method that penetrates the seabed recovering material samples for analysis
GIS	Geographical Information System
GPS	Global Positioning System
Holocene	Period of geological time spanning from 12,000 years BP
ICOMOS	International Council on Monuments and Sites
JNAPC	Joint Nautical Archaeology Policy Committee
LAT	Lowest Astronomical Tide
Lithic	Stone tool that may be associated with prehistoric cultures

LIVE Wreck	Wreck considered existing
Mesolithic	Archaeological period of time of past cultures approximately 9,000 – 4,000BC
Macrofossils	Fossils that can be identified by eye, e.g. shell fragments
Microfossils	Small fossils that can only be viewed under a microscope, e.g. pollen
MOD	Ministry of Defence
Neolithic	Archaeological period of time of past cultures approximately 4,000-2,500BC
NMR	National Monument Record
OD	Ordnance Datum
Palaeo-channel	Submerged former course of a prehistoric river or other fluvial flow, typically filled with sediment
Palaeo-environmental	Prehistoric environmental conditions
Palaeolithic	Prehistoric era distinguished by the development of stone tools, 780,000-18,000 years BP
Peat	An organic material formed by decayed vegetation matter that can preserve important environmental and archaeological evidence
Pleistocene	Period of geological time spanning 1.8 million years ago to the Holocene
Quaternary	Of (or belonging to) the geologic time, system of rocks, or sedimentary deposits from the end of the Tertiary Period through to the present
Receptor	Any environmental or other defined feature that is sensitive to - or has the potential to be affected by - an impact
ROW	Receiver of Wreck, the wreck administration within the MCA/UKHO
Scheduled Monument	Nationally important archaeological sites which have legal protection assigned to them
SeaZone	SeaZone Solutions Ltd. who supply up-to-date UKHO GIS data
Silt	A geological deposit that can contain evidence of past sea levels and landscapes
TCE	The Crown Estate
The Project	Moyle interconnector cable
UKHO	United Kingdom Hydrographic Office
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WSA	Wider Study Area comprising a 5km buffer zone beyond the CSC

SECTION TWO INTRODUCTION

1.1 Headland Archaeology (UK) Ltd was commissioned by Intertek Energy and Water Consultancy Services to prepare a maritime cultural heritage assessment for the proposed installation of replacement low voltage (LV) cables (henceforth 'the Project') which will be laid in close proximity to the existing Moyle Interconnector cables that run between the east coast of Northern Ireland and the west coast of Scotland. This will include an assessment of the landfall sections of the proposed cable installation corridors.

1.2 This assessment is based on COWRIE (2007) and the Crown Estate (TCE) (2010) guidelines for desk-based assessments, geotechnical and geophysical surveys, and historic environment and setting appraisals undertaken to input into the Environmental Assessment (EA) for the Moyle Interconnector between Scotland and Northern Ireland.

1.3 The purpose of this report is to identify any sites and features of cultural heritage significance within and in proximity to the project that may be affected by the proposal. The report comprises the results of an archaeological baseline study and outlines the archaeological potential of the marine environment and includes information on sites and areas of archaeological significance identified within and in proximity to the project. The level of significance of each site will be determined once the geophysical survey results have been analysed and compared with the results from this baseline assessment.

1 Project Background

1.4 The Moyle Interconnector has linked the electricity grids of Northern Ireland and Scotland since 2002 thereby commercially linking the SEM and BETTA wholesale electrical markets. Moyle Interconnector Ltd (henceforth MIL) is owned and operated by Mutual Energy as is Premier Transmission Ltd, the Scotland to Northern Ireland natural gas transmission pipeline which conveys all of Northern Ireland's natural gas.

1.5 The interconnector runs for a distance of some 63km between converter stations at Ballycronan More in Island Magee, County Antrim in Northern Ireland, and Auchencrosh, Ayrshire in Scotland. The interconnector consists of two separate High Voltage Direct Current (HVDC) cables, each with a high voltage (HV) and a low voltage (LV) conductor integrated into a co-axial design.

1.6 Each cable is rated to transfer 250MW in either direction, but since 2010 there have been four system faults on the LV conductor resulting in the interconnector running at half capacity. MIL is now investigating options for the restoration of full capacity by installing new separated LV return conductors whilst leaving the two existing HV conductors in situ and operational as originally installed.

1.7 Both consenting authorities (Marine Scotland Licensing and Operations Team (MS-LOT) and the Department of Environment Northern Ireland (DoENI) Marine Licensing) have confirmed that the proposed installation of new LV return cables does not constitute an 'EIA development' as defined under the Marine Works (EIA) Regulations 2007 (Scotland) and the Marine Works (EIA) Amendment Regulations 2011 (Northern Ireland) respectively.

1.8 However, MIL considers it appropriate to undertake an Environmental Appraisal (EA) of the proposed installation of the separated LV return cables. Whilst not a statutory EIA, the EA will be undertaken by Intertek on behalf of MIL in accordance with all relevant industry best practice. An Environmental Report (ER) will be prepared and will accompany the application to MS-LOT and DoENI Marine Licensing. This will describe the environmental effects of the proposed marine cables and will set out the proposed mitigation.

1.9 MIL will submit an application to MS-LOT for a marine licence under the Marine (Scotland) Act 2012 for the extent of the marine cables in Scottish territorial waters and to DoENI Marine Licensing under the Marine and Coastal Access Act (MCAA) 2009 for the extent of the marine cables in Northern Irish territorial waters.

1.10 Owing to the considerable lead in period from the point of order to the delivery of the LV cables, MIL are seeking an early opinion from MS-LOT and DoE NI Marine Licensing on the provision of conditional marine licences prior to committing to considerable up-front expense in the placement of the order for the LV cables.

1.11 The decision to grant conditional licences would be based on this DBA and preliminary archaeological analysis of existing geophysical (side-scan sonar) survey data, which has been collected for inspection and maintenance purposes for the existing cables. The condition placed on the licences would commit MIL to conduct a full pre-installation geophysical survey utilising the full suite of geophysical techniques which would then be subjected to full archaeological analysis prior to any intrusive works being undertaken in association with this project.

1.12 MIL plans to install the two new LV return conductors between the existing converter stations at Ballycronan More and Auchencrosh with landfall at the same locations as the existing cables at Portmuck South, Islandmagee in Northern Ireland and Currarie Port, Ayrshire in Scotland. The preferred option for the marine section of the route is for each LV cable to be installed parallel to and offset between 50m and 100m south of each of the existing north and south cables. In near-shore areas, however, they will be installed as close as practically possible to the existing HV conductors (approximately 4m apart).

1.13 This DBA includes an assessment of the approximately 53km long submarine section. It is hoped that this initial assessment will provide sufficient information to enable the award of conditional marine licences. MIL or the appointed cable installation contractor will then commission full geophysical and geotechnical surveys of the proposed cable routes prior to cable installation which will then be subjected to full archaeological review.

2 Aims and Objectives

2.14 The aims of this assessment are to review the known and potential cultural heritage receptors within the area that will be subject to impact from the project so that mitigation can be embedded prior to the commencement of any intrusive works. The objectives of the assessment are:

- To set out the statutory, planning and policy context relating to the historic environment within the study area;
- To provide an overview of the historic environment in the project study area, based on existing archaeological records and secondary sources;
- To highlight known maritime sites that may be impacted by the proposed project, with particular reference to:
  - Shipwrecks, crashed aircraft and wreck material;
  - Submerged prehistoric sites and artefacts, and
  - Areas of archaeological potential.

3 Legislative Framework and Guidance

3.15 As the proposed project is located in the northern Irish Sea within Northern Irish and Scottish territorial waters and falls within the Strategic Environmental Assessment (SEA) area 6, this assessment takes account of the following national and international legislative procedures and guidelines:

- Protection of Wrecks Act 1973;
- Protection of Military Remains Act 1986;
- Marine Act (Northern Ireland) 2013;
- Marine (Scotland) Act 2012;
- Historic Monuments and Archaeological Objects (Northern Ireland) Order 1995 (HMAO);
- Marine and Coastal Access Act (MCAA) 2009:
- Merchant Shipping Act 1995;
- Burial Act 1857;
- Planning Policy Statement 6: Planning, Archaeology and the Built Heritage (Department of Environment, Northern Ireland (DOENI 1999) ;
- European Convention on the Protection of the Archaeological Heritage (Valetta) 1992;
- UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001);
- International Council of Monuments and Sites (ICOMOS) Charter on the Protection and Management of Underwater Cultural Heritage (1996) (the Sofia Charter); and
- United Nations Convention on the Law of the Sea (UNCLOS) 1982.

3.16 The desk-top baseline study and assessment has been compiled in line with industry best practice and the relevant offshore renewables and marine historic environment guidance. These include:

- Institute for Archaeologists (IfA) guidelines: Standard & guidance for archaeological desk-based assessment (2008);
- Joint Nautical Archaeology Policy Committee (JNAPC) code of practice for seabed development (2008);
- COWRIE Historic environment guidance for the offshore renewable energy sector (2007);
- COWRIE Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore renewable Energy (2008);
- COWRIE Guidance for offshore geotechnical investigations and historic environment analysis: guidance for the renewable energy sector (2011);
- The Crown Estate (2010). Offshore renewables protocol for archaeological discoveries;
- The Crown Estate (2010). Round 3 offshore renewables projects model clauses for archaeological written schemes of investigation; and

4 Methods and data sources

4.17 The following section sets out the methods followed for this report, including geographical scope and the sources used for collation of data.**Geographical scope**

4.18 The following study areas have been used for this baseline report:

- **Cable study corridor** (CSC) (Figure 1) – for the purposes of this baseline assessment the area assessed extends 1km either side of each cable over the proposed c 53km marine route between Scotland and Northern Ireland up to and including the landfall sites; and

- **Wider study area** (WSA) (Figure 2) – an area extending 5km from the CSC has been examined to identify sites in close proximity to inform the potential to discover hitherto unidentified cultural heritage assets.

4.19 All known maritime cultural heritage assets and potential maritime cultural heritage assets identified are included in this baseline study and are presented in the tables below which detail each maritime cultural heritage asset identified during this assessment with a unique HA number (to aid with identification). Sites within the cable corridor and the Wider Study Area are shown in Figures 1 & 2.

Desk-based survey sources

4.20 The DBA is a documentary and cartographic search utilising a number of sources in order to locate all known cultural heritage assets within the study area of the proposed development, and to identify the archaeological potential of the area, in this case the northern Irish Sea. Sources used for this assessment include:

- The Northern Irish Sites and Monuments Record held by the NIEA;

- Databases of designated and undesignated cultural heritage assets including maritime records (NMR) maintained by Historic Scotland including designated wrecks;

- Databases of sites and monuments held by County Antrim Historic Environment Record;

- Ayrshire County Council

- UK Hydrographic Office (UKHO) Wrecks and Obstructions Database (SeaZone);

- UKHO review of cartography, historic charts and sailing directions;

- Ministry of Defence (military remains only);

- Receiver of Wreck (ROW);

- Relevant Strategic Environmental Assessment (SEA) reports (eg UK Continental Shelf SEA archaeological baseline) and Coastal Survey Assessment reports;

- Records held with the Archaeology Data Service (ADS);

- Marine Environment Data information Network (MEDIN);

- Relevant external marine historic environment specialists;

- British Geological Survey regional guide and previous work in the area;

- Relevant dive groups and local interest groups;

- Relevant external marine historic environment specialists (eg palaeo-environmental); and

- Readily accessible published sources and grey literature (eg. results from previous studies).

Consultation with statutory bodies

4.21 In addition, relevant statutory bodies and stakeholders consulted include (not exhaustively):

- Historic Scotland
- Northern Ireland Environment Agency
- Ministry of Defence (military remains only)
- Receiver of Wreck (UK Maritime Coastguard Agency)

SECTION THREE BASELINE ENVIRONMENT

1.22 The following sections outline the nature of the existing environment and cultural heritage baseline.

1.23 The aim of this section is to provide a brief assessment of the palaeoenvironmental potential of sediments affected by the proposed route of the replacement LV cables. This assessment will provide data that will aid in identifying potential sediments of palaeoenvironmental and archaeological interest.

1.24 The specific objectives of this palaeoenvironmental assessment are:

- to review available data in respect of seabed and sub-seabed deposits likely to be of palaeo-environmental and archaeological interest;
- to identify any deposits of palaeoenvironmental and archaeological potential.

1 **Overview of the area**

1.25 In order to place the results of the geo-technical report in the wider context of the palaeoenvironment of the two areas affected by the cable route it is important to consider the previous work done in these areas. A brief overview of this work is given below.

2 **Portmuck South, Islandmagee, Northern Ireland**

2.26 Following the end of the last glacial period, the combination of an increase in water from ice melt and the isostatic uplift of land caused by the release in weight from ice masses, has resulted in regional fluctuations in relative sea-level (RSL) in coastal areas of the UK over the past 12,000 years (Smith et al, 2012). In places along the Irish coastline RSL was lower by as much as 30m between 10,000 to 9000 BP (Brooks et al, 2008).

2.27 There are no RSL studies specific to the area of Portmuck South and thus studies from the north east of Ireland must be used to interpret how sea-level has changed in the area since the last glacial period.

2.28 RSL studies in the north east of Ireland, in the area around Belfast (Carter 1982) showed that RSL rose steeply from the early Mesolithic period at c. 9000 BP to peak at around 6500 BP at c. 2m OD during the late Mesolithic period (Carter et al, 1989; Bradley et al, 2011). This culmination in RSL rise is known as the main postglacial transgression.

2.29 More recent predictive RSL modelling for the areas of North Antrim and North Down (Brooks et al 2008), which envelope Portmuck, suggest a similar trend with RSL peaking in the late Mesolithic around 6000 BP at c. 4-6m OD. A rise in RSL to this date is also indicated by the RSL curve for east central Ireland (Taylor et al 1986), which shows a gradual rise in RSL from the early Mesolithic to the Neolithic period, between c. 10.000 BP to c. 45000 BP to 0.5-1m OD.

2.30 In the Belfast area, RSL gradually fell to levels below that of current sea-level from the Neolithic to the Iron Age period between 5000 BP to 2500 BP (Carter 1982), before rising to its present level (Carter et al, 1989). This is in line with the suggested RSL curve for east central Ireland (Taylor et al 1986), which indicates that the rise in RSL was followed by a period of falling RSL to the Iron Age at c. 2500 BP before rising again to its present level. However, other models suggest that RSL fell to its present level following its peak in the later Mesolithic period (Brooks et al 2008).

2.31 From the above studies it seems most likely that at Portmuck South, RSL rose gradually from the end of the last glacial period, peaking sometime in the late Mesolithic period. RSL then continued to fall gradually, with some fluctuations to its present level. Therefore there is the potential for previously terrestrial deposits from the early Mesolithic to be submerged in the offshore area.

2.32 That Northern Ireland was colonised by people during the early Mesolithic is known from artefactual evidence, whilst comparisons of these assemblages with those from Scotland has suggested links between these two locations from this period onwards (Wickham-Jones and Woodman, 1998).

2.33 The area around Larne in particular has a rich heritage of Mesolithic lithic finds and in particular those from the later Mesolithic, which had led to the term 'Larnian' being coined for this period (e.g. Woodman 1985a, 1985b; Anderson 1993). Indeed the area of Islandmagee has been shown to have a rich prehistoric and historic archaeological history, including settlements, burials and megalithic sites (e.g. Suddaby 2003; Anderson and Rees, 2004) suggesting this area has been attractive to people through time.

2.34 Activity by Mesolithic peoples in the coastal areas of Northern Ireland has been well documented (e.g. Pollard, 2011) and is a further indication of a period when RSL was lower, and hence that activities took place in areas seaward of the present day coastline. It has been proposed that during this period people were active in a maritime sense through the use of log boats (Tolan-Smith, 2008; Garrow and Sturt, 2011), which again suggests that contacts may have existed between Ireland and the west coast of Scotland.

2.35 There is evidence for such an early maritime culture in Co. Antrim including in Larne Lough where fragments of two log boats have been discovered (Fry, 2000). At Greyabbey Bay, Co. Antrim intertidal sediments have also produced a wealth of archaeological materials including a Neolithic log boat and medieval fish traps (Forsythe & Gregory 2007).

2.36 The growing number of recorded intertidal peats (including submerged forest remains) underlying sand deposits in Northern Ireland, dating from the early Mesolithic to the late Mesolithic at thicknesses up to 1.1m (Carter and Wilson, 1990; McErlean et al, 2002; Wilson and Plunkett, 2010; Wilson, et al, 2011), highlights the potential for organic deposits to be present in offshore and inter-tidal areas. Such intertidal peats have been recorded to the south of Portmuck in Belfast Lough and to the north at Carnlough.

2.37 At Belfast Lough peat was recorded at a depth of -12m OD and has been radiocarbon dated to 9130±120 BP (8702-7971 Cal BC). A wood fragment at a depth of -9m OD was also dated to 8715±200 BP (8301-7358 Cal BC) and indicates the presence of trees growing in this area during the early Holocene (Morrison et al, 1970). At Carnlough intertidal peats have also provided early Holocene dates and were present at between 1.5-2.25m OD (Prior et al, 1981) indicating a strong vertical variation along this part of the coastline for the presence of peats.

2.38 The high potential for submerged landscapes around the north coast of Ireland around Derry and Antrim has recently been highlighted (Westley et al 2011) who produced palaeogeographic reconstructions from multibeam bathymetric data. This study identified up to ten potential new sites of archaeological significance. New palaeogeographic models (Sturt et al 2013) have also been produced for the British Isles and Ireland and although they show little change from marine inundation along the north eastern Irish coastline, it is accepted that on a more regional level the coastline would have been transforming due to RSL change.

2.39 Evidence of these submerged landscapes has been found by the presence of submerged peats of around 2-3m thickness, recorded on the submerged inner continental shelf off the north coast of Northern Ireland at depths of around -13-14m OD (e.g. Cooper et al, 2002) and show the potential for such organic deposits to be found in present day fully marine areas. Such organic deposits have great palaeoenvironmental potential to be able to inform on former environmental and RSL change, together with evidence of human-environmental interaction in these previously terrestrial landscapes (e.g. Jessen 1949; Wilson & Plunkett 2010).

3 **Currarie Port, Ayreshire, Scotland**

3.40 As with Portmuck, Co Antrim there are no RSL studies specific to Currarie Port; instead RSL change in this area is inferred from studies along the Ayrshire coastline. A general trend for RSL change for this part of Scotland has been observed from radiocarbon dated deposits (e.g. peats) used as RSL index points (Shennan & Horton 2002). This suggests that the main post glacial RSL rise in this area began at c. 10,000 BP and attained a maximum of c. 10 m OD at approximately 7500 BP. Following this, RSL then began to fall to its present level (Shennan & Horton, 2002). This fall in RSL is due in part to falling sea levels and also to the rate of glacio-isostatic uplift in this part of Scotland following the melting of the ice sheets. The rate of uplift has been calculated at 2-1mm per annum for this part of western Scotland (Shennan & Horton 2002).

3.41 Recent studies along the Ayrshire coastline have shown that RSL change is more complicated when investigated on a local scale. Studies from the northern area of the central west coast (e.g. Sissons 1974) have shown that the main post glacial shoreline lies some 10m above OD, which has been confirmed from onshore basal peat deposits (see above) and that the main post glacial shoreline is at the highest altitude, being closer to the centre of glacio-isostatic uplift.

3.42 However other studies have shown that this shoreline is widely displaced along the coast and overlaps in places with the Blairdrummond shoreline, which is of a later age (Smith et al 2006). These features have been dated along the southern Ayrshire coast as occurring at 6800 BP (at 7.8m OD) and 4200 BP (at c.9m OD), respectively; thus showing RSL rise around 4200 BP with the formation of the Blairdrummond shoreline, occurring at the periphery of the area of glacio-isostatic uplift (Smith et al, 2007). Following this the area conforms to the model of Shennan and Horton (2002), with sea-level falling to its current level.

3.43 The steep rise in sea-level in this area combined with the rate of isostatic uplift and rocky nature of the steep, imposing coastline suggests there is little potential for the presence of intertidal organic deposits at Currarie Port. There are also no recorded peat deposits around the area inland of Currarie Port, which is instead covered by brown earths, fringed by gleys and podzols, as shown in soil maps for Scotland (Macaulay Land Use Research Institute, 2010). This suggests that there is little potential for organic deposits present that could provide palaeoenvironmental information.

3.44 Similarly there is little in the way of archaeological remains in the onshore area with those features that have been recorded, such as the potential cairn at Court Knowe and the enclosure at Craigins having been shown to represent natural features in the landscape (RCAHMS, 1981). Therefore there is little potential both archaeologically and palaeoenvironmentally in this area.

SECTION FOUR RECORDED MARITIME CULTURAL HERITAGE

1 Limitations of data

1.45 One of the greatest limitations when researching known and potential offshore cultural heritage is the difficulty of locating recorded maritime losses. For many losses the location of the sinking of the vessel can be in the form of a general area description, as in 'crashed into the sea off Loch Ryan' or '6 miles NW by N of Coreswall Point', which is not practically useful for the purpose of accurate assessment, except to show the potential exists to encounter lost cultural remains.

1.46 Wrecks have been identified through sonar survey but this too presents difficulties as many of these wrecks have been located using GPS, which until relatively recently were only accurate to 100m (Baird, 2009; see also Satchell 2012); or by DECCA which can give locations accurate to only one kilometre. In addition, recorded maritime losses are heavily biased towards the nineteenth and twentieth centuries when more comprehensive records of losses began to be compiled by the UK Hydrographic Office.

1.47 The details for specific offshore cultural heritage assets within this study area are derived from three main sources; the Northern Ireland wreck database held on behalf of the NIEA by the Centre for Maritime Archaeology, University of Ulster, the National Monuments Record of Scotland (NMRS) held by the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS)(accessed via South Ayrshire HER), and SeaZone Hydrospatial data (which are largely derived from UK Hydrographic Office data). These databases are each derived in turn from a variety of sources including various published lists of marine losses and marine surveys. Consequently there are considerable overlaps and discrepancies between the datasets.

1.48 The tables and discussion below cover all NMRS, NIEA, and UKHO entries (as held by SeaZone) within the study areas including dead entries. This is because the locations in which vessels may not have been detected in recent geophysical surveys, may still contain remains of cultural heritage interest. It is important to note that although the route of the interconnector cable has undergone basic geophysical survey using side scan for maintenance purposes it has never been subjected to a systematic archaeological survey.

1.49 Given locational discrepancies (Satchell 2012) the possibility that wrecks lie outside previous search areas cannot be discounted. The old archaeological adage that absence of evidence is not evidence of absence seems particularly apposite here. In other cases, however, it is clear from the details of the entry that there is no reason to believe that there are now or ever have been archaeological remains. These entries have also been included in the text and illustrations and are discussed on a case by case basis below.

1.50 The co-ordinate system used for the wrecks database is World Geodetic System (WGS) 1984 and for the geophysical targets is Universal Transverse Mercator (UTM) Zone 30.

2 Sites of cultural heritage interest in the cable study corridor (CSC)

2.51 The various datasets used in the compilation of the baseline assessment have been amalgamated to remove duplicate entries and are presented in the tables below. This section presents the findings from within the CSC whilst the next section presents those that fall within a 5 km buffer zone from the CSC in the wider study area (WSA).

2.52 The DBA established that there are no Designated Wrecks or other cultural heritage assets with legal designations within the CSC or the WSA. There are currently six sites in the SEA 6 area protected under Section One of the PWA 1973 Act and one under section Two (Wessex 2005), none of which are in the vicinity of the proposed development. Under the terms of the PMRA 1986 there is one Protected Place (whose location is unknown) but no Controlled Sites in the vicinity of the study area.

2.53 There are seventeen recorded wrecks and obstructions within the CSC, nine of which are known and eight that are unidentified; nine of the seventeen are live sites in that their location on the seabed has been confirmed. These have been presented in chronological order in the table below. Of the nine known wrecks, two date from the nineteenth century, four are casualties of the First World War, one dates from the inter-war years, there is an aircraft from WW2 and one modern recent wreck. The dates of the remaining six wrecks and two obstructions are unknown.

Table 1 Wrecks within the cable corridor (see Figure 1)

HA	Name	Type	Date	Status	Latitude*	Longitude*	Source
1	Woods	Wreck	??/03/1827	Dead	54.84622	-5.7131	wrecksite.eu
2	Dryad	Wreck	17/01/1895	Dead	55.05383	-5.24523	NMRS
3	Longwy	Wreck	04/11/1917	Live	55.05475	-5.17666	UKHO WO3823
4	Angelo	Wreck	16/11/1917	Dead	55.0047	-5.34872	NMRS
5	Neptune	Wreck	17/12/1917	Dead	54.84158	-5.68888	wrecksite.eu
6	Setter (SS)	Wreck	13/09/1918	Live	55.02542	-5.3761	UKHO WO3815
7	Elizabeth Jane	Wreck	06/05/1924	Dead	55.00553	-5.33955	NMRS
8	Boulton Paul Defiant I	Wreck	05/10/1941	Dead	55.04243	-5.11007	NMRS
9	Empress of Japan (poss)	Wreck	Pre-1972	Live	55.03587	-5.23832	UKHO WO3817
10	Unknown	Wreck	Unknown	Live	54.93365	-5.49107	UKHO WO5203
11	Unknown	Wreck	Unknown	Live	54.9542	-5.49802	UKHO WO5204
12	Unknown	Wreck	Unknown	Live	54.97115	-5.44302	UKHO WO5208
13	Unknown	Wreck	Unknown	Live	54.97837	-5.42663	UKHO WO5216
14	Unknown	Wreck	Unknown	Live	55.02197	-5.34747	UKHO WO3999
15	Unknown	Wreck	Unknown	Dead	54.96123	-5.47207	NMRS
16	Unknown	Obstn	Unknown	Live	55.0417	-5.14278	UKHO WO3819
17	Unknown	Unknown	Unknown	Dead	55.0477	-5.2231	NMRS

(*WGS 1984)

2.54 The oldest known wreck within the CSC is a sailing brig called Woods (**HA1**), which sank in March 1827 after it ran aground during a gale. The remains of the ship have not been located.

2.55 The Dryad (**HA2**) was a four ton iron-built steam ship which was constructed in 1895. It began to take on water on 17 January 1895 and foundered 12 miles WNW of Coreswell Point. This record comes only from the NMRS and the wreck has yet to be identified.

2.56 As stated, there are four casualties of the First World War. The Longwy (**HA3**) was a French cargo ship carrying iron ore from Glasgow to Bilbao when it was attacked by German submarine UC-75 (Kapt Johannes Lohs) on 4 November 1917. It was torpedoed and sunk 8 miles east of Copeland Island with the loss of thirty-eight lives. This wreck is regularly dived; the deck and sides have collapsed but the wreck still stands 2m above the seabed.

2.57 The Angelo (**HA4**) was a large steel-built cargo steamship, which was sunk on 16 November 1917 in the North Channel. The position of its loss is recorded by the NMRS but no other records for the vessel exist.

2.58 The Neptune (**HA5**) was an Irish fishing smack which sank after it struck a mine 4.5 miles north of Black Head on 17 December 1917 with the loss of four crew members. The minefield, known as 'Barrage 93', was laid on 17 May 1917 by German submarine U-80 captained by Karl Scherb. The location of the wreck is unknown.

2.59 The SS Setter (**HA6**) was a British defensively-armed passenger steamer carrying a general cargo from Manchester to Glasgow when she was attacked and sank on 13 September 1918 with the loss of nine lives. She was struck by a torpedo fired by German submarine UB-64 (Kapt Ernst Krieger) 6 miles north-west by north of Coreswall Point. The wreck has been located at 91m depth and is approx. 69m long.

2.60 According to RCAHMS records, a small tug called the Elizabeth Jane (**HA7**) took on water and then foundered while under tow off Corsewell Point on 6 May 1924. The vessel was en route for the breakers yard at Ardrossan.

2.61 There is a recorded air crash site within the CSC dating from the Second World War. According to the NMRS, a Boulton Paul Defiant Mk I (**HA8**) (turreted fighter of a similar design to the Hurricane) crashed into the sea off Loch Ryan on 5 October 1941. The exact location of the wreck is unknown but under the terms of the PMRA 1986 all military aircraft including those whose locations are unknown are Protected Places.

2.62 The wreck of a small fishing boat, possibly the Empress of Japan (**HA9**), was located in 1972 in 84m of water. The wreckage is scattered over some 30m.

2.63 There are five further wrecks (**HA10 - 14**) whose locations are known but their identities, as yet, remain unknown. The location of another recorded incident involving an unknown vessel (**HA15**) has yet to be located. There are also two obstructions, only one of which (**HA16**) is live.

3 Cultural heritage assets within the wider study area

3.64 A wider study area extending 5km from the CSC boundary was also examined in order to identify and inform the archaeological potential of the area. These results are presented below.

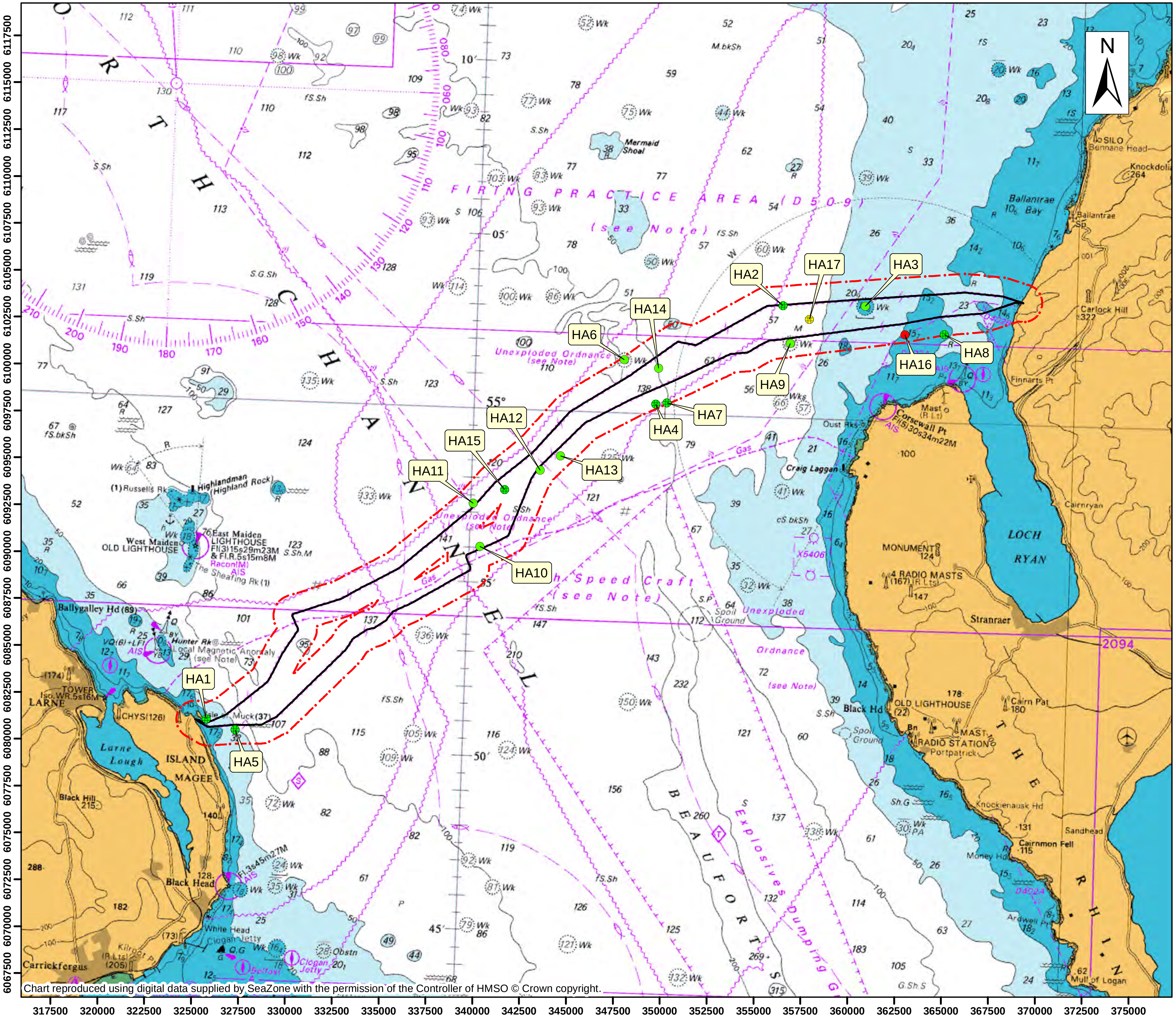
3.65 There are a total of forty-six recorded wrecks and obstructions within the 5km buffer zone, including:

- twenty-five known wrecks, twenty-one of which are live;
- nine unidentified wrecks, eight of which are live; and
- twelve recorded obstructions, (including bronze cannon) nine of which are live.

3.66 Of the known wrecks, nine date from the nineteenth century, one dates from the early twentieth century, eight are casualties of WW1 and one from WW2, two wrecks date from the inter-war years, one from just after WW2, and five modern wrecks dating from 1975 onwards.

Table 2 Wrecks and obstructions within the 5km wider study area (see Figure 2)

HA	Name	Type	Date	Status	Latitude*	Longitude*	Source
18	Berbice	Wreck	01/01/1827	Dead	54.853683	-5.769783	wrecksite.eu
19	George	Wreck	01/01/1876	Dead	54.85223	-5.79081	NI NMR
20	George of Workington	Wreck	20/12/1876	Live	54.850867	-5.78925	wrecksite.eu
21	State of Louisiana	Wreck	24/12/1878	Live	54.881983	-5.752717	UKHO WO 5227
22	Alcedo	Wreck	??/01/1892	Live	54.81548	-5.6962	NI NMR
23	SS Ailsa	Wreck	26/02/1892	Live	54.852483	-5.738217	UKHO WO 5273
24	SS Argyll	Wreck	17/09/1893	Live	55.0192	-5.1003	UKHO WO 3814
25	Firth of Cromarty (poss)	Wreck	27/08/1898	Live	55.002467	-5.165883	UKHO WO3805
26	SS Morag Glen	Wreck	29/11/1898	Live	55.033367	-5.0903	UKHO WO 4031
27	SS Peridot	Wreck	25/10/1905	Live	54.859717	-5.762517	UKHO WO5275
28	SS Harrington	Wreck	03/01/1916	Live	54.851717	-5.79105	UKHO WO5173
29	SS M J Craig (prob)	Wreck	19/03/1918	Live	54.890317	-5.534383	UKHO WO5176
30	SS Ardglass	Wreck	01/04/1918	Live	54.956167	-5.586067	UKHO WO5190
31	SS Carrick Castle	Wreck	04/04/1918	Dead	54.816033	-5.649433	wrecksite.eu
32	SS Lakemoor	Wreck	11/04/1918	Live	55.0053	-5.225533	UKHO WO3807
33	Sandhurst (poss)	Wreck	06/05/1918	Live	54.97838	-5.38498	UKHO WO5199
34	Buffalo (poss)	Wreck	13/09/1918	Live	55.08058	-5.26387	UKHO WO3830



HEADLAND ARCHAEOLOGY

Key

Heritage asset (live)

- Obstruction
- Unknown object
- Wreck

Heritage asset (dead)

- Unknown object
- Wreck
- Cable
- Cable corridor

Kilometers

0 10

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NMRS data provided by the RCAHMS dated 23/06/2014© Crown Copyright (RCAHMS)

Northern Ireland information derived from The University of Ulster's Center for Maritime Archaeology dated 23/06/2014© University of Ulster

UKHO data derived from SeaZone Solutions dated 06/2014 © SeaZone Solutions, 2014, L062014.0011

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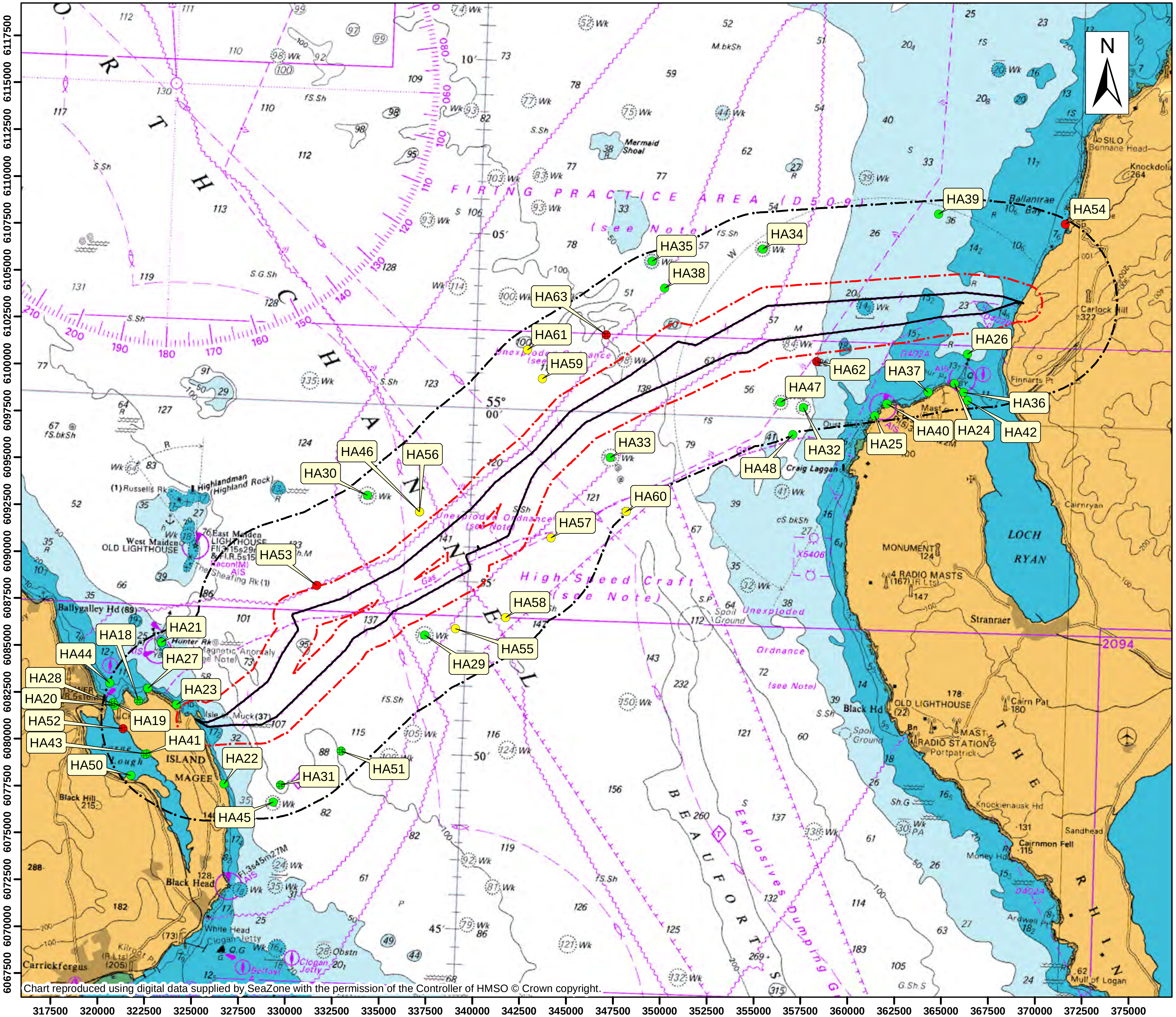
Figure 1: Wrecks and obstructions within the cable corridor

HA	Name	Type	Date	Status	Latitude*	Longitude*	Source
35	SS Bonvilston	Wreck	07/10/1918	Live	55.073033	-5.355767	UKHO WO3829
36	Perilia	Wreck	18/02/1930	Live	55.015033	-5.0928	UKHO WO3813
37	Nora	Wreck	23/11/1938	Live	55.014483	-5.12195	UKHO WO3811
38	Prince Philippe	Wreck	15/07/1941	Live	55.0603	-5.344683	UKHO WO3820
39	Aarla	Wreck	??/??/1947	Live	55.100017	-5.117767	UKHO WO4028
40	Boy John R	Wreck	06/09/1975	Live	55.008367	-5.156117	UKHO WO3812
41	Teanua	Wreck	??/??/1976	Dead	54.828183	-5.762567	wrecksite.eu
42	Highland Laddie	Wreck	10/07/1980	Live	55.01115	-5.08903	UKHO WO3961
43	Unknown	Wreck	??/??/1975	Live	54.828367	-5.76105	UKHO WO5219
44	Unknown	Wreck	??/??/1992	Live	54.861667	-5.794317	UKHO WO5267
45	Unknown	Wreck	Unknown	Live	54.807667	-5.654817	UKHO WO5159
46	Unknown	Wreck	Unknown	Live	54.94921	-5.54218	UKHO WO5205
47	Unknown	Wreck	Unknown	Live	55.007533	-5.2447	UKHO WO3809
48	Unknown	Wreck	Unknown	Live	54.992267	-5.2336	UKHO WO5222
49	Unknown	Wreck	Unknown	Live	54816983	-5.772983	UKHO WO5161
50	Unknown	Wreck	Unknown	Live	54.81783	-5.77355	UKHO WO5160
51	Unknown	Wreck	Unknown	Dead	54.833333	-5.6	UKHO WO5164
52	Bronze cannon	Obstrn	Unknown	Dead	54.84003	-5.78176	NI NMR
53	Unknown	Obstrn	Unknown	Live	54.912167	-5.625483	UKHO WO65771
54	Unknown	Obstrn	Unknown	Live	55.096867	-5.011667	UKHO WO57366
55	Unknown	Unknown	Unknown	Live	54.893883	-5.508883	UKHO WO5210
56	Unknown	Unknown	Unknown	Live	54.949217	-5.542183	UKHO WO5205
57	Unknown	Unknown	Unknown	Live	54.938933	-5.432183	UKHO WO5208
58	Unknown	Unknown	Unknown	Live	54.90005	-5.467733	UKHO WO5178
59	Unknown	Unknown	Unknown	Live	55.015017	-5.443833	UKHO WO4000
60	Unknown	Unknown	Unknown	Live	54.952817	-5.370433	UKHO WO5188
61	Unknown	Unknown	Unknown	Live	55.028633	-5.457167	UKHO WO4001
62	Unknown	Obstrn	Unknown	Dead	55.027533	-5.215833	UKHO WO3816
63	Unknown	Obstrn		Dead	55.036967	-5.391917	UKHO WO3818

(*WGS 1984)



HEADLAND ARCHAEOLOGY

Key

Heritage asset (live)

- Obstruction
- Unknown Object
- Wreck

Heritage asset (dead)

- Obstruction
- Wreck

- Cable
- Cable corridor
- 5km buffer

Kilometers

0 10

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Figure 2: Wrecks and obstructions within the wider study area

3.67 Two of the oldest wrecks within the WSA both wrecked on New Year's Day; the Berbice (**HA18**), a four-masted square-rigged barque ran aground and was stripped in 1827, carrying coal from Greenock to Havana. The brig, George (**HA19**) wrecked in 1876 also carrying coal. There is very limited information about this scattered wreckage.

3.68 The remaining seven nineteenth century wrecks include the George of Workington (**HA20**) which ran aground on the rocks between Ballylumford Harbour and Ferris Point lighthouse on 20 December 1876 and currently lies badly broken up in 5m of water.

3.69 The State of Louisiana (**HA21**) was en route from Glasgow to Larne with 2000 tons of cargo when she ran aground on Christmas Eve 1878 on the Hunter Rocks after the buoy marking the rocks became dislodged. The crew and the seventeen passengers were all rescued. Although recorded as breaking into three parts when sunk she is now recorded in two sections (bow - UKHO WO5227 and stern - UKHO WO5278).

3.70 The Alcedo (**HA22**) built in 1891 weighing 164 tons, ran aground and sank in January 1892 on her maiden voyage. She is badly broken up but still stands 2.5m off the sea floor.

3.71 The SS Ailsa (**HA23**) ran aground on 26 February 1892 one mile off Port Muck near Magee Island whilst carrying a general cargo and one passenger. Discovered by divers in 1965 she was lying in shallow water badly broken up. Parts of the vessel could be seen on shore above MHW.

3.72 The SS Argyll (**HA24**) ran aground in fog near Milleur Point on 17 September 1893. Attempts to recover the vessel were abandoned when it began to list dangerously. She was found scattered over a large area of shallow water.

3.73 Broken up pieces of what is believed to be the Firth of Cromarty (**HA25**) remain in rock gullies on Coresewall Point after she ran aground on 27 August 1898 after her tow was cast off. The crew was rescued.

3.74 The British cargo ship SS Morag Glen (**HA26**) foundered off Corsewall Point on 29 November 1898 after being damaged running aground at Mull of Galloway.

3.75 The Irish steamship SS Peridot (**HA27**) was carrying coal when she foundered in a gale on Skernaghan Point on 25 October 1905, with the loss of the entire crew of nine. Divers recovered the bell in 1995 but the wreck is now badly broken up.

3.76 The SS Harrington (**HA28**) is the first of eight wrecks in the WSA dating from WW1, and one of two not sunk by enemy action. She was carrying potatoes when she ran aground off Ferris Point after a mooring rope got entangled around the propeller on 3 January 1916. The remains of the vessel which was approx. 1000 tons and 200ft in length is badly broken up over a wide area.

3.77 The possible wreck of the cargo ship SS M J Craig (**HA29**) has been tentatively identified. She was an armed merchant ship sunk by torpedo by UB-64 (Ernst Krieger) on 19 March 1918 with the loss of four crew.

3.78 The wreck of the cargo ship SS Ardglass (**HA30**) was located in 1972. She had been torpedoed and then captured and scuttled by UC-31 with the loss of six lives on 1 April 1918.

3.79 Three days later the cargo ship SS Carrick Castle (**HA31**) carrying coal from Ayr to Carrickfergus collided with SS Hound and sank off Black Head but the crew of nine were saved.

3.80 Seven days later on 11 April the US cargo ship SS Lakemoor (**HA32**) was torpedoed by UB-64 (Otto von Schrader) during passage from Newport News to Glasgow and sank with forty-six casualties. The same

U-boat and commander sank the entire Northern Irish fishing fleet one month later. The wreck is believed to sit upright on the seabed and is recorded as three wrecks on Kingfisher trawler maps.

3.81 A well broken up wreck lying in 134m is possibly that of the steamship Sandhurst (**HA33**) which was en route from Bilbao to Ardrossan when she was torpedoed while by UB-62. She sank on 6 May 1918 with the loss of twenty men.

3.82 The steamship Buffalo (**HA34**) was torpedoed on 13 September 1918 off Corsewall Point whilst on passage from Ayr to Dundalk with the loss of ten lives. She was attacked by the same German submarine that sank the SS Lakemoor (UB-64). A wreck examined in 1972 in a general depth 70 m, with an approximate length of 200ft has been tentatively identified as that of the Buffalo.

3.83 The final casualty from WW1 in this area is that of the SS Bonvilston (**HA35**) an armed merchantman that was attacked on 7 October 1918. She was torpedoed by UB-92 (Johannes Paul Muller) off Corsewell Point but suatained no casualties. The wreck appears to be upright and intact.

3.84 There are two recorded incidents from the inter-war years. All that remains of the drifter Perilia (**HA36**), which stranded on Milleur Point on 18 February 1930, is the boiler, the screw and the propeller. This was originally identified as the wreck of the Argyle. The puffer, Nora (**HA37**) ran aground in poor weather on passage to Creetown on 23 November 1938. The highest part of the dispersed wreck is just 3m below the water surface.

3.85 The only WW2 casualty in the area was a vessel that had been requisitioned by the Belgian Government. Rather than the result of enemy action, the Prince Phillipe (**HA38**) sank as a result of a collision with the British steamer Empire Wave. Until a data review in 1997, the site had originally been identified as the SS Bovilston.

3.86 The yacht Aarla (**HA39**) sank in 1947 with no survivors after an explosion during a passage from Tighnabruaich to Lowestoft. The fishing boat Boy John R (**HA40**) ran aground on rocks and then floated off on a rising tide and sank on 6 September 1975 after the crew had evacuated. The wreck lies approx. 50 yds off Corsewall Point. The elderly Schooner Teanua (**HA41**) sank at anchor in Lough Larne in 1976. The yacht Highland Laddie (**HA42**) beached and broke up on 10 July 1980 and now lies 0.5 miles off Milleur Point.

3.87 There is limited information about the eight unidentified wrecks and nine obstructions whose positions on the seabed are known. It is surprising that there is so little recorded information about the vessel that sank in 1975 (**HA43**) or the one that sank in 1992 (**HA44**). Even less is known about the one unidentified wreck and three obstructions classed as 'dead' in that their locations are not even known. One of these includes an undisclosed number of 'bronze' cannon (**HA52**).

4 Cultural heritage assets in the inter-tidal zones

4.88 A desk-based assessment was conducted of the inter-tidal zones in the vicinity of the proposed landfall locations at Portmuck South, Islandmagee in Northern Ireland and at Currarie Port, Ayrshire in Scotland, which are the same landfall locations as those of the existing cables. This assessment has shown that there are no recorded cultural heritage assets in the vicinity of either location.

5 Geophysical survey data assessment

5.89 As stated above, this baseline assessment includes basic archaeological analysis of existing geophysical (side scan sonar (SSS)) survey data that is collected routinely biennially under the inspection and maintenance programme for the existing interconnector cables. This analysis is not intended to circumvent a full pre-installation geophysical survey which will be subjected to full archaeological analysis before any intrusive operations associated with this project are undertaken.

5.90 These data are reviewed here to contribute to the baseline assessment of the proposed route and to provide a basic baseline characterisation of the archaeology of the area. These surveys cover an area of the seabed approximately 75m either side of the existing cables therefore covering a swath approximately 150m wide.

5.91 It is hoped that this analysis will be sufficient to enable marine licences to be awarded conditionally prior to archaeological analysis of the full geophysical survey. The condition placed on the licences would commit MIL to conduct these surveys utilising the full suite of geophysical techniques which would then be subjected to full archaeological analysis prior to any intrusive works being undertaken.

5.92 The reason for this is that MIL need to be confident that marine licences will be awarded prior to committing considerable sums in ordering these specialist cables which they need to do soon owing to the considerable delay between ordering and delivery of the cables.

5.93 A total of thirty-six potential targets (**HA64-99**) have been identified along the length of the existing cables in the maintenance SSS data (see Table 3).

5.94 Seven sites (**HA81, 85, 91, 93, 94, 95, & 97**) are considered of high potential. Four targets (**HA81, 91, 93, 94, & 97**) appear to be associated with existing cables, whilst two targets (**HA85 & 95**) appear to bear the hallmarks of wreck sites.

5.95 Five sites are considered of medium potential (**HA66, 75, 78, 88, 89, & 99**) as they are all sitting proud of the seabed and bear characteristics which suggest a man-made object rather than a natural feature of the seabed.

5.96 The remaining twenty-three sites have been graded as low potential as they are more likely to represent natural or geological features rather than cultural assets.

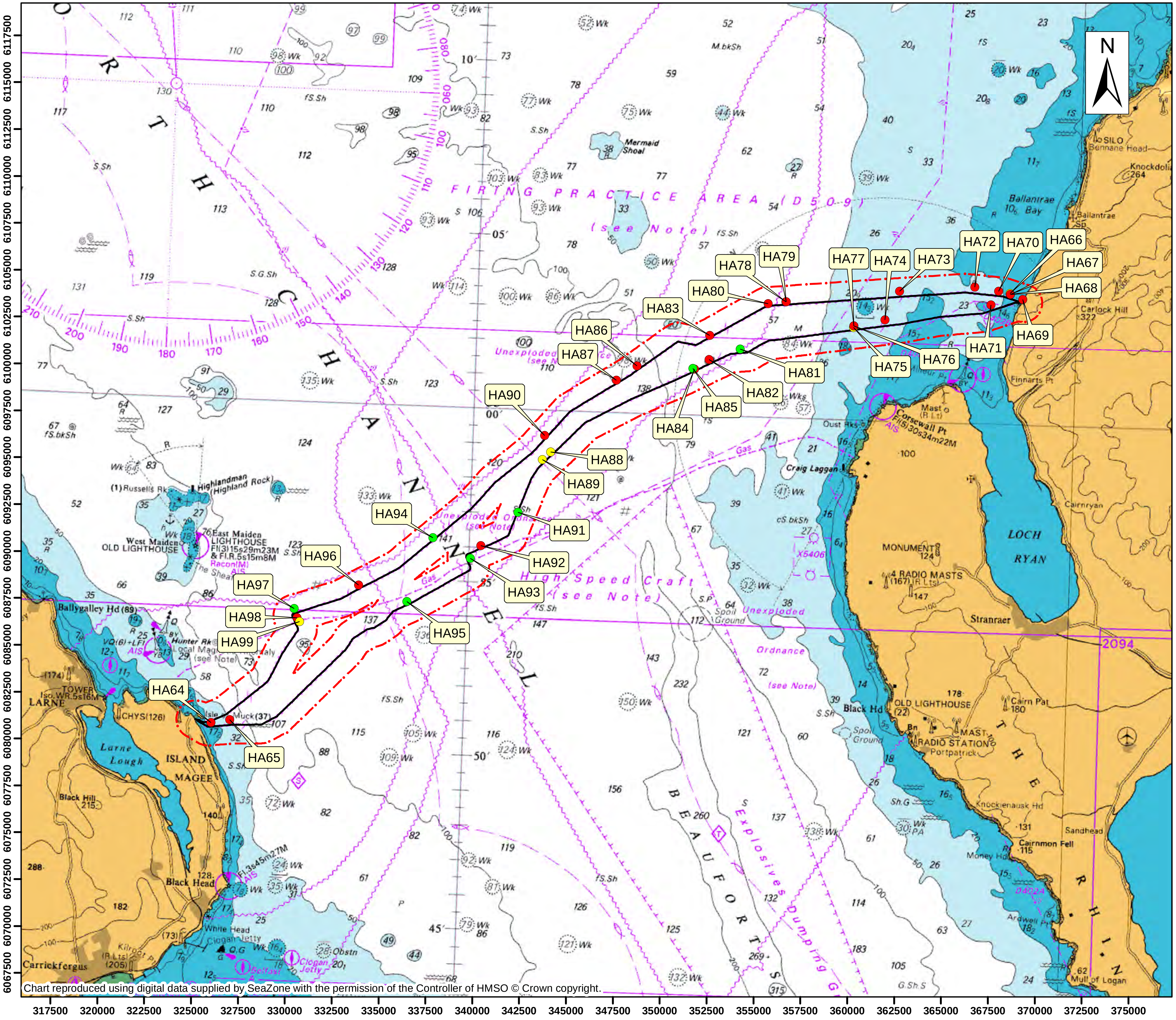
5.97 This assessment of the available geophysical data has been useful as it shows that even relatively low resolution survey data can pick up potential cultural assets in the vicinity of the proposed cable routes and enables a broad characterisation of the general area.

5.98 This assessment suggests that the distribution of wrecks in the vicinity of the proposed cable route is fairly sparse so there is ample opportunity to micro-site the cable around any significant unexpected features that come to light once the full geophysical survey has been conducted.

Table 3 Geophysical targets identified in maintenance survey data (see Figure 3)

HA	Target	Target size	Potential	Latitude*	Longitude*	Km along cable
64	Unknown	2.33m	Low	326065.29	6080852.72	0
65	Unknown	1.33m shadow	Low	327065.7	6081000.41	0
66	Unknown	20m	Medium	368676.62	6103732.51	0
67	Unknown	4.46m	Low	368690.96	6103675.86	0
68	Unknown	2.20m	Low	368691.4	6103675.22	0
69	Unknown	2.53m	Low	369351.9	6103400.31	0
70	Unknown	3.94m	Low	368080.75	6103839.37	0
71	Unknown	2.91m	Low	367664.45	6103122.21	1.89
72	Unknown	4.63m	Low	366810.25	6104062.64	2.784
73	Unknown	6.51m	Low	362786.96	6103847.09	6.782
74	Unknown	4.52m	Low	362003.14	6102315.01	7.641
75	Unknown	4.60m	Medium	360335.72	6101917.51	9.35
76	Unknown	4.49m	Low	360350.14	6102002.06	9.315
77	Unknown	-	Low	360352.89	6101996.17	9.318
78	Unknown	9.20m	Medium	356719.33	6103283.16	12.883
79	Unknown	8.92m	Low	356738.74	6103287.22	12.883
80	Unknown	7.55m	Low	355775.42	6103181.07	13.869
81	Unknown	-	High	354287.53	6100765.75	15.578
82	Unknown	2.45m	Low	352631.06	6100210.01	17.335
83	Unknown	19.41m	Low	352658.41	6101490.1	17.424
84	Unknown	40.71m	Low	351849.42	6099704.15	18.27
85	Unknown	40.20m	High	351769.85	6099736.33	18.321
86	Unknown	2.79m	Low	348783.66	6099869.88	21.843
87	Unknown	2.82m	Low	347687.93	6099104.07	23.171
88	Unknown	4.53m	Medium	344174.85	6095275.57	27.206
89	Unknown	4.53m	Medium	343738.02	6094872.35	27.795
90	Unknown	3.00m	Low	343856.22	6096156.43	28.058
91	Unknown	8.36m	High	342442.28	6092068.61	30.908
92	Unknown	2.90m	Low	340458.07	6090279.24	33.768
93	Cable	-	High	339890.49	6089605.23	34.949
94	Cable	-	High	337896.67	6090703.44	36.145
95	Unknown	4.63m	High	336515.83	6087310.56	39.372
96	Unknown	1.08m	Low	333933.96	6088189.23	40.872
97	Cable	-	High	330497.83	6086935.15	44.548
98	Unknown	1.06m	Low	330647.99	6086434.04	45.059
99	Unknown	3.30m	Medium	330791.99	6086242.31	45.298

(*UTM Zone 30)



HEADLAND ARCHAEOLOGY

Key

Geophysical targets

- High potential
- Medium potential
- Low potential
- Cable
- Cable corridor

Kilometers

0 10

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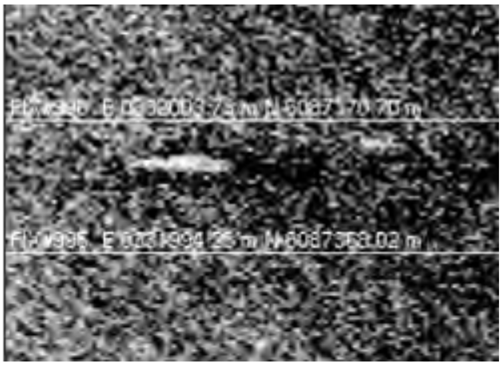
Figure 3: Geophysical targets identified in SSS survey data

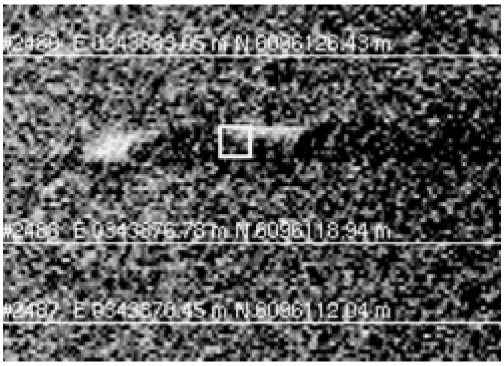
HA64

A discrete linear object approx. 2.3m in length sitting proud of the seabed



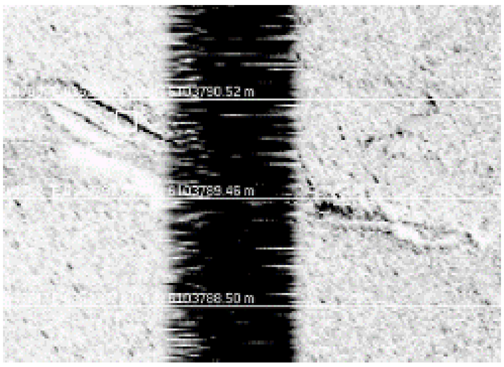
HA65

A series of raised objects sitting proud of the seabed casting a shadow of approx 1.3m in length



HA66

A series of parallel curvi-linear reflections approx 20m in length sitting proud of the seabed



HA67

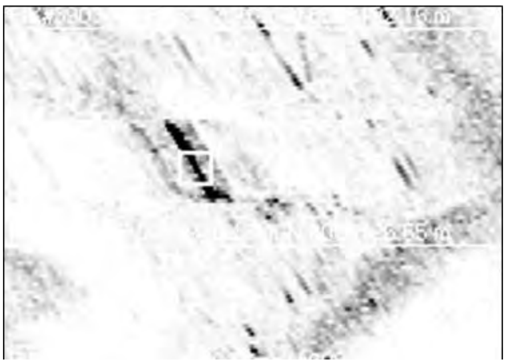
A discrete recta-linear object approx 4.5m in length sitting proud of the seabed

HA68

An amorphous discrete object approx 2.2m in length sitting in a scour pit

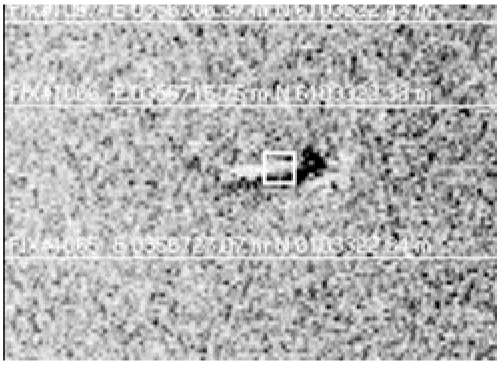
HA69

A series of dark linear objects, the largest being 2.5m in length, probably geological in origin



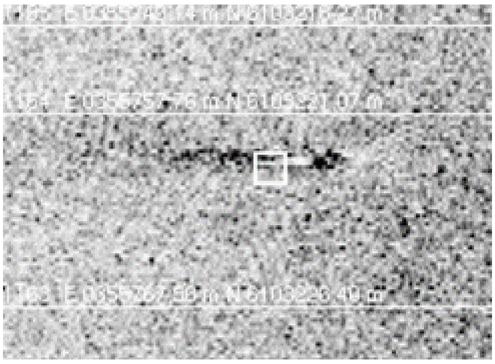
HA70

A discrete recta-linear object approx 4m in lengthsitting proud of the seabed



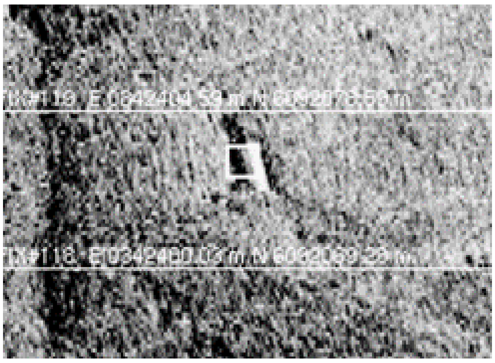
HA71

A discrete linear object approx 3m in length sitting proud of the seabed with associated scar



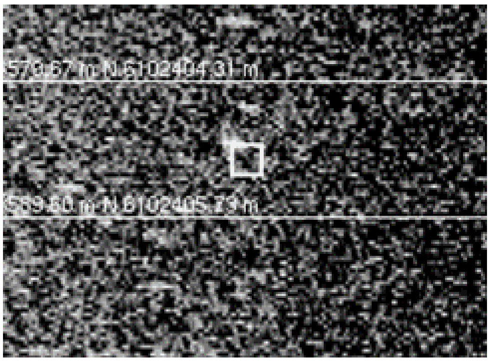
HA72

A discrete linear feature approx 4.6m long sitting proud of the seabed



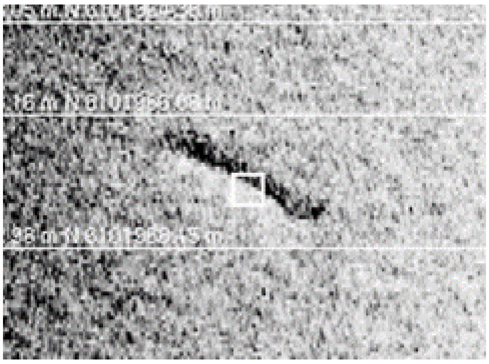
HA73

A series of amorphous blobs, probably geological in origin



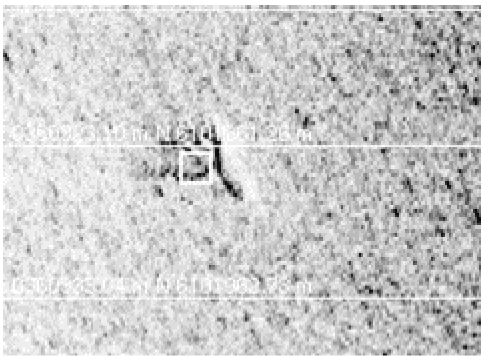
HA74

A discrete linear depression approx 4.5m long with strong reflection from hollow



HA75

A discrete curvilinear object approx 4.6m in length of medium potential sitting proud of seabed

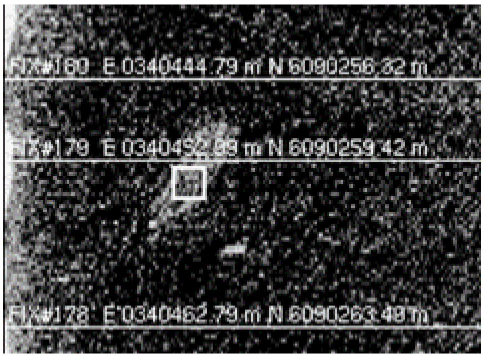


HA76

A discrete linear object approx 4.5m in length sitting proud of the seabed

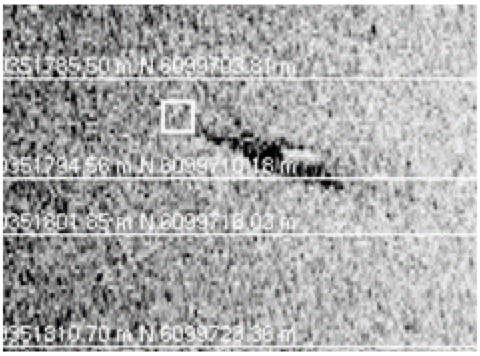
HA79

A discrete amorphous blob approx 9m in length which may be exposed bedrock



HA77

A discrete amorphous object sitting proud of the seabed with associated scour

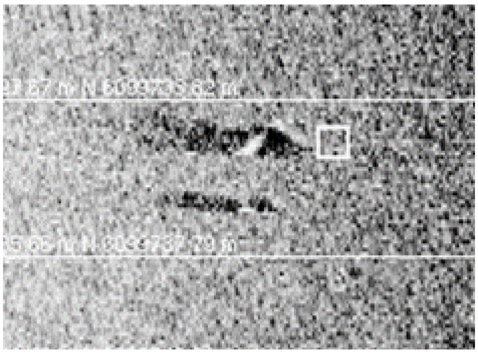


HA80

A line of isolated objects approx 7.5m in length sitting proud of the seabed

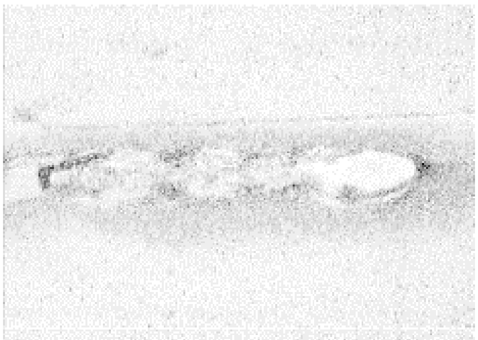
HA78

A pair of parallel objects approx 9.2m in length sitting proud of the seabed with associated scour



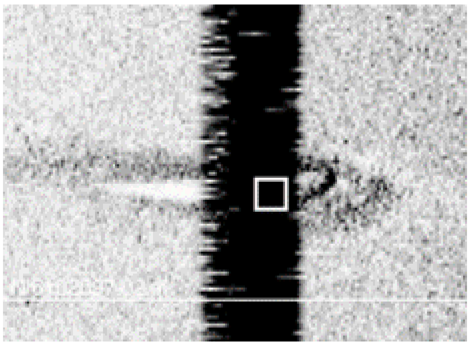
HA81

A possible cable loop



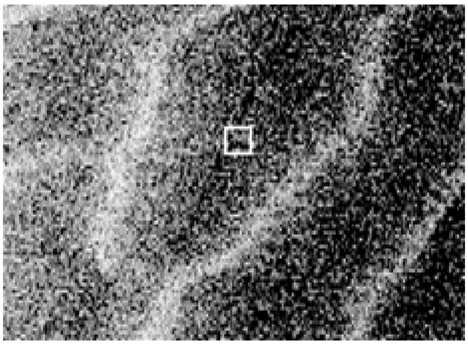
HA82

A discrete curved object approx 2.5m in length with long shadow obscured by sonar track



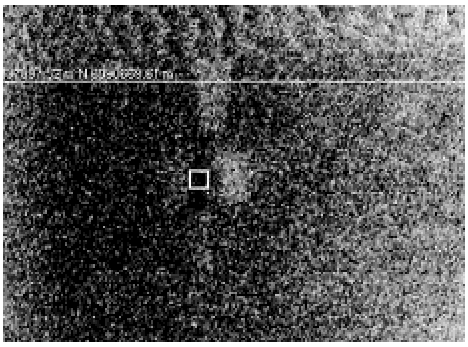
HA83

A long, discrete linear object approx 19.5m in length in sand wave bed



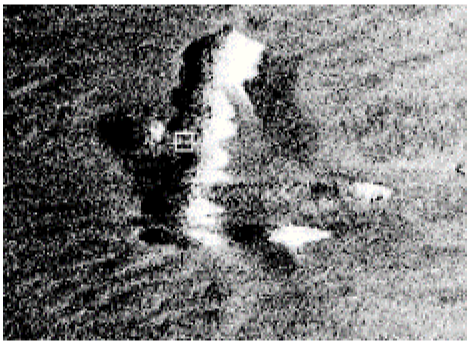
HA84

Long scar measuring some 41m, probably from cable run



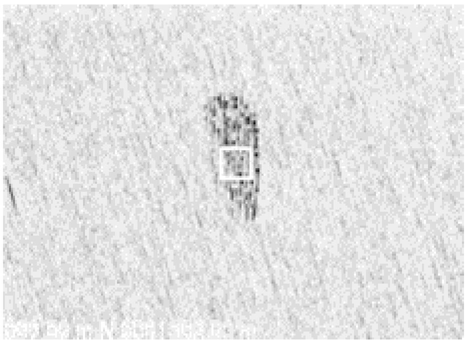
HA85

A large linear object with small circular objects that cable appears to avoid – possible wreck?



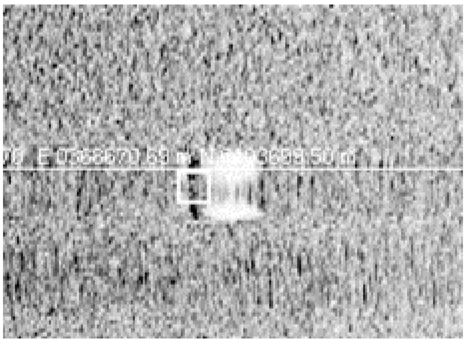
HA86

A discrete ‘teardrop’ shaped spread variation in back scatter, approx 2.8m in length.



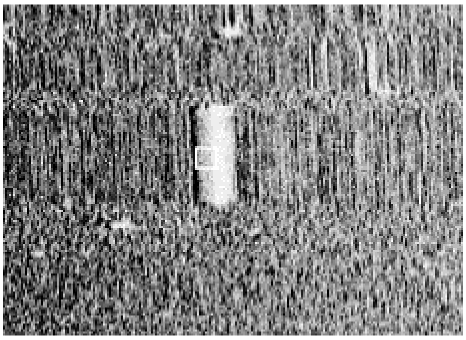
HA87

A discrete linear object approx 2.8m in length sitting proud of seabed, possibly geological



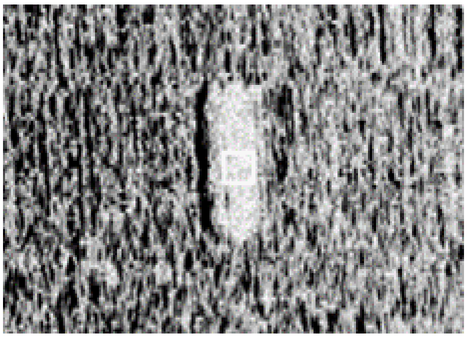
HA88

A discrete linear object measuring approx 4.5m in length sitting proud of seabed



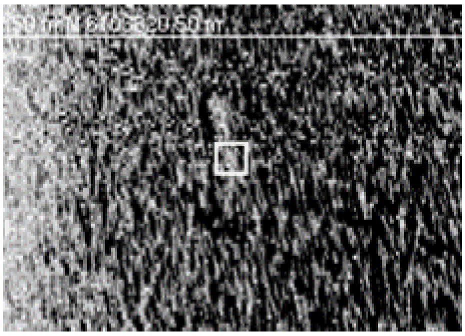
HA89

A discrete linear object measuring approx 4.5m in length sitting proud of seabed (possibly=HA89)



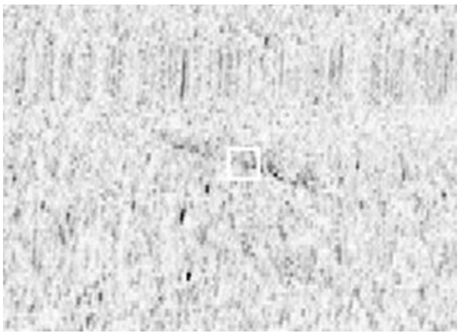
HA90

A discrete linear object measuring 3m in length sitting proud of seabed



HA91

A discrete linear target measuring approx 8m in length, probably cable run or chain

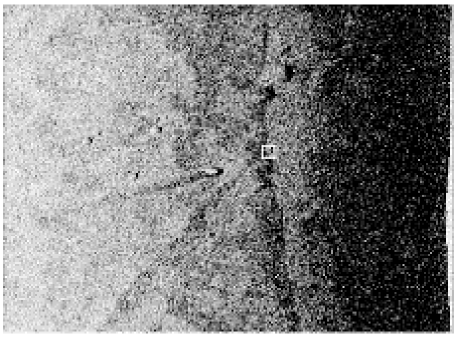


HA92

A discrete curvilinear object measuring some 3m in length with scour pit

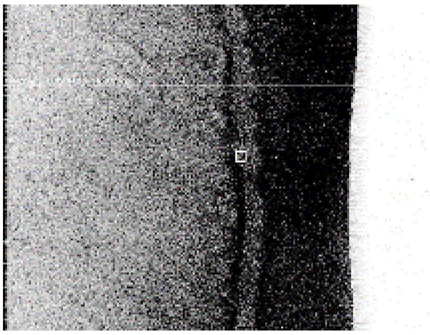
HA93

Linear features interpreted as cable cross over point



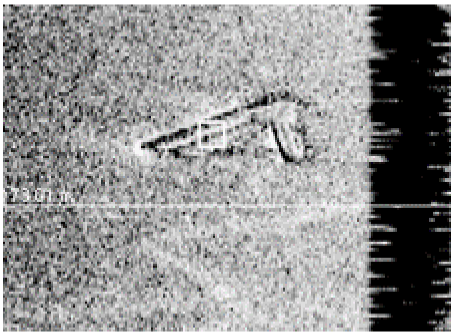
HA94

Long linear features interpreted as cable cross over points



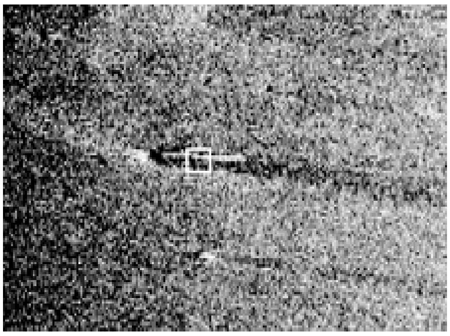
HA95

A discrete recta-linear feature forming a right angle on seabed approx 4.6m in length



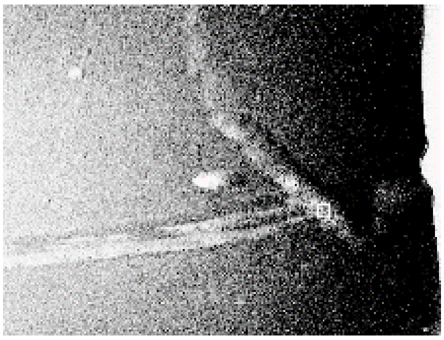
HA96

A discrete linear object approx 1m long with associated seabed scarring



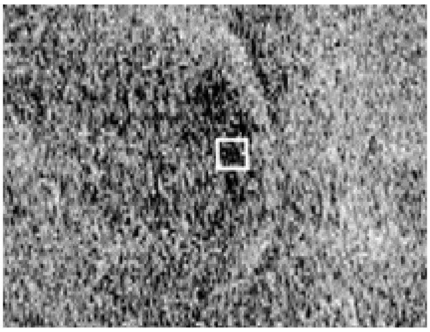
HA97

Long linear features interpreted as cable cross over points



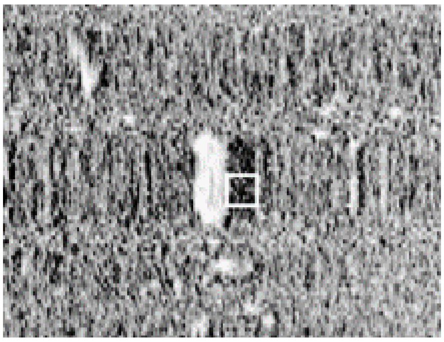
HA98

Bank or backscatter that appears to relate to seabed feature, possible sand wave



HA99

A discrete linear object, approx. 3.3m in length sitting proud of the seabed



SECTION FIVE CONCLUSIONS

1.99 This assessment established that there are no designated wrecks or other cultural heritage assets with legal designations within the study area. Under the PMRA 1986, there is potentially one Protected Place (a WW2 military aircraft) within the study area but its location is unknown and the crash location is so vague that there is a good potential that it is not within the study area.

1.100 There are seventeen recorded wrecks and obstructions within the CSC, nine of which are known and eight that are unidentified; nine of the seventeen are live. Two wrecks date from the nineteenth century, four date from WW1 and one from WW2, one dates from the inter-war years, and one is a modern wreck. The dates of the remaining six wrecks and two obstructions are unknown.

1.101 Within the wider study area a further forty-six wrecks and obstructions have been identified including twenty five known wrecks, nine unidentified wrecks and twelve obstructions. Thirty eight of the forty-six sites are live. Nine of the wrecks date from the nineteenth century, one dates from the early twentieth century, eight were sunk in WW1, one in WW2, two wrecks date from the inter-war years, one from just after WW2 and five are modern wrecks dating from 1975 onwards.

1.102 Analysis of the geophysical survey data collected under the inspection and maintenance regime for the existing cables has shown that the ability to identify sites on the seabed in the vicinity of the existing cables is good, and that the distribution of wrecks in the vicinity is fairly sparse. This assessment identified seven sites of high potential, five of which appear to be associated with the cables and two which seem to indicate wreck sites. Six further sites are of medium potential as they seem to indicate the characteristics of man-made objects on the seabed.

1.103 No cultural heritage assets have been recorded in the inter-tidal zones in the vicinity of either of the proposed landfall locations at at Currarie Port, Ayrshire in Scotland or at Portmuck South, Islandmagee in Northern Ireland.

1.104 Given that this analysis of fairly low resolution survey data appears to have successfully identified a number of cultural assets on the seabed, the potential for identifying further sites once the full pre-installation geophysical survey has been conducted and analysed must be high. Therefore it is considered that there is low potential for the project to encounter unexpected cultural heritage remains including artefacts within the study areas once the installation of the cables commences. The volume of maritime traffic historically within this area of the Irish Sea has always been considerable.

1.105 Previous studies have shown that there is high potential for organic deposits, such as peats to be present in the marine and intertidal areas at Portmuck which would be of palaeoenvironmental and archaeological significance.

1.106 The rich archaeological history of Larne, including the finds of log boat fragments at Larne Lough near to Portmuck indicates that there is also high potential for the recovery of artefacts from the Mesolithic period onwards.

1.107 The rate of isostatic uplift combined with the nature of the coastline at Currarie Port, Ayreshire suggests there is low potential for intertidal and shoreline deposits of palaeoenvironmental interest.

1.108 The absence of archaeological features and peats within the onshore area at Currarie Port also suggests that there is low potential for the presence of organic deposits of palaeoenvironmental and archaeological interest and for the presence of archaeological finds.

Potential Mitigation

1.109 Recommended mitigation for cultural heritage and potential cultural heritage sites should include;

- Exclusion zones around the known extent of wreck sites and sites of high archaeological potential identified in the pre-installation geophysical and geotechnical surveys;
- Following the geophysical survey data assessment, further investigation through ROV or diver survey of sites considered to be of medium archaeological potential that could potentially be impacted by the development; and
- Further examination of potential offshore prehistoric deposits including geotechnical investigations and/or ROV diver.

1.110 The evidence gathered for this baseline assessment suggests that, subject to further investigation, the impact on assets from the proposed installation of the replacement LV cables are manageable through the implementation of standard mitigation measures.

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2 Online Resources

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A.2.9 – Shipping and Navigation Risk Assessment

Moyle Interconnector

Shipping and Navigation Assessment

Prepared by:	Anatec Limited
Presented to:	Intertek
Date:	03/09/2014
Revision No.:	01
Reference:	A3431-INT-RA-1

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This study has been carried out by Anatec Ltd on behalf of Intertek. The assessment represents Anatec's best judgment based on the information available at the time of preparation and the content of this document should not be edited without approval from Anatec. Any use which a third party makes of this report is the responsibility of such third party. Anatec accepts no responsibility for damages suffered as a result of decisions made or actions taken in reliance on information contained in this report.

Revision Number	Date	Summary of Change
00	19/08/2014	Initial Draft
01	03/09/2014	Impact Assessment Added

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Abbreviations

AIS	-	Automatic Identification System
CA	-	Cruising Association
CATS	-	Central Area Transmission System
DWT	-	Dead Weight Tonnage
GT	-	Gross Tonnage
HSC	-	High Speed Craft
ICES	-	International Council for the Exploration of the Sea
MAIB	-	Marine Accident Investigation Branch
MMO	-	Marine Management Organisation
MOD	-	Ministry of Defence
nm	-	Nautical Miles
RYA	-	Royal Yachting Association
TSS	-	Traffic Separation Scheme
VMS	-	Vessel Monitoring System

1. Introduction

1.1 Overview

Anatec Ltd has been commissioned by Intertek to produce a Shipping and Navigation Assessment for the proposed installation of new replacement cables for the Moyle Interconnector between Northern Ireland and Scotland. The two cables will work to augment the existing cables which were installed in 2001. The new cables will be installed within 100m corridors to the south of each existing cable.

A total of 3 months of AIS data was used to assess the shipping activity in the vicinity of the proposed cable installation corridors. The AIS data was also used to assess the risk to the cable routes from dragged and emergency anchoring. Six weeks of summer and six weeks of winter were chosen to account for seasonal changes in shipping within the analysis.

1.2 Objectives

The objectives of the work are as follows:

- Identify the main navigational features in the vicinity of the cable corridors
- Assess the nature of the shipping activity in the vicinity of the cable corridors
- Assess the fishing and recreational vessel activity in the vicinity of the cable corridors
- Present information on historic incidents of vessel interaction with subsea cables and pipelines
- Estimate the risk to the new cables and shipping from dragged and emergency anchoring

2. Site Overview

2.1 Original Cable Routes

The original cable routes installed in 2001 connected the electricity grids of Northern Ireland and Scotland. The cables cross the North Channel between Islandmagee on the Northern Irish coast and Currarie Port on the Scottish coast. A study area covering 5nm either side of the original cable routes was chosen for the analysis in this report, allowing a variety of passing shipping to be included in the analysis.

A general overview of the original cable routes and study area is presented in Figure 2.1.

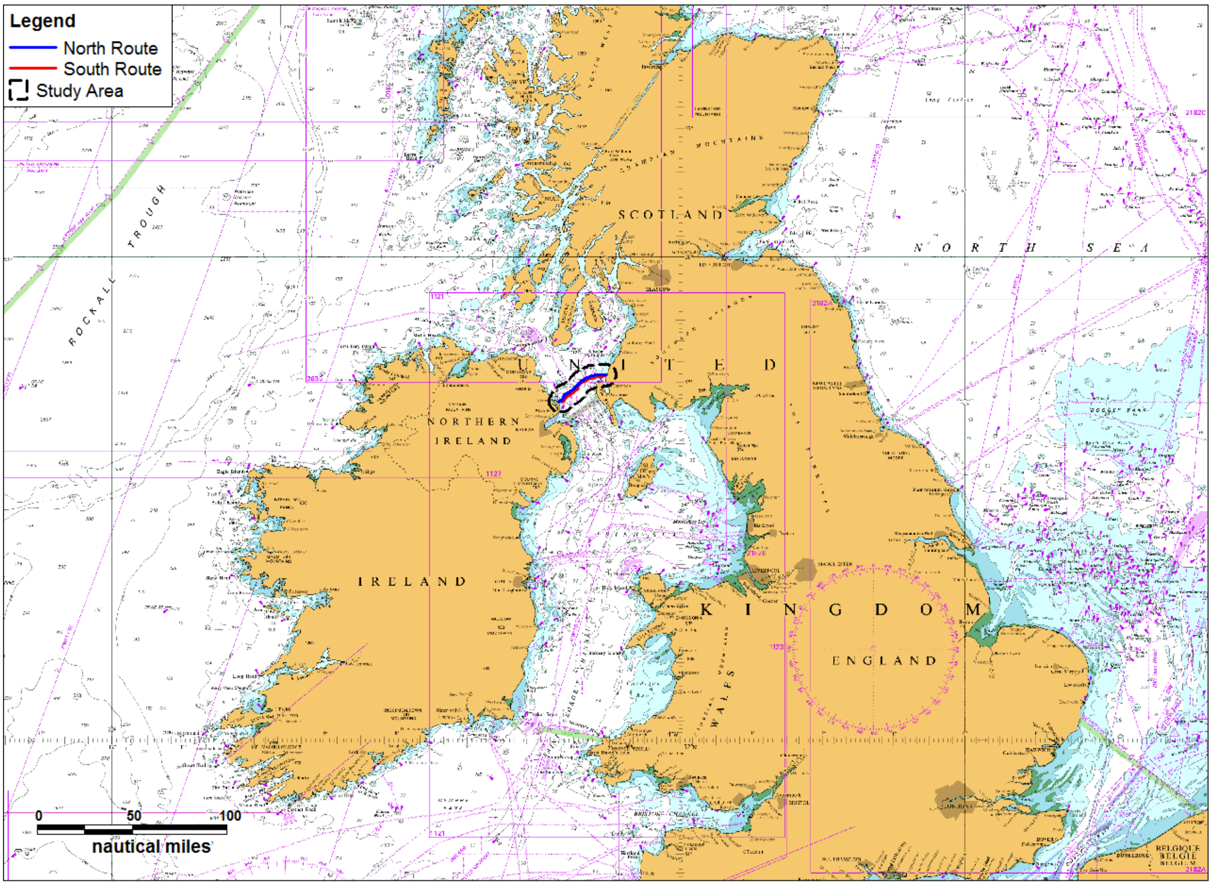


Figure 2.1 General Overview of Cable Routes

2.2 New Cable Routes

The location for the new cable routes has not yet been finalised, but it is known that they will be installed within corridors extending 100m south of the original routes. The corridors are presented in Figure 2.2.

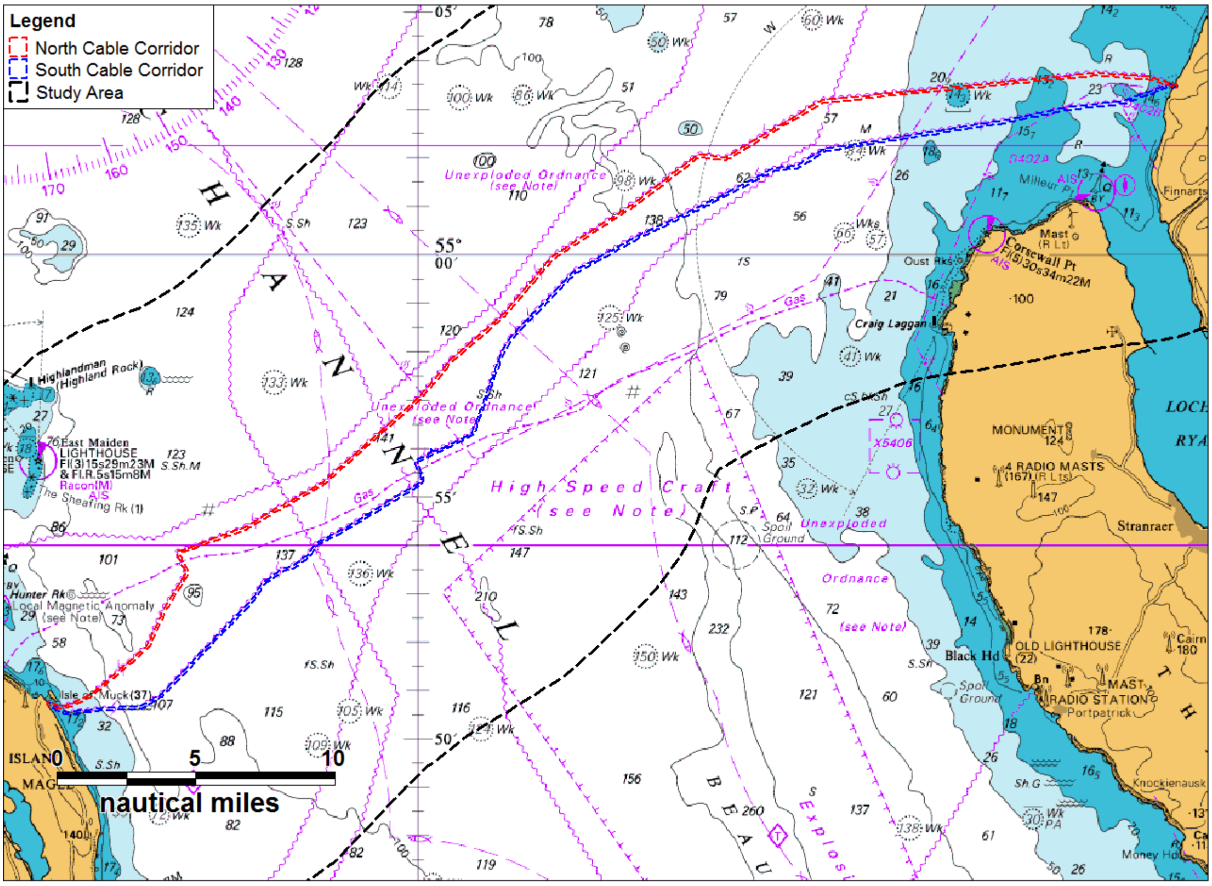


Figure 2.2 Detailed Overview of Cable Corridors

3. Navigational Features

3.1 Introduction

The cable corridors are located in the North Channel between Northern Ireland and the UK which is a busy area for commercial shipping and ferry routes. The key shipping and navigational features in the vicinity of the study area were identified and are presented in this section.

3.2 Ports

The ports in the vicinity of the study area surrounding the two cable corridors are presented in Figure 3.1.

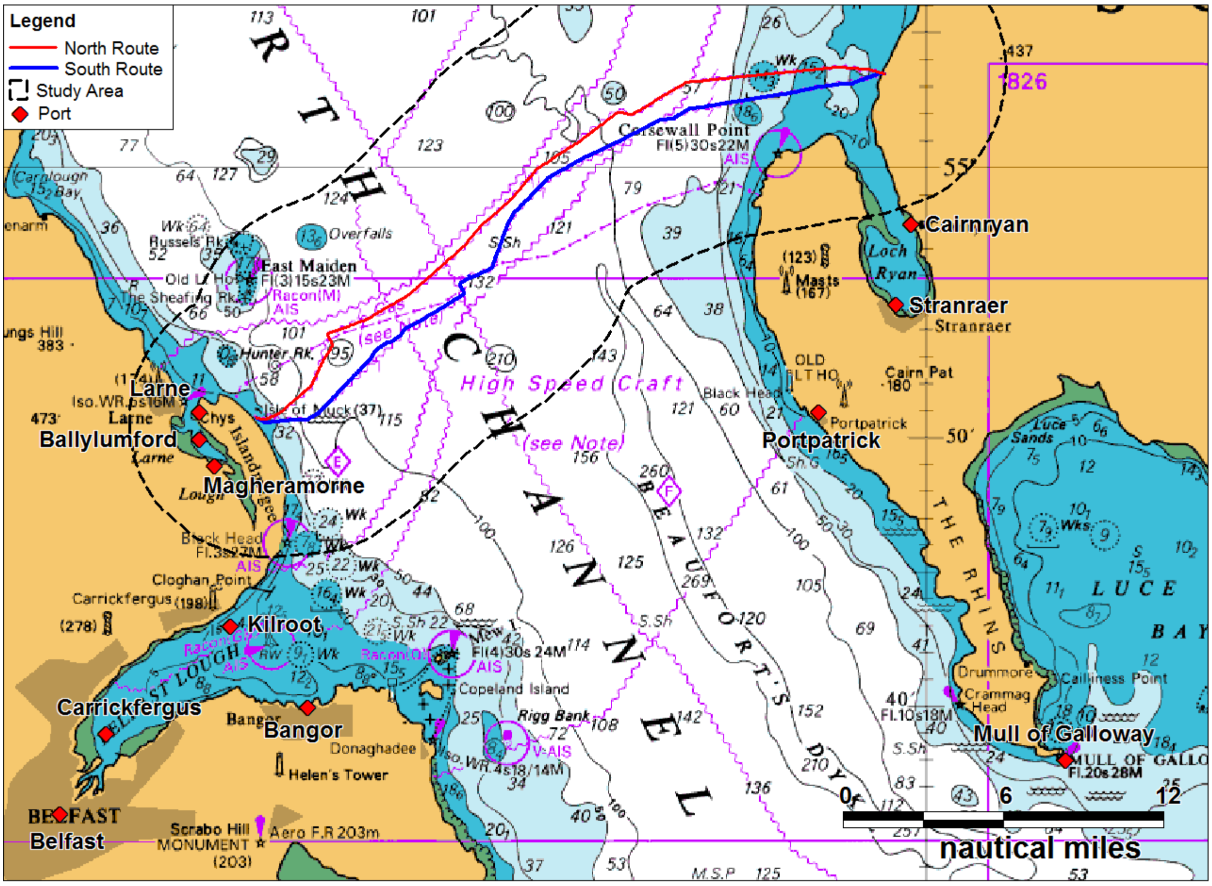


Figure 3.1 Ports in the Vicinity of Cable Corridors

There are three ports within the study area. All three lie within Larne Lough west of the cable Irish landfall point on Islandmagee. The Port of Larne is a busy commercial port equipped with a ferry terminal. The main ferry routes from Larne travel to Cairnryan and Troon on the west coast of Scotland. Ballylumford is a small port used by fishing vessels and leisure craft. It is also equipped with a ferry terminal, with a passenger service running to Larne. The nearby power station is installed with a jetty that receives oil tankers. The port of Magheramorne is a small village port mainly used for leisure purposes.

The major port near the study area is found at Belfast Harbour located approximately 17nm south of the Irish landfall point for the cables. Belfast is equipped to handle all forms of commercial shipping and also has a ferry terminal for passenger vessels. The port of Cairnryan is located 6nm south of the Scottish landfall point and is one end of ferry routes to Belfast and Larne, both of which travel daily through the study area.

3.3 Anchorages

There are two charted anchorages within the study area, these are presented in Figure 3.2.

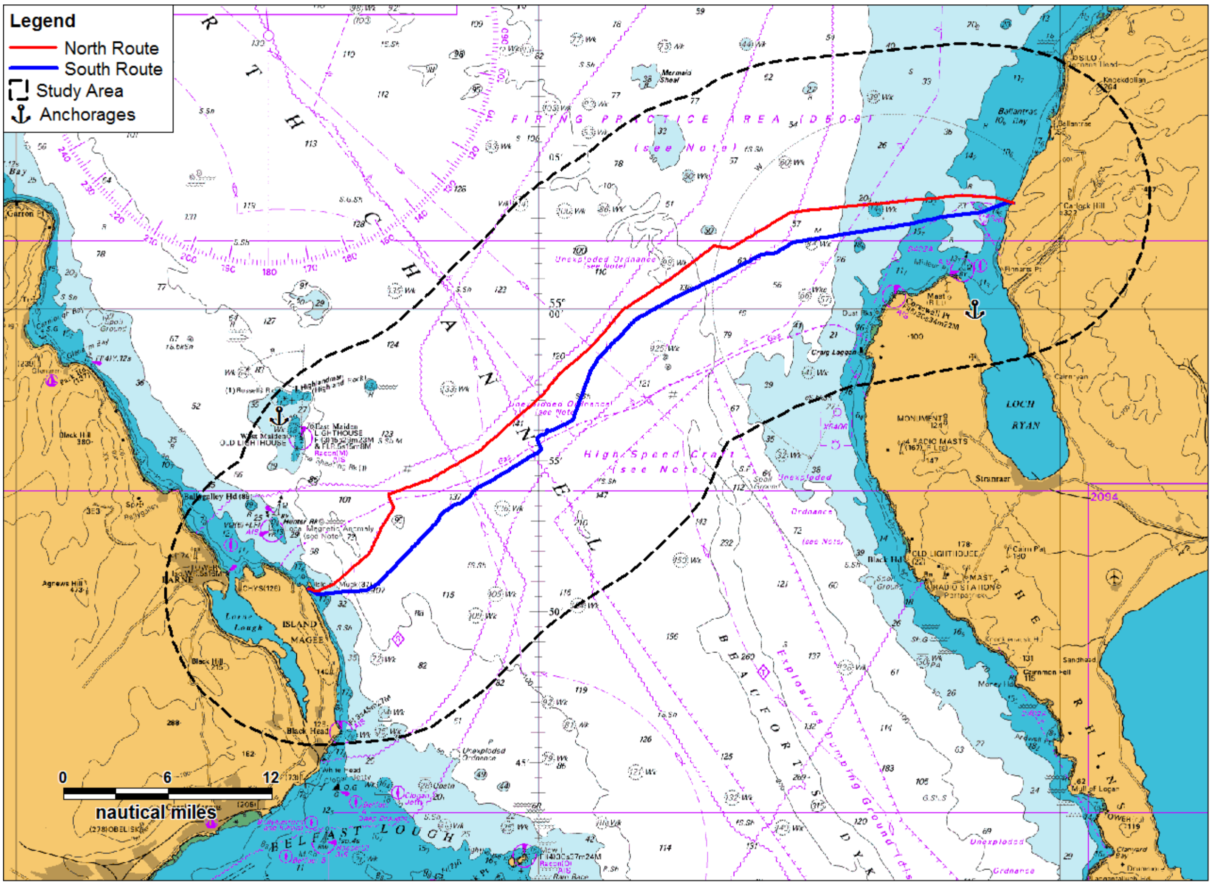


Figure 3.2 Anchorages within Study Area

The first anchorage is located at the West Maiden rock formation approximately 4nm east of the Irish coast and 5nm north of the cable route's western landfall point. There is an automated lighthouse on the East Maiden rock formation approximately 1nm east of the anchorage. The second anchorage is located near the mouth of Loch Ryan 2nm south of the southern cable route. The Pilot Book for this area (Ref i) states that secure anchoring is available in this anchorage but that the foul ground to the east and restricted areas to the north must be avoided.

3.4 IMO Routeing

There is a traffic separation scheme (TSS) located between the north east corner of Northern Ireland and Kintyre, this is presented in Figure 3.3.

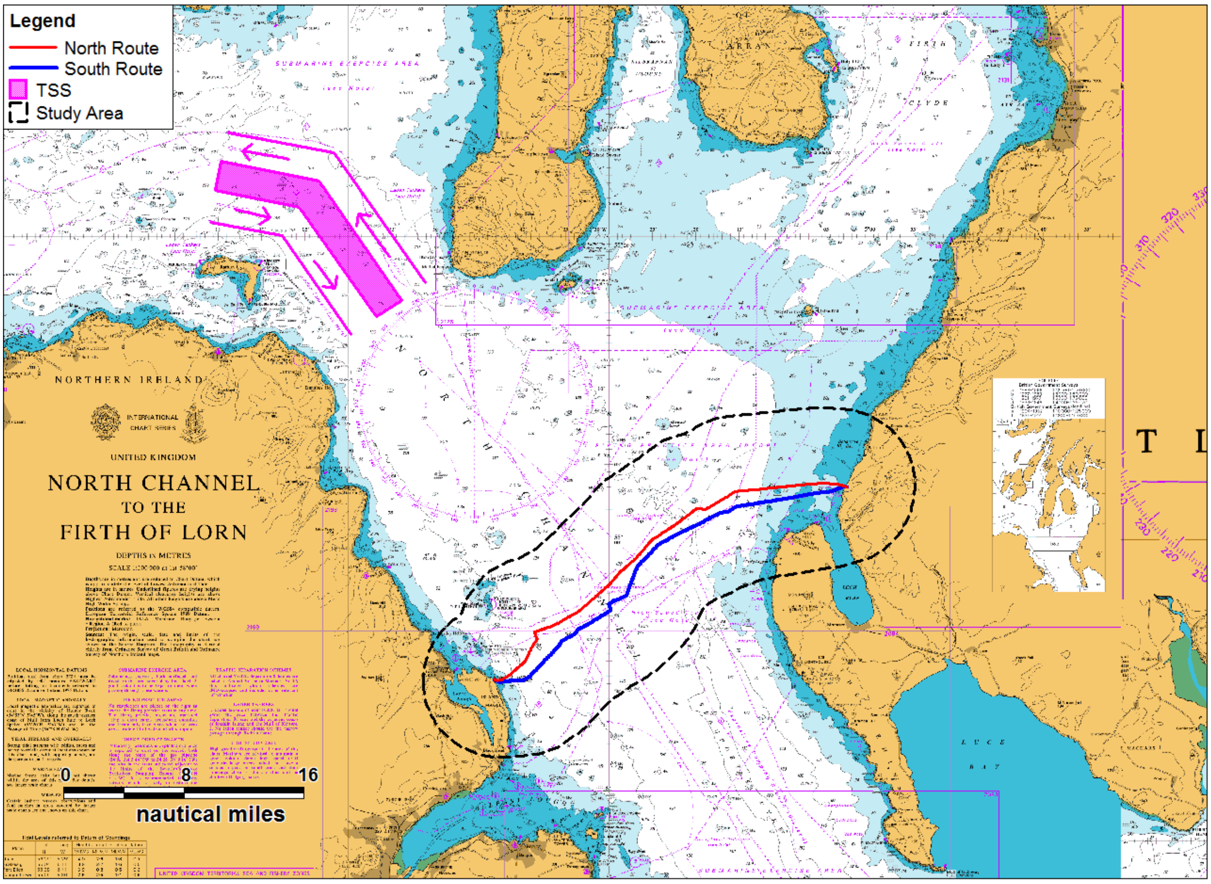


Figure 3.3 Traffic Separation Scheme

Traffic separation schemes are used in busy areas of shipping to separate traffic going in opposite directions into separate lanes. In this case it separates the commercial traffic frequenting the North Channel. See Section 4 for Automatic Identification System (AIS) tracks of the commercial shipping using the TSS.

3.5 Military Practice Areas

The military practice areas covering the study area are presented in Figure 3.4.

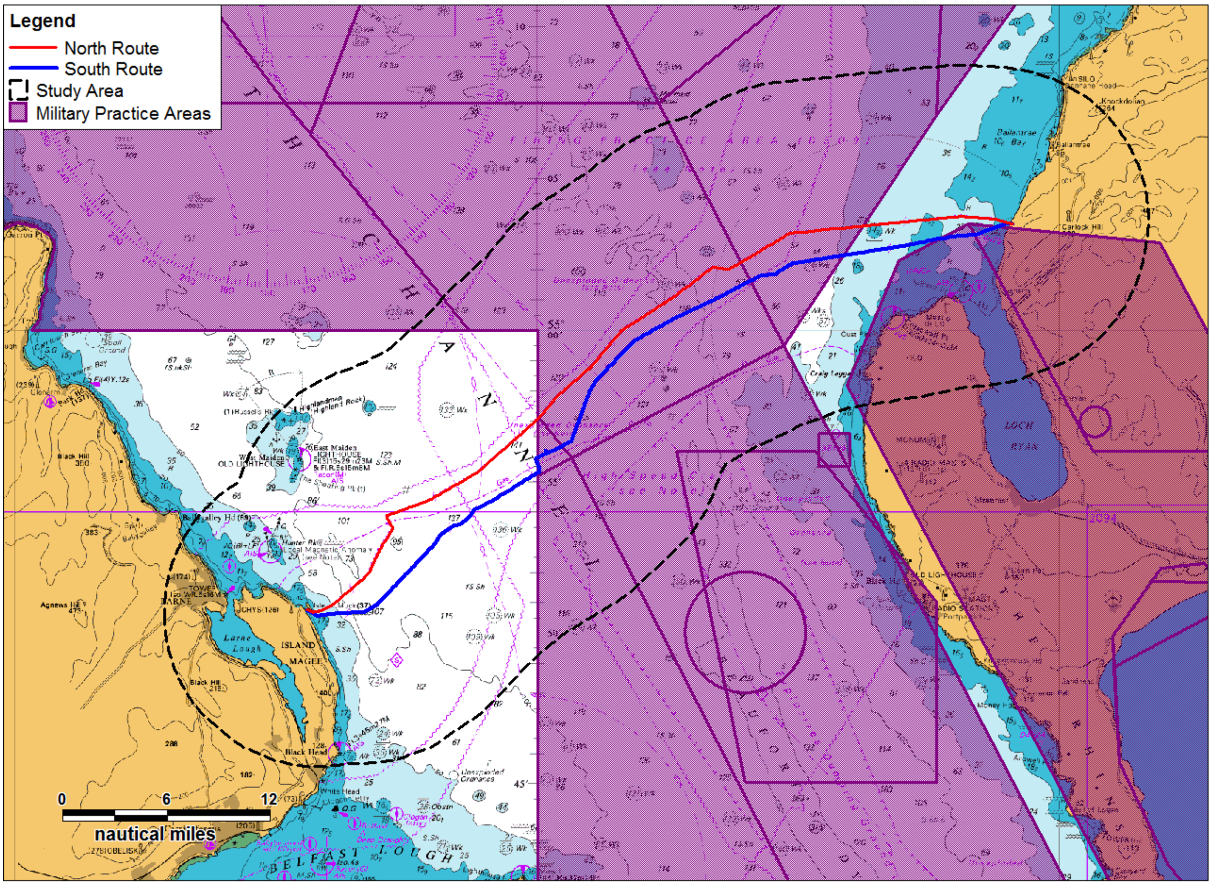


Figure 3.4 Military Practice Areas

The military areas are used by the Ministry of Defence (MOD) for firing and submarine practice. A note on the Admiralty Charts says the following regarding MOD practice areas: *"No restrictions are placed on the right to transit the firing practice areas at any time. The firing practice areas are operated using a clear range procedure; exercises and firing only take place when the areas are considered to be clear of all shipping."*

4. Shipping Analysis

4.1 Introduction

A total of three months of AIS data was used to assess the shipping activity in the vicinity of the cable corridors, six weeks from summer 2013 and six weeks from winter 2014 as follows:

- 20th to 30th July 2013 and 1st to 31st August 2013
- 13th to 30th January and 5th to 28th February 2014

The three months of data was used to analyse the numbers, types, sizes, and density of vessels in the vicinity of the cable routes. The analysis for summer and winter were performed separately so that the seasonal variations could be compared.

4.2 AIS Overview

AIS is required to be fitted on all vessels of 300GT and upwards engaged on international voyages, cargo vessels of 500GT and upwards not engaged on international voyages and passenger vessels irrespective of size built on or after 1 July 2002. It also applies to vessels engaged on international voyages constructed before 1st July 2002 according to the following timetable:

- All passenger vessels, not later than 1st July 2003;
- Tankers, not later than the first survey for safety equipment on or after 1st July 2003;
- Vessels, other than passenger vessels and tankers, of 50,000GT and upwards, not later than 1st July 2004.

On the 31st May 2013, AIS carriage became mandatory for all fishing vessels of length greater than or equal to 18m in length. This was changed to all fishing vessels of greater than or equal to 15m on the 31st May 2014. The summer and winter survey periods in this report fall in between these dates so coverage is only guaranteed for fishing vessels of length 18m and above, however smaller vessels may have carried voluntarily.

4.3 Summer Analysis

4.3.1 Daily Count

The number of unique vessels per day during summer is presented in Figure 4.1.

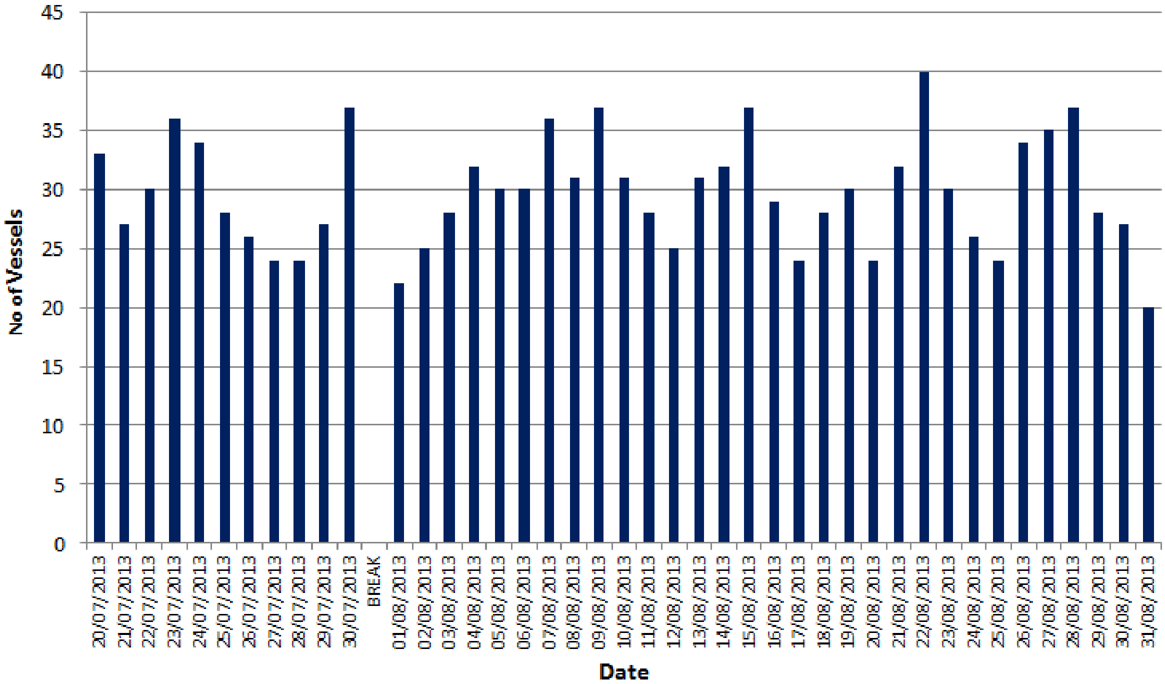


Figure 4.1 Number of Unique Vessels per Day in Summer

There was an average of 30 unique vessels per day passing through the study area during summer. A total of 40 unique vessels passed through the study area on the busiest day, and a total of 20 unique vessels on the quietest day.

A plot of the busiest day colour coded by vessel type is presented in Figure 4.2.

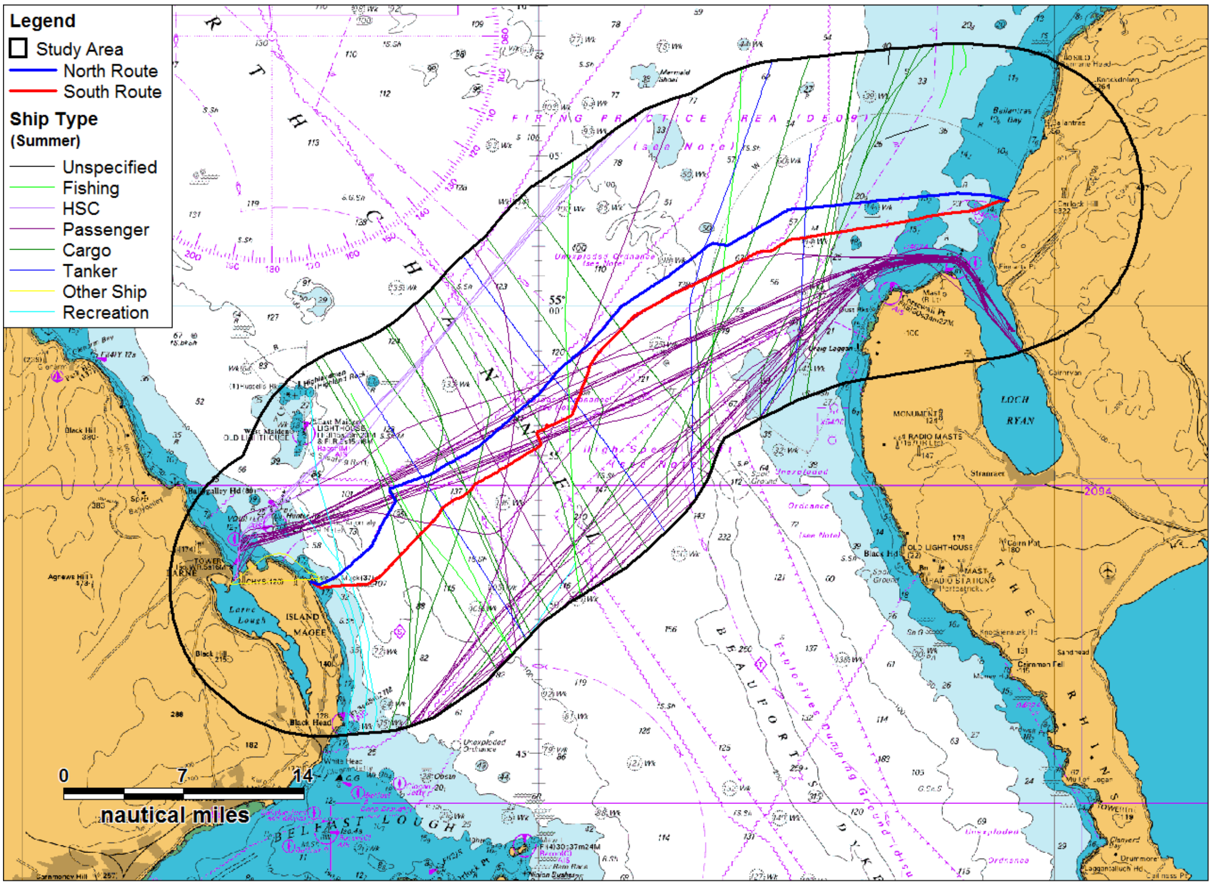


Figure 4.2 Busiest Day during Summer, 22nd August 2013

4.3.2 Vessel Type

A plot of the summer AIS data by vessel type is presented in Figure 4.3.

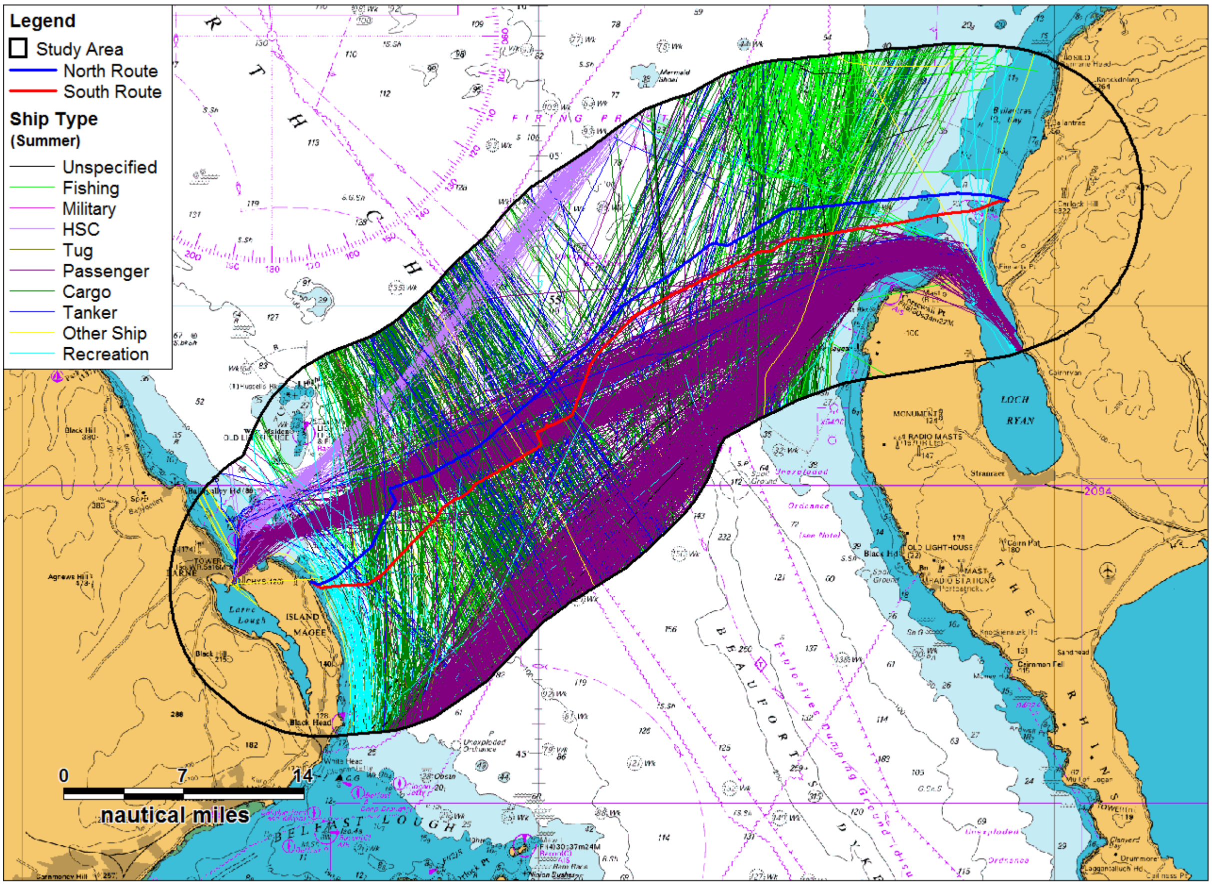


Figure 4.3 Summer AIS by Vessel Type

It is seen that there is a regular passenger route between Larne and Cairnryan. This route is operated by P&O Ferries and used by two vessels: the *European Causeway* and the *European Highlander*. Current timetables show that this route sails up to seven times per day from each destination. The Stena operated route between Belfast and Cairnryan was also noted, used by the *Stena Superfast VII* and the *Stena Superfast VIII*. There are currently six crossings per day sailing between each destination on this route. The High Speed Craft (HSC) route heading northeast from Larne is operated by P&O Ferries. This route has two sailings between Larne and Troon on the *Express*.

Commercial vessel routes used by tanker and cargo vessels were seen crossing the cable corridors in the western section of the study area. Fishing activity was also noted in the north east section of the study area (see Section 5.2 for more information on the AIS fishing vessel tracks).

A plot of the distribution of vessel type (excluding unspecified) during summer is presented in Figure 4.4. The analysis is based on unique vessels per day.

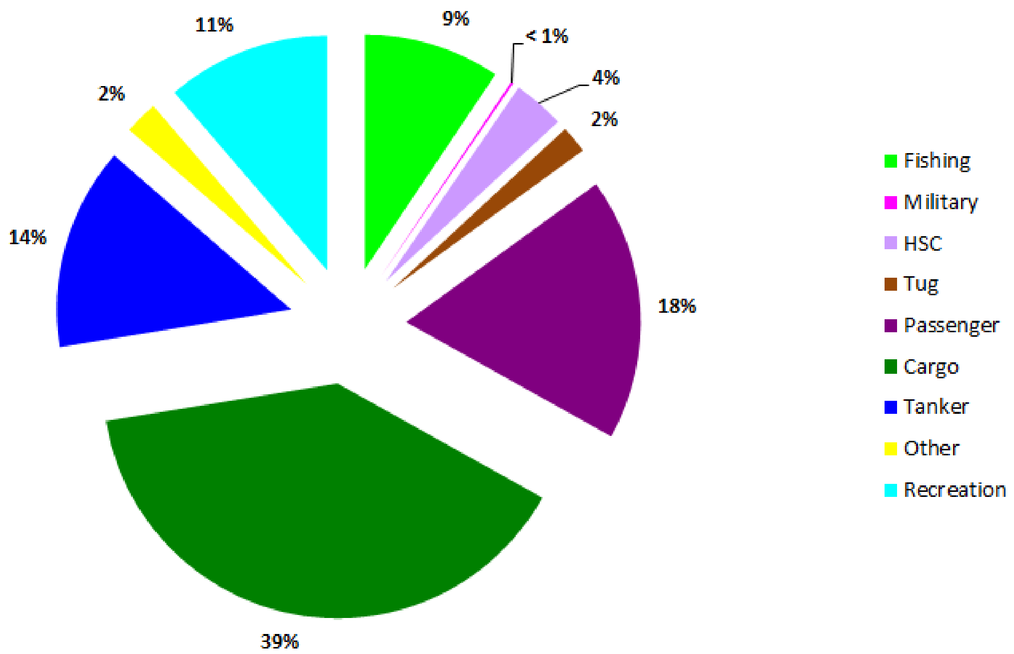


Figure 4.4 Summer AIS Vessel Type Distribution

During summer, the majority of shipping was commercial. The most common vessel type was cargo vessels (39%), followed by passenger vessels (18%) and tankers (14%). Recreational vessels made up 11%. There were also a small number of fishing vessels, HSC, tugs, and military vessels noted in the study area during summer.

4.3.3 Vessel Size

The summer AIS data colour coded by vessel length is presented in Figure 4.5.

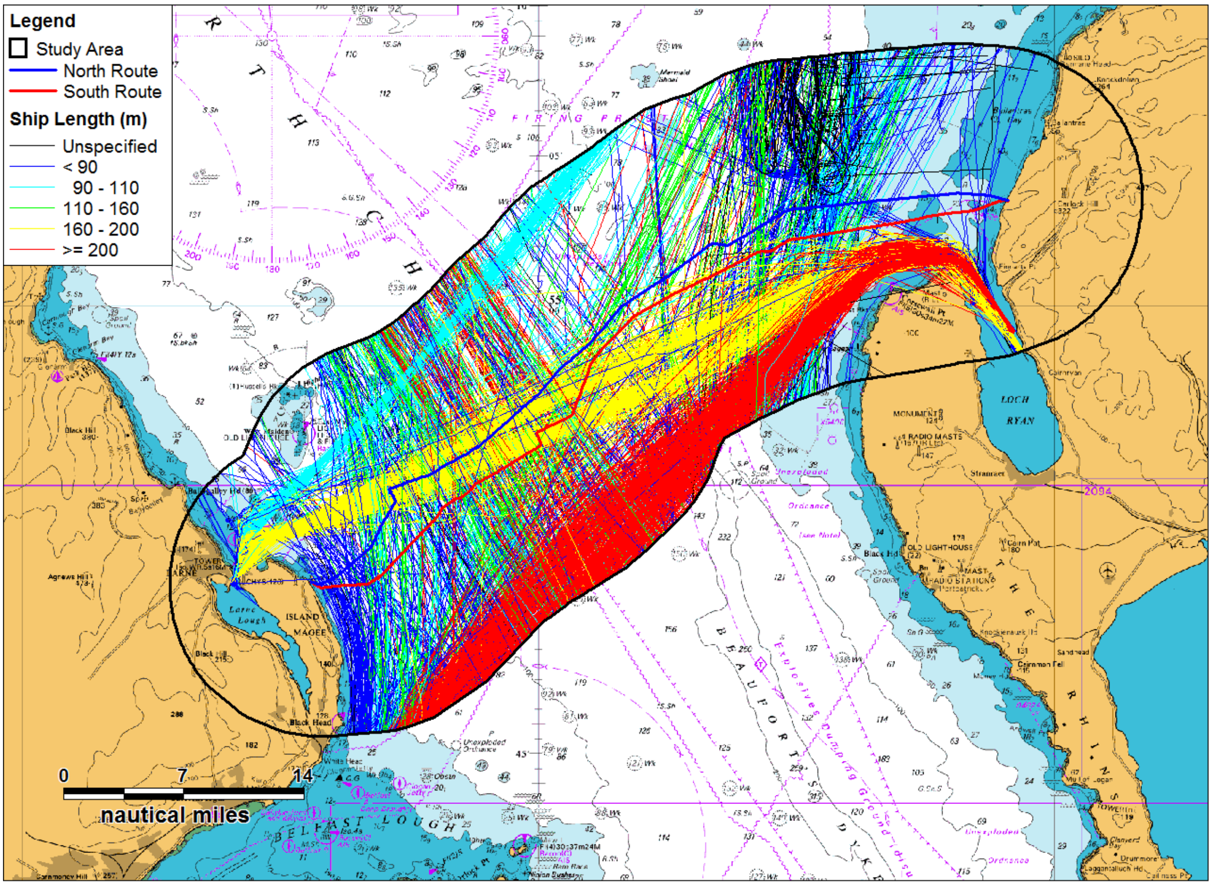


Figure 4.5 Summer AIS by Vessel Length

It can be seen that the vessels over 200m were mainly passenger vessels using the route between Cairnryan and Belfast. The majority of vessels less than 90m were seen to stay close to the coast.

The distribution of vessel length (excluding unspecified) during summer is presented in Figure 4.6.

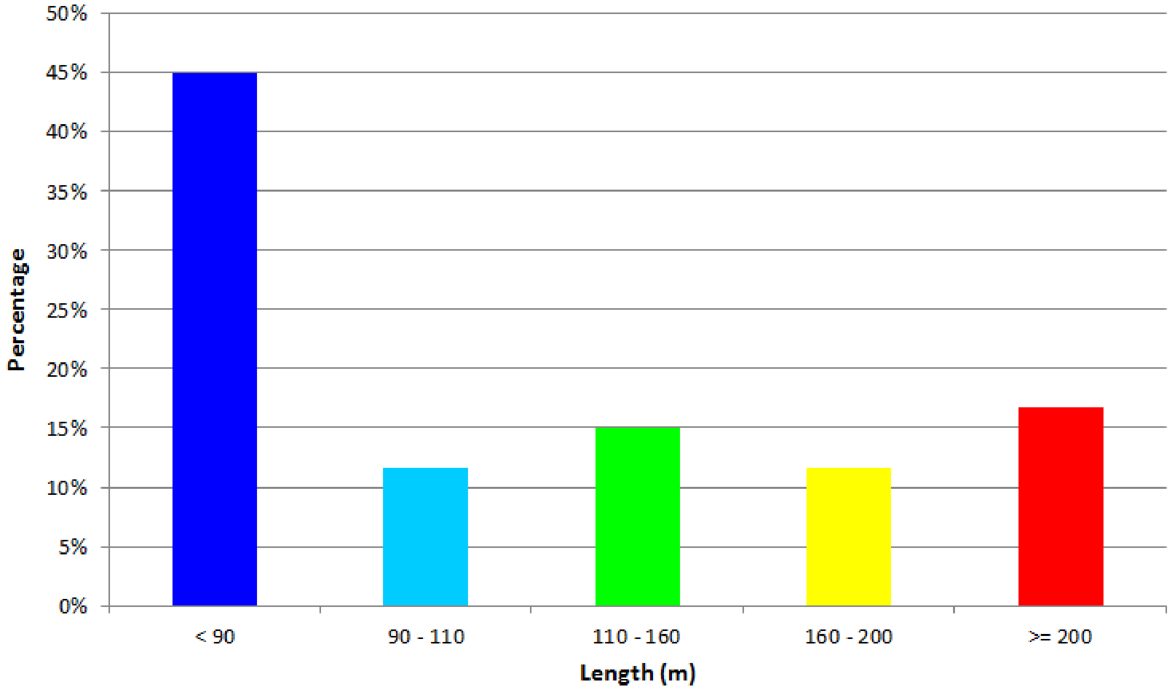


Figure 4.6 Summer AIS Vessel Length Distribution

Overall, 45% of vessels were less than 90m in length. Vessels greater than 200m in length made up 17% of the total. Vessels between 90 and 110m, 110 and 160m, and 160 and 200m made up 12%, 15%, and 12% respectively. The average length of vessel was 112m.

The largest vessels tracked in the AIS data during summer were the *Celebrity Infinity* and the *Queen Elizabeth*. Both were passenger vessels with lengths of 294m.

4.3.4 Vessel Density

The three weeks of summer AIS data was used as input to Anatec's ship density calculator. The program calculated the number of track intersects for every cell of a 250m by 250m grid covering the study area during the three month AIS survey period. The results, factored to an annual value, are presented in Figure 4.7.

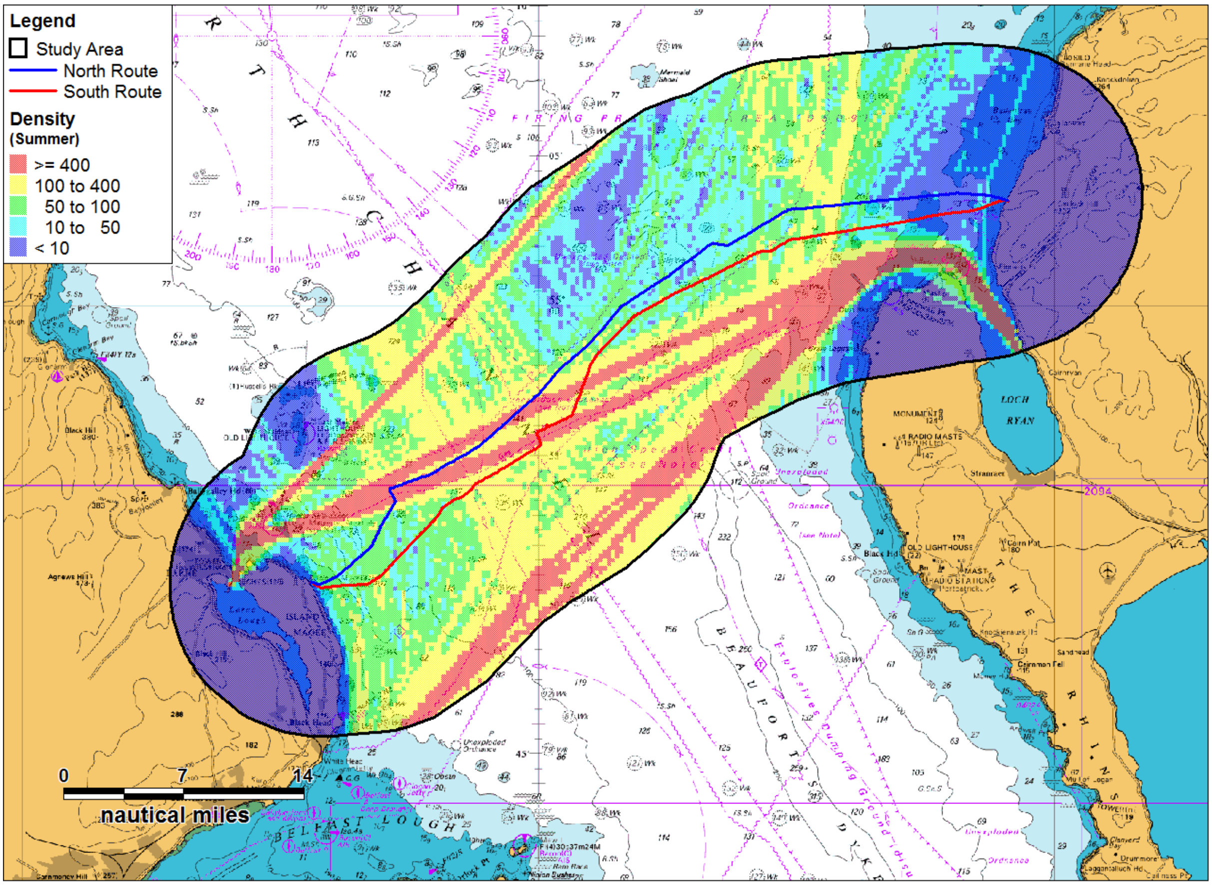


Figure 4.7 Shipping Density during Summer

The highest density areas were caused by the routes used by passenger vessels. High density areas were considered to be cells with more than 400 intersects per year. An area of medium density was seen between 2nm and 10nm east of the Irish coast caused by commercial shipping using the North Channel, and by fishing activity northwest of Corsewall Point. Medium density areas were considered to be cells with between 50 and 400 track intersects per year.

4.4 Winter Analysis

4.4.1 Daily Count

The number of unique vessels per day during winter is presented in Figure 4.8.

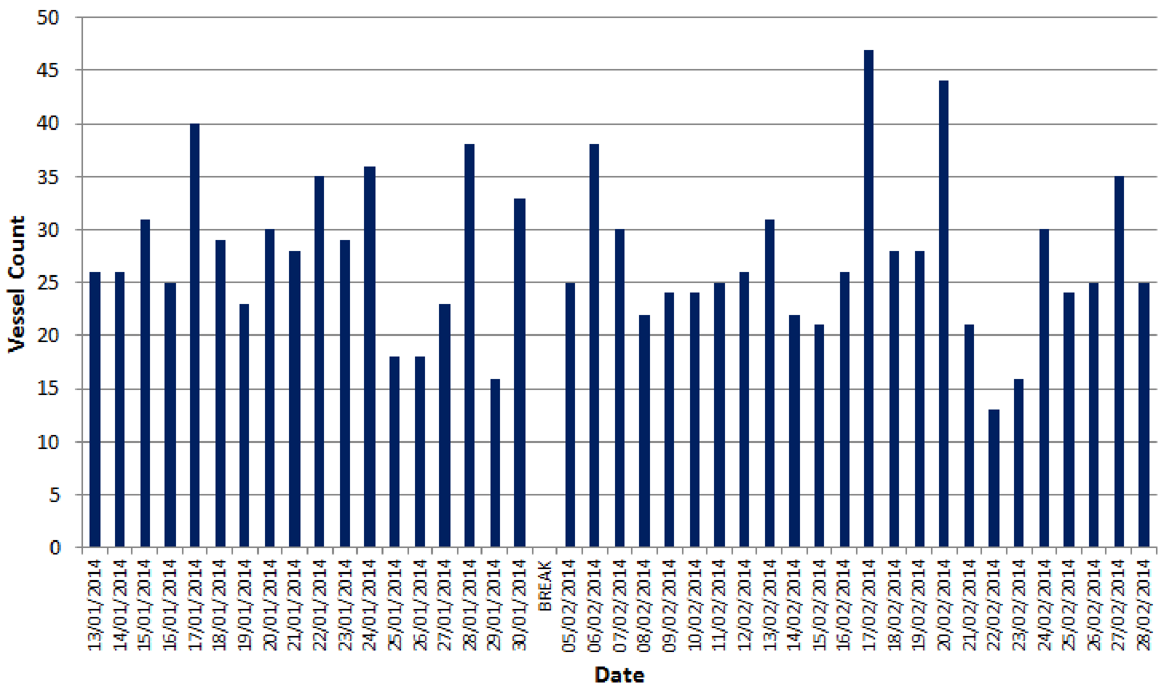


Figure 4.8 Number of Unique Vessels per Day in Winter

There was an average of 27 unique vessels per day passing through the study area in winter, down from 30 unique vessels in summer. On the busiest day during winter, 47 unique vessels passed through the study area. A total of 13 unique vessels passed through the study area on the quietest day.

A plot of the busiest day during winter is presented in Figure 4.9.

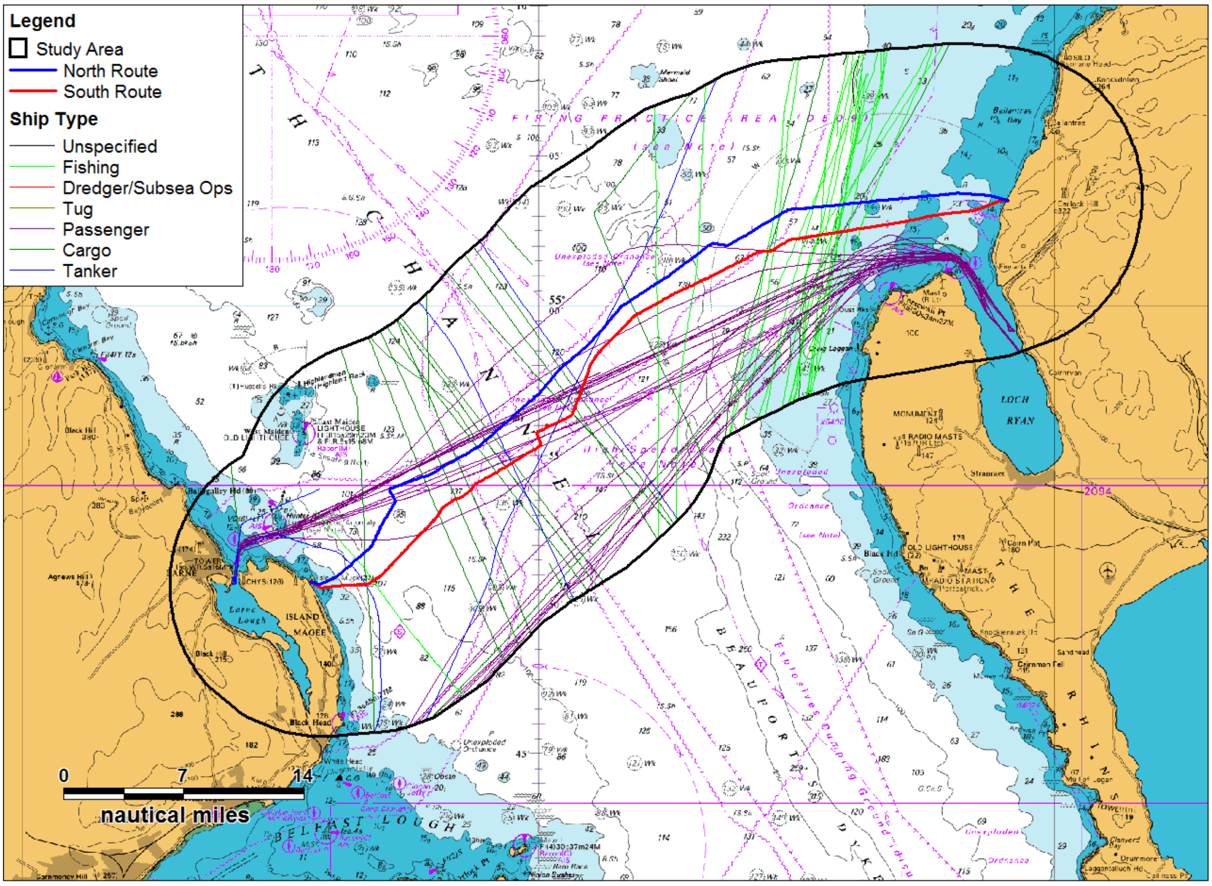


Figure 4.9 Busiest Day during Winter, 17th February 2014

4.4.2 Vessel Type

The winter AIS data colour coded by vessel type is presented in Figure 4.10.

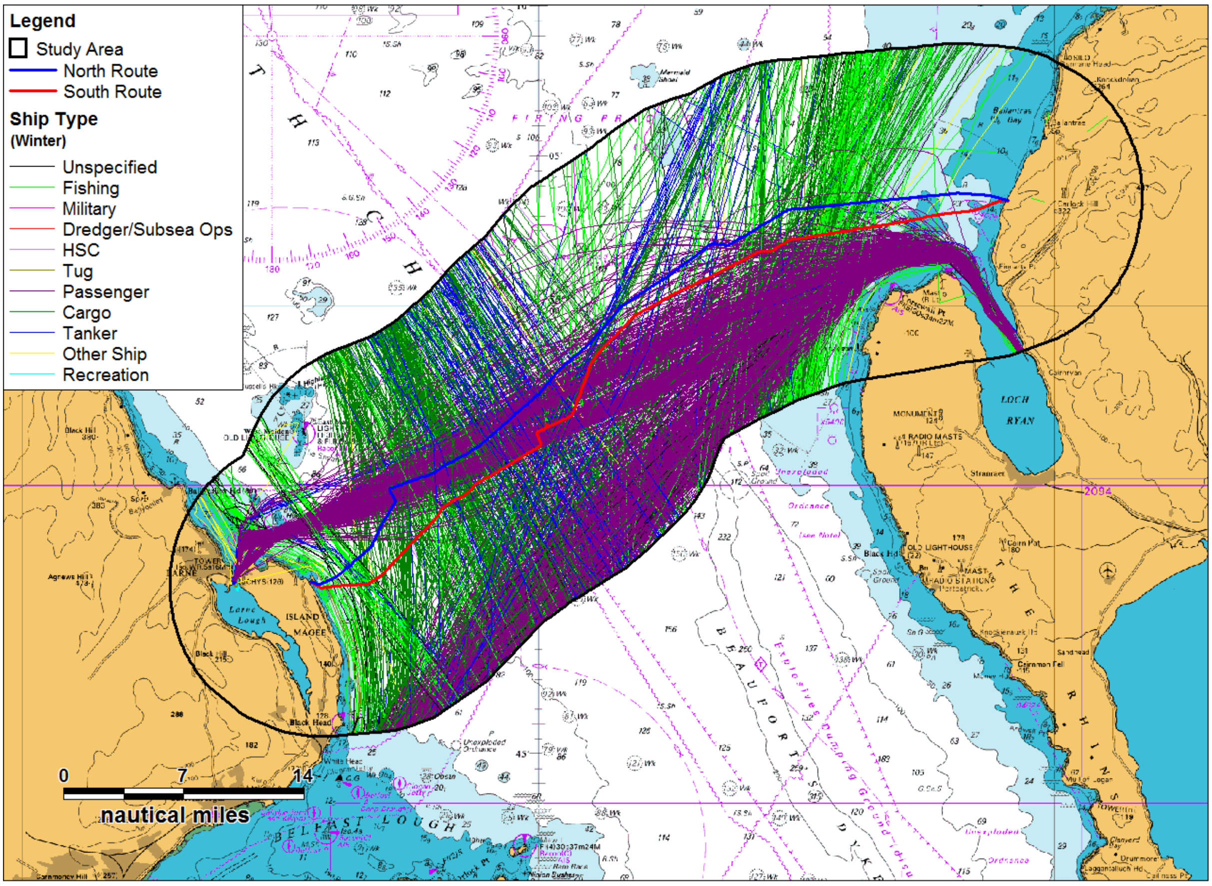


Figure 4.10 Winter AIS by Vessel Type

As in summer the passenger routes between Cairnryan and Larne, and Cairnryan and Belfast were being regularly used. However the service between Troon and Larne did not run over winter. Commercial shipping was observed using the North Channel. It appeared that fishing vessels recorded in the winter data tended to be steaming on passage rather than actively fishing.

The winter AIS vessel type distribution (excluding unspecified) is presented in Figure 4.11.

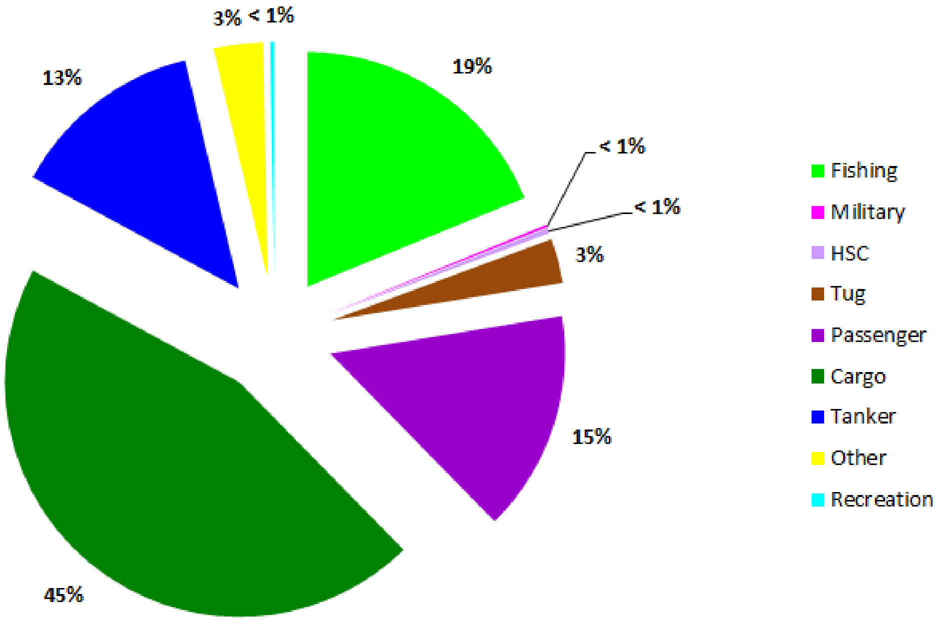


Figure 4.11 Winter AIS Vessel Type Distribution

As in summer, the most common vessel type was cargo (45%). Fishing vessels made up approximately 19%, up from 9% in summer. Passenger vessels made up a further 15%, and tankers made up 13%. Military vessels, HSC, and tug boats were also noted during the winter period.

A total of 60 unique fishing vessels were seen during winter, compared to 41 in summer. This increase is possibly down to seasonal variations in fishing activity, or more small fishing vessels installing AIS equipment in preparation for the new AIS regulations on the 31st May 2014 (see Section 4.2).

4.4.3 Vessel Size

The winter AIS data colour coded by vessel length is presented in Figure 4.12.

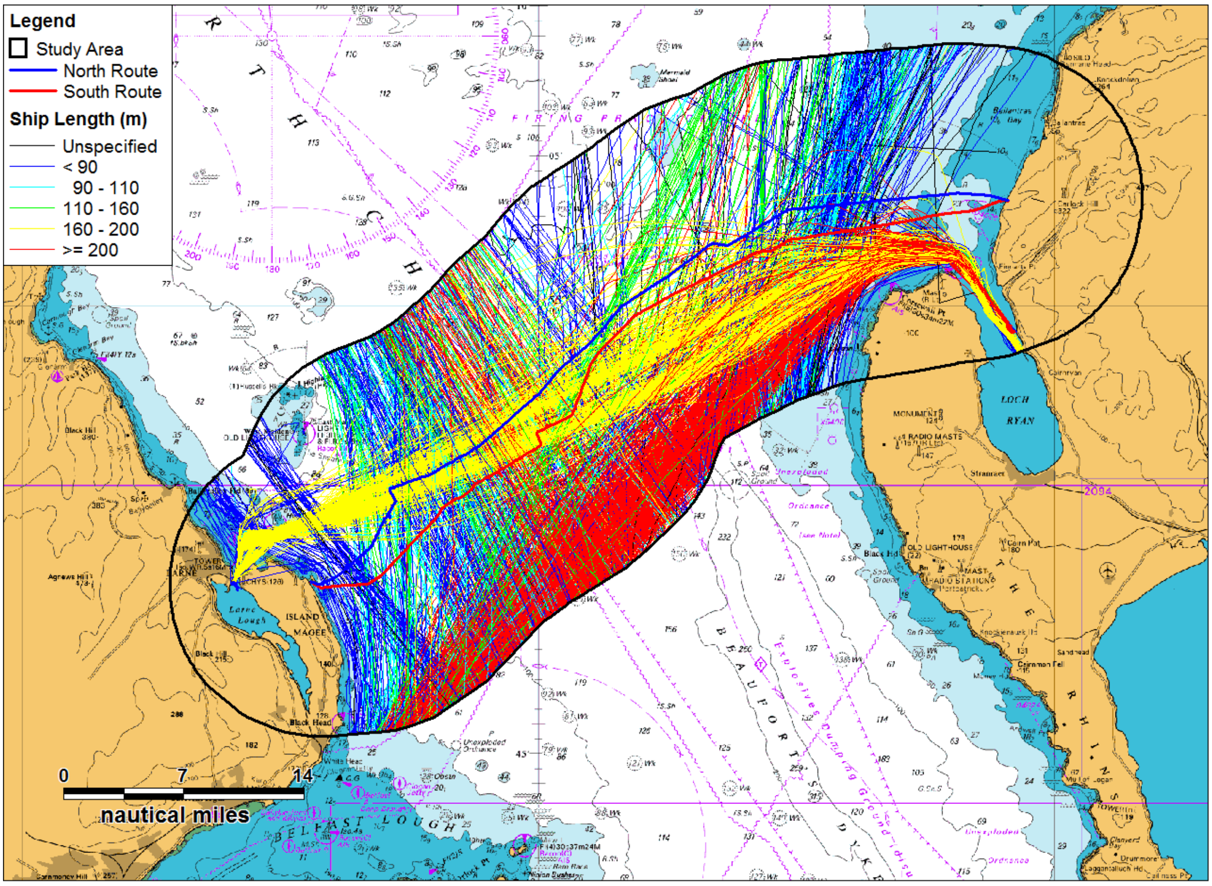


Figure 4.12 Winter AIS by Vessel Length

The largest vessels were the passenger vessels using the route between Cairnryan and Belfast, and commercial shipping travelling through the North Channel.

The winter length distribution (excluding unspecified) is presented in Figure 4.13.

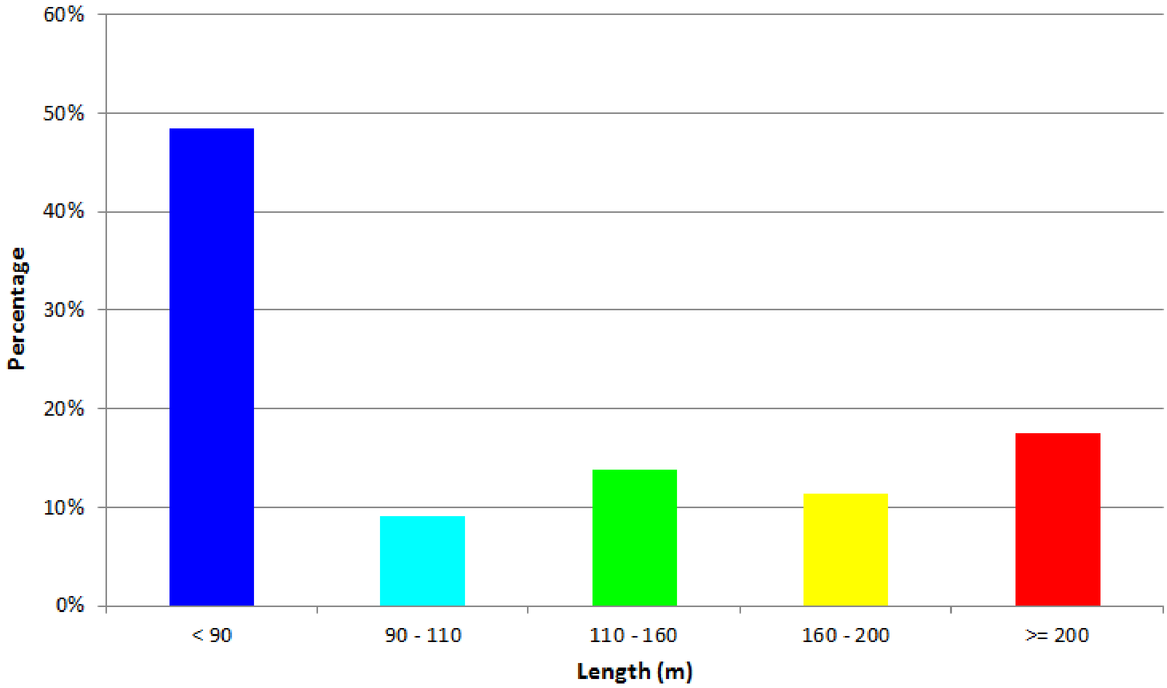


Figure 4.13 Winter AIS Vessel Length Distribution

The winter and summer length distributions were similar. In winter, 48% of vessels were less than 90m in length, and 17% were greater than 200m. Vessels between 90 and 100m, 110 and 160m, and 160 and 200m made up 9%, 14%, and 11% respectively. The average vessel length was 112m.

The vessel with the greatest length during winter was the *Atlantic Cartier,* a cargo vessel with a length of 293m.

4.4.4 Vessel Density

The winter AIS data was used as input to Anatec's Ship Density program. The results, factored to an annual value, are presented in Figure 4.14. The same density ranges were used in both summer and winter figures for comparison. High density areas were considered to cells with more than 400 intersects a year, and medium density areas were considered to be cells with between 50 and 400 intersects.

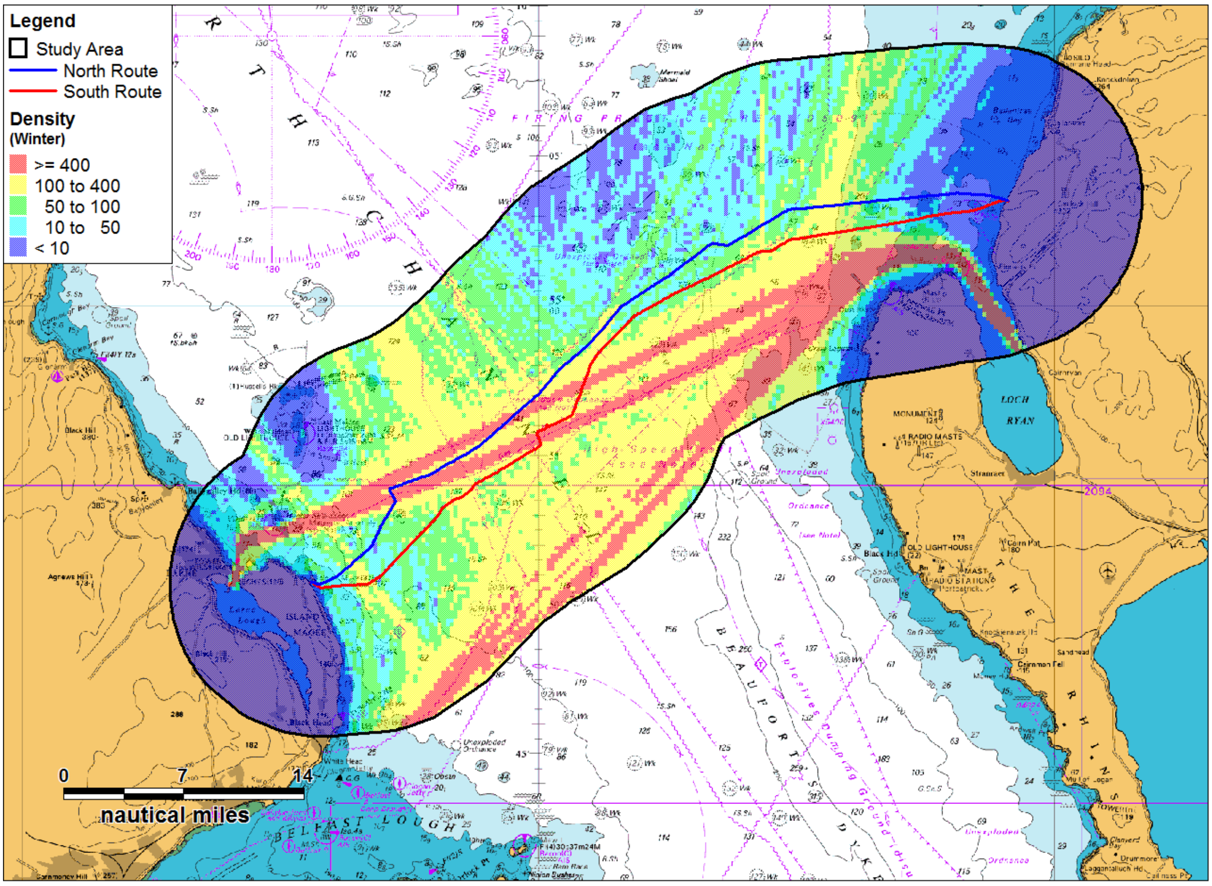


Figure 4.14 Shipping Density during Winter

The overall density was seen to be lower in winter than in summer. As with the summer data the highest density areas (i.e. more than 400 intersects per year) were the passenger vessel routes and medium density areas (i.e. between 50 and 400 intersects per year) were caused by commercial shipping using the North Channel routes. The area of fishing activity northwest of Corsewall Point was seen to have less medium density cells than the same area in summer.

5. Fishing Analysis

5.1 Introduction

This section analyses the fishing activity within the vicinity of the two cable route corridors. Certain types of fishing gear are operated close to or on the seabed, and therefore have the potential to interact with subsea equipment. This can cause damage to both subsea cables and to the fishing gear. In more serious cases, snagged gear can also cause a vessel to capsize as it attempts to free its gear.

Three data sources were used in order to provide a comprehensive analysis of the fishing vessel behaviour. The three data sources are described below.

5.1.1 AIS

The fishing vessels tracks recorded within the AIS data in Section 4 were extracted and analysed. As previously discussed, in Section 4.2, the summer 2013 and winter 2014 AIS survey data covers all fishing vessels with 18m length and over. A proportion of smaller vessels may carry AIS voluntarily but they are not obliged to broadcast.

5.1.2 Sightings

Fishing vessel sightings data in UK waters are obtained through the deployment of patrol vessels, surveillance aircraft and the sea fisheries inspectorate. All vessels are logged, irrespective of size, provided they can be identified by their Port Letter Number. Data is collated by the MMO within the ICES Subsquares covering UK waters. It should be taken into account that patrols mostly take place in daylight and good weather and that the number of patrols varies per ICES Subsquare, this is highlighted within the analysis. The most recent available data set is 2005-2009.

5.1.3 Satellite

Fishing vessel satellite tracking (or VMS) data have been analysed for the whole of 2009, which was the latest positional data set available. This covers all fishing vessels (UK and foreign) of 15m length and above. Vessel position reports are received approximately every two hours when at sea (the tracking devices may be switched off in port).

Density data from 2012 has also been presented in the form of a grid showing the total amount of time vessels spent actively fishing within each grid cell.

5.2 AIS

The fishing vessel tracks from Section 4, colour coded by gear type, are presented in Figure 5.1.

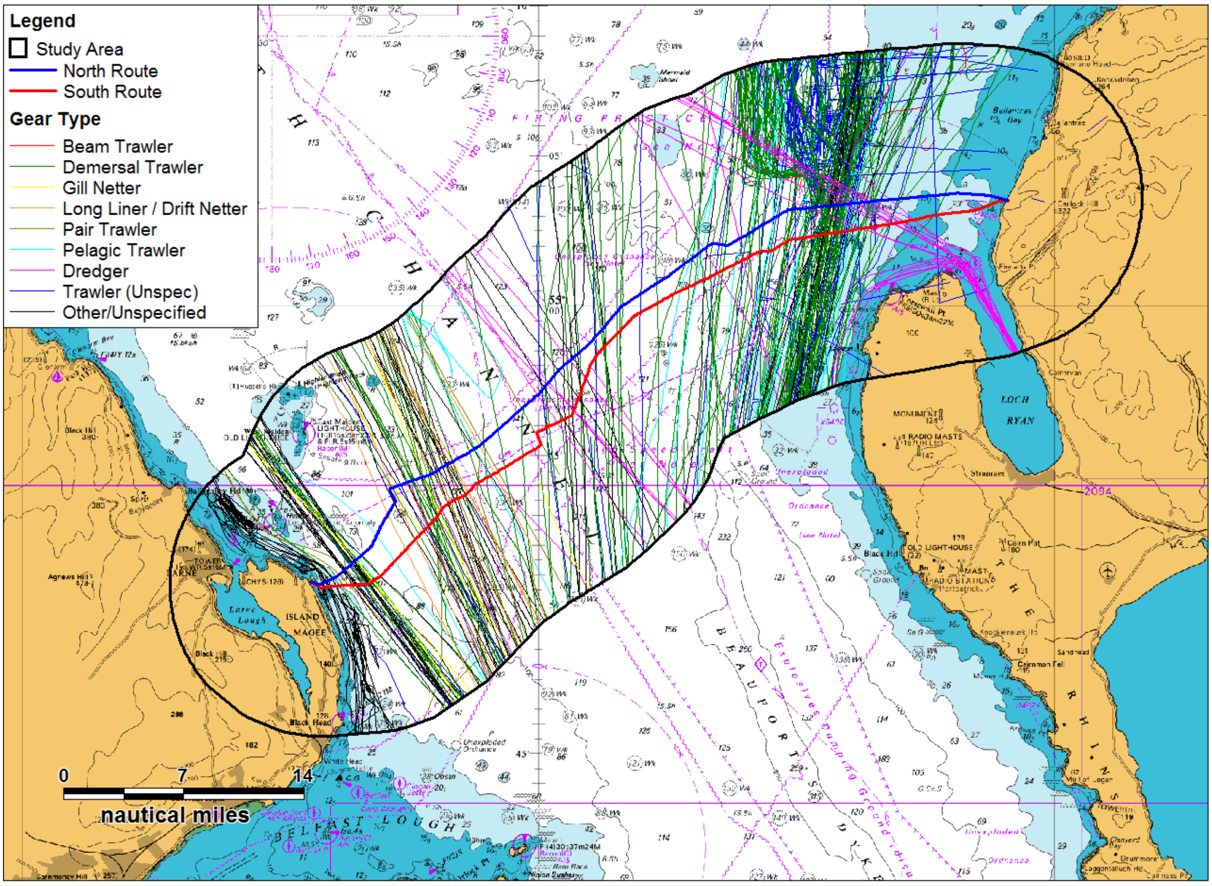


Figure 5.1 AIS Fishing Vessel Tracks

The majority of vessels in the study area appeared to be steaming on passage rather than actively fishing but trawling activity was noted 1nm north of the north cable route approximately 6nm west of the Scottish coast. Demersal trawling gear has the potential to interact with a subsea cable.

The gear type distribution within the AIS data is presented in Figure 5.2.

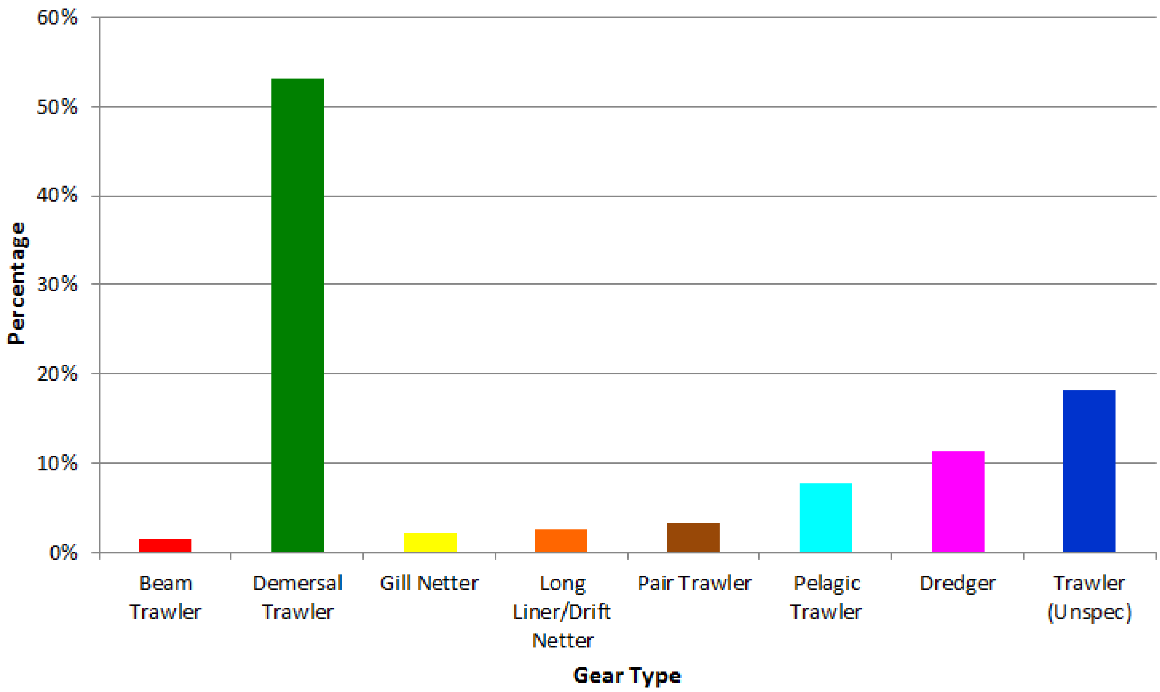


Figure 5.2 AIS Gear Type Distribution

Demersal trawling equipment was the most common gear type seen over the three months, making up 53% of the total. Unspecified trawlers made up 18%, and dredgers made up 11%. Pelagic trawlers made up a further 8%. No other gear type contributed more than 5% of the total.

5.3 Sightings

The ICES Subsquares covering the study area are presented in Figure 5.3. The number of patrols per subsquare between 2005 and 2009 are included in the figure.

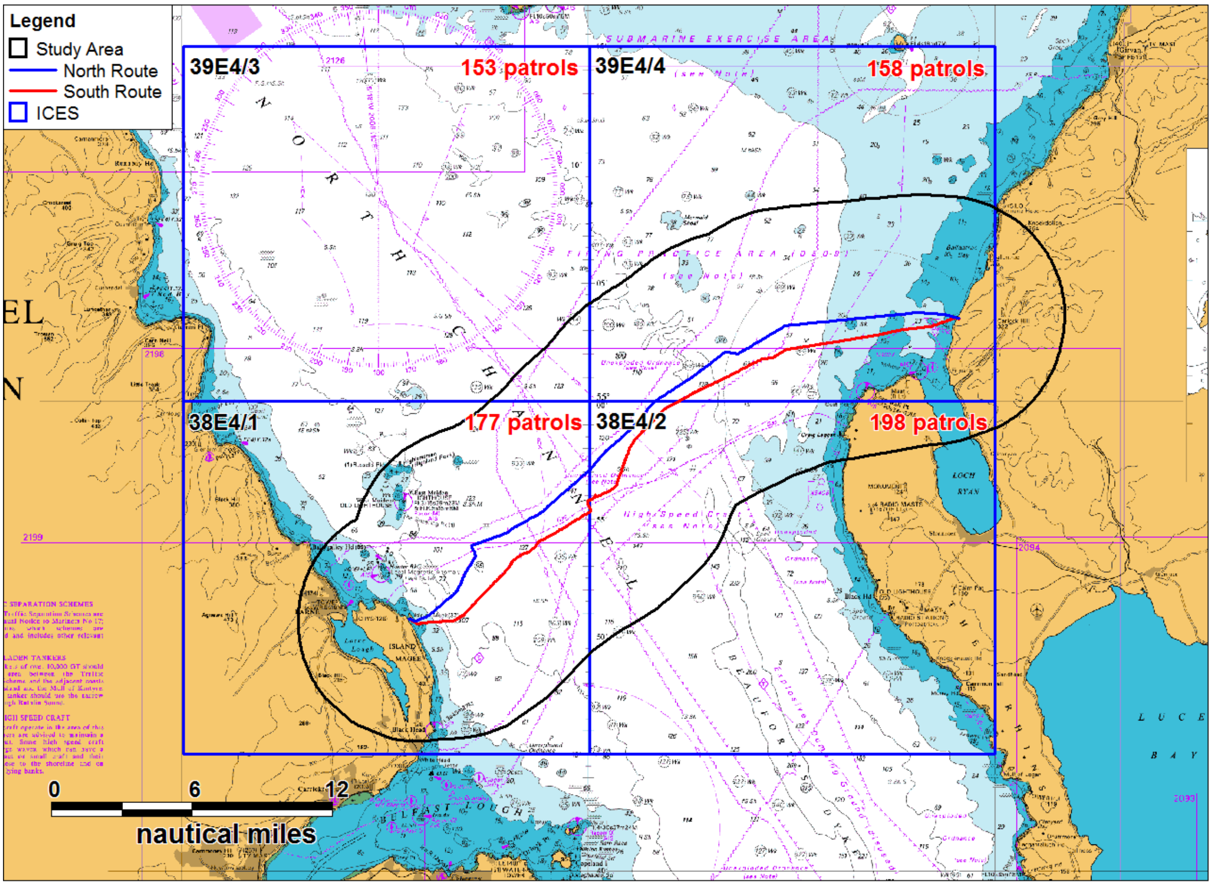


Figure 5.3 ICES Subsquares covering Study Area

It is seen that the number of patrols varied from 153 patrols in 39E4/3 to 198 patrols in 38E4/2. This should be taken into consideration when viewing the sightings data analysis.

The sightings data, colour coded by gear type, is presented in Figure 5.4.

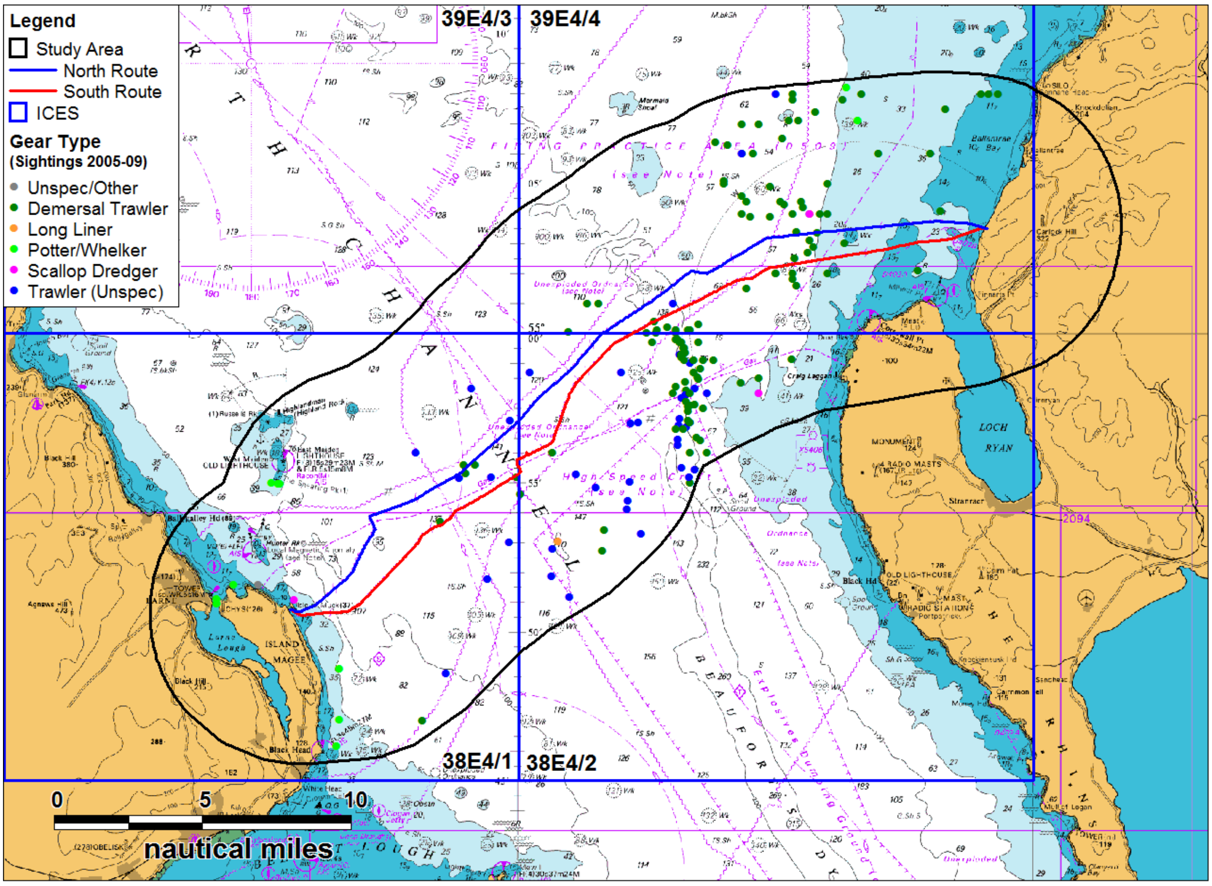


Figure 5.4 Sightings Data by Gear Type (2005–09)

Demersal trawling activity was noted within the study area in ICES Subsquares 39E4/4 and 38E4/2, this tends to agree with the location of demersal trawling activity in the AIS data.

Excluding the <1% unspecified, the distribution of gear type within the sightings data is presented in Figure 5.5.

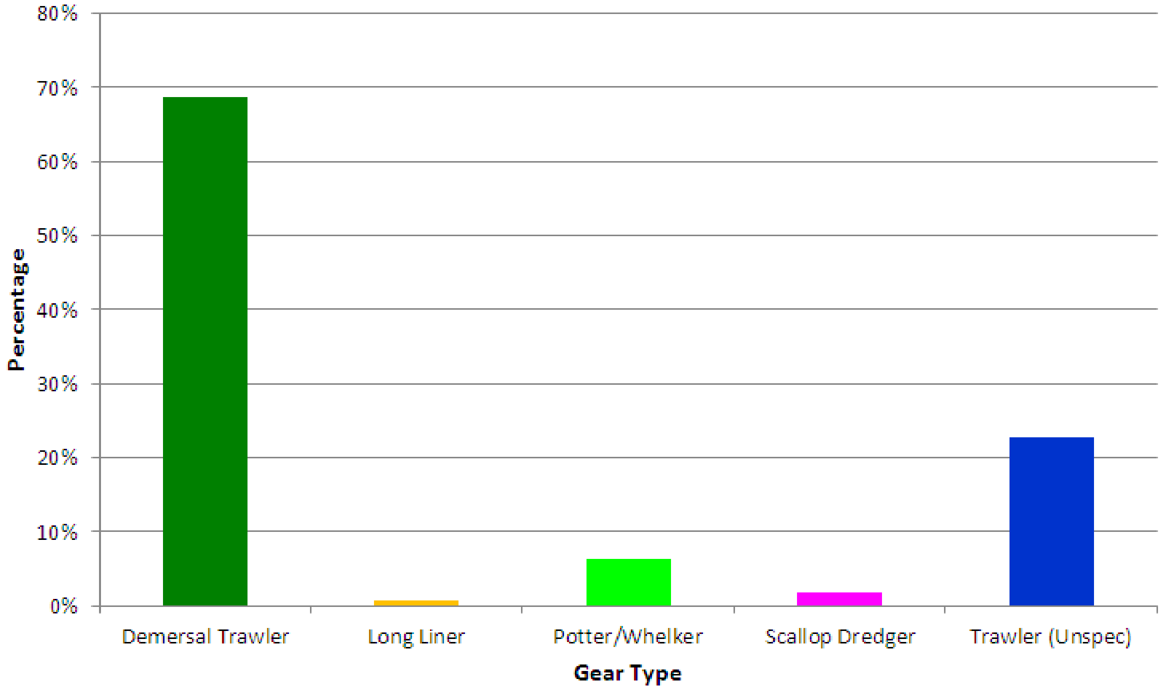


Figure 5.5 Sightings Data Gear Type Distribution (2005-09)

The majority (69%) of the sightings were demersal trawlers. A further 23% were classified as unspecified trawlers. Potters/whelkers made up 6%, scallop dredgers made up 2% and long liners made up 1%.

The sightings data, colour coded by activity, is presented in Figure 5.6.

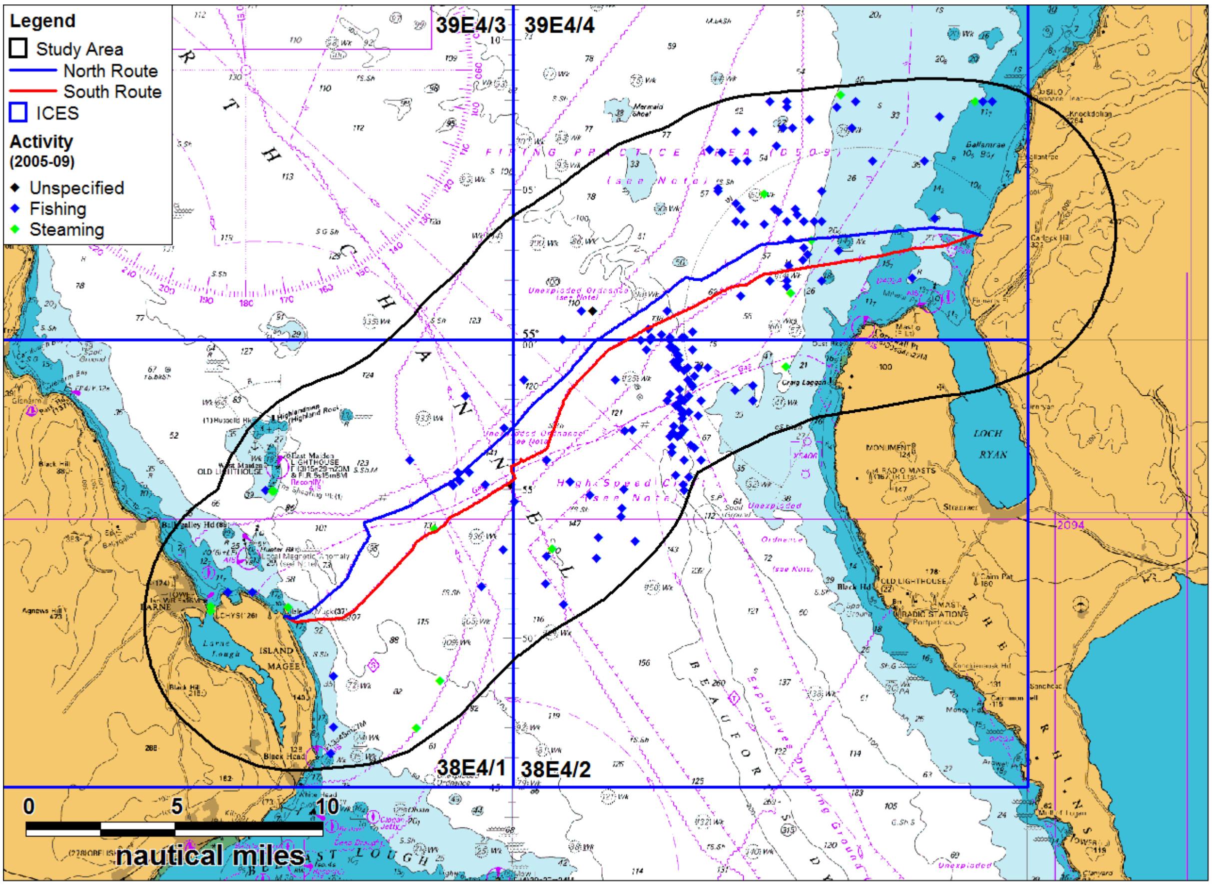


Figure 5.6 Sightings Data by Activity (2005-09)

Excluding the <1% unspecified, 91% of the sighted positions were from vessels engaged in fishing, with the remaining 9% steaming on passage. Active fishing occurred over and near to both cable routes. It is noted that the vessels actively fishing were mainly demersal trawlers.

5.4 Satellite

5.4.1 2009 Positional Data

The satellite positional data from 2009 is presented in Figure 5.7, colour coded by gear type. Gear type data was only available for a small subset of the satellite data.

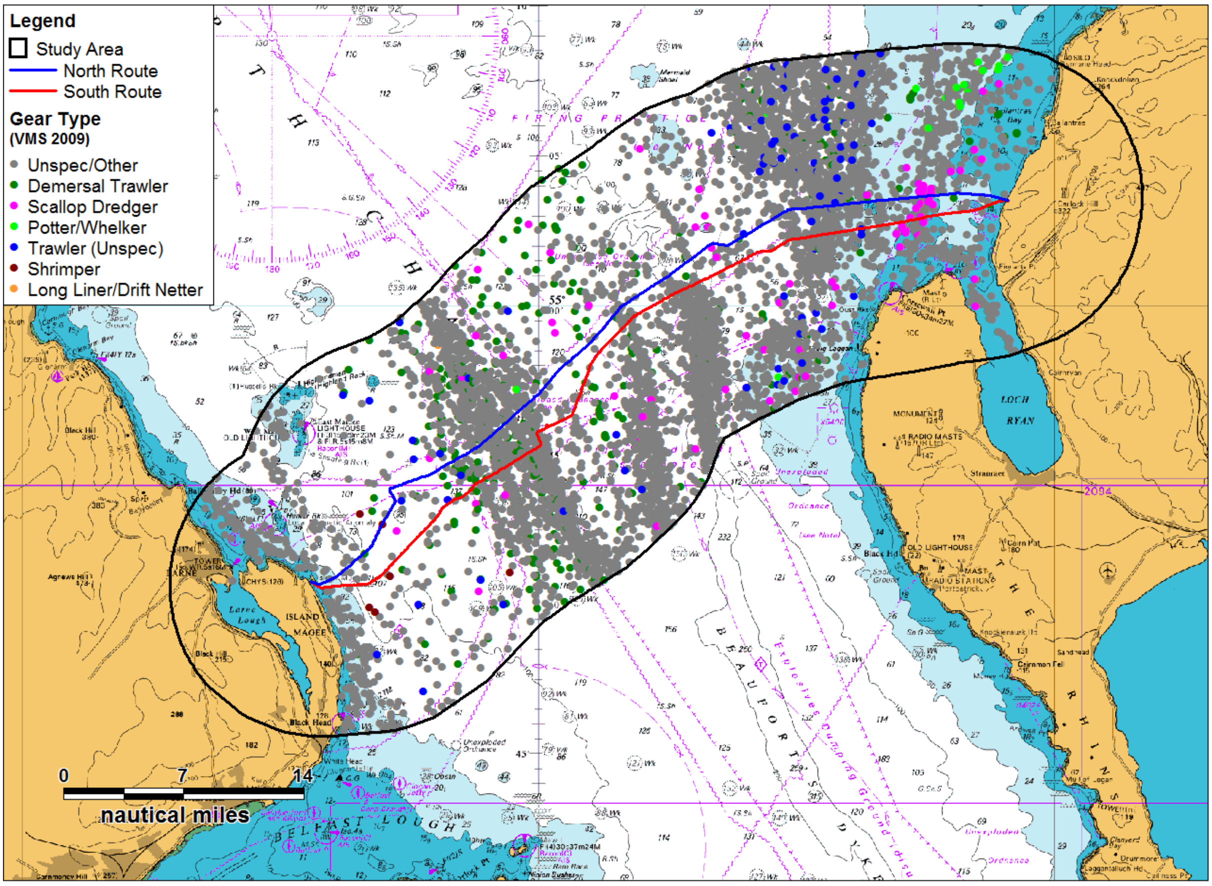


Figure 5.7 Satellite Data by Gear Type (2009)

The distribution of gear type within the satellite data (excluding 91% unspecified) is presented in Figure 5.8.

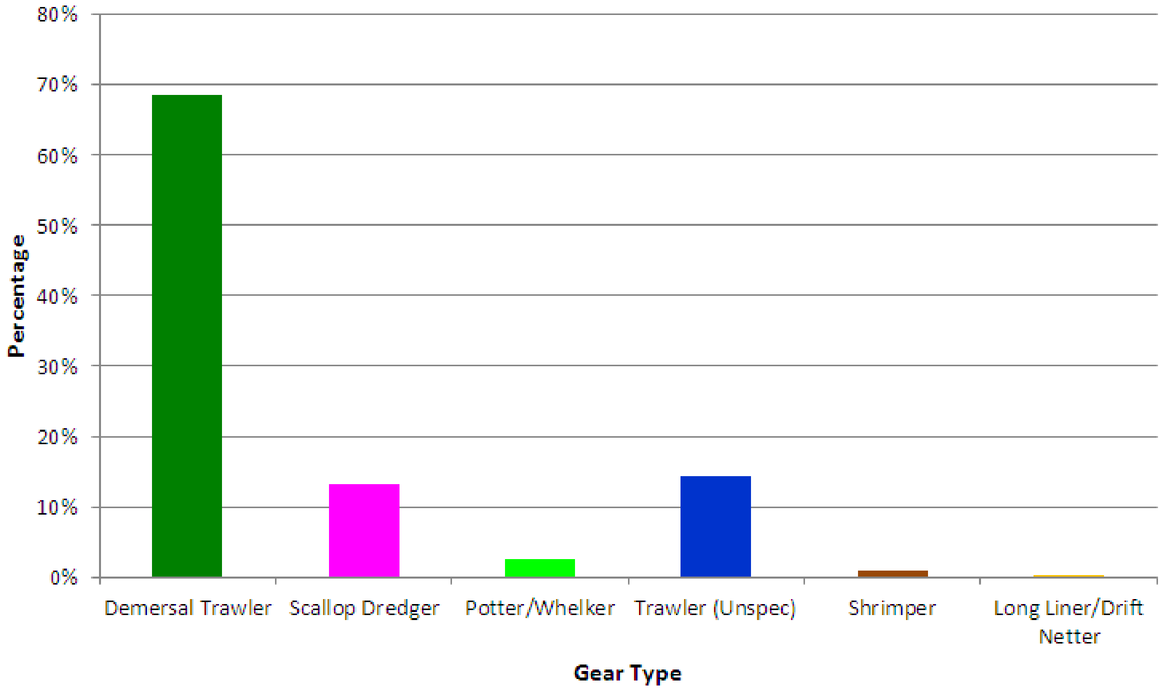


Figure 5.8 Satellite Data Gear Type Distribution (2009)

The majority of satellite positions (69%) came from demersal trawlers. Unspecified trawlers made up 14% of the positions with scallop dredgers making up 13%. There were also low numbers of positions from potters/whelkers (3%), shrimpers (1%), and long liner/drift netters (< 1%).

The satellite data, colour coded by vessel speed, is presented in Figure 5.9.

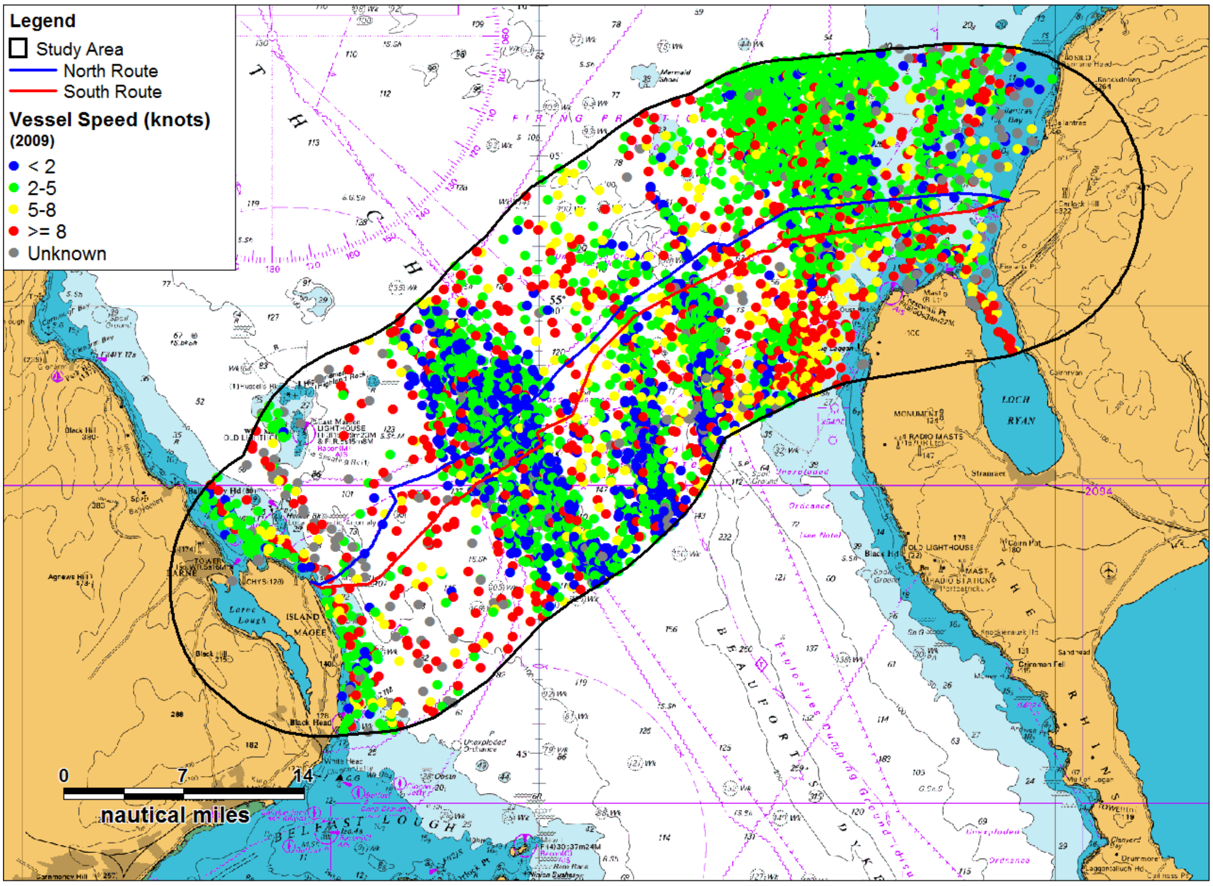


Figure 5.9 Satellite Data by Speed (2009)

In general vessels travelling at less than 5 knots are likely to be engaged in fishing, though certain gear types can be used at faster speeds. Excluding the 7% unspecified, the speed distribution is presented in Figure 5.10.

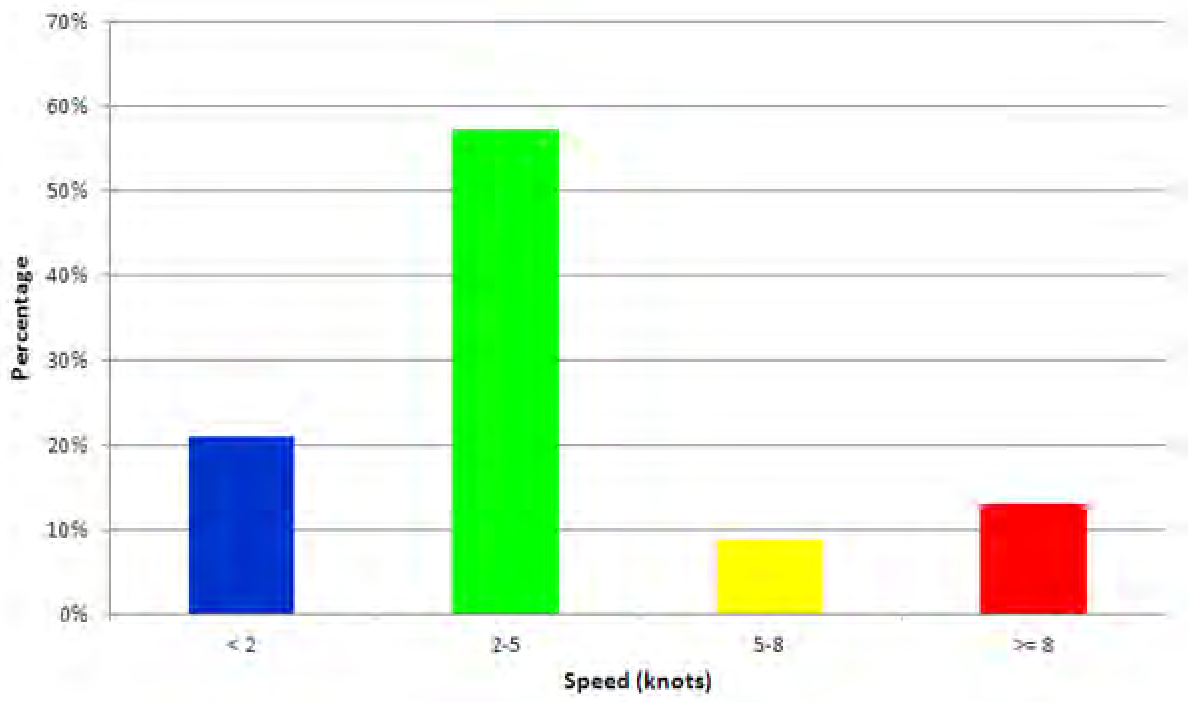


Figure 5.10 Satellite Data Speed Distribution (2009)

Overall 78% of vessel positions were recorded as travelling at less than 5 knots which suggests possible fishing activity.

5.4.2 2012 Grid Density Data

The satellite data positions presented in Section 5.4.1 were from 2009. More recent satellite data from 2012 was available in the form of a grid, where each cell was detailed with information on the amount of time spent actively fishing by vessels within its boundaries. The cells intersecting the 5nm study area are presented in Figure 5.11.

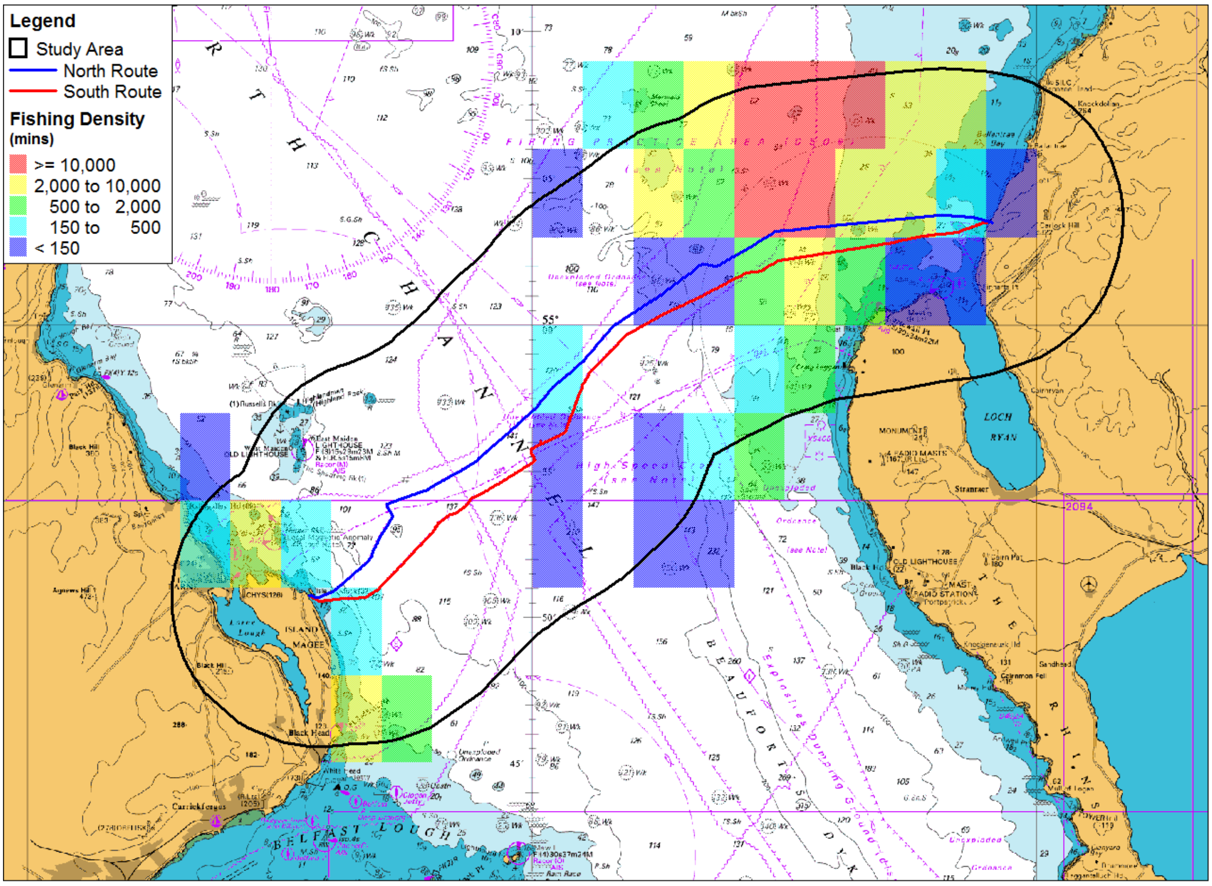


Figure 5.11 2012 Satellite Fishing Density Grid

A total of 3,168 hours of fishing occurred in the cells intersecting the study area during 2012. It is seen that the busiest area occurred where the active demersal trawling activity was seen within the AIS data (see Figure 5.1).

6. Recreation

6.1 Introduction

This section analyses the recreational vessel activity within the study area around the cable corridors. Two data sources were used; the AIS data from Section 4 and the RYA Coastal Atlas.

6.2 AIS

The recreational vessel tracks from the shipping analysis are presented in Section 4. It is noted that AIS carriage is not mandatory for recreational vessels, and it is therefore likely that recreation vessel activity is under-represented in the AIS data.

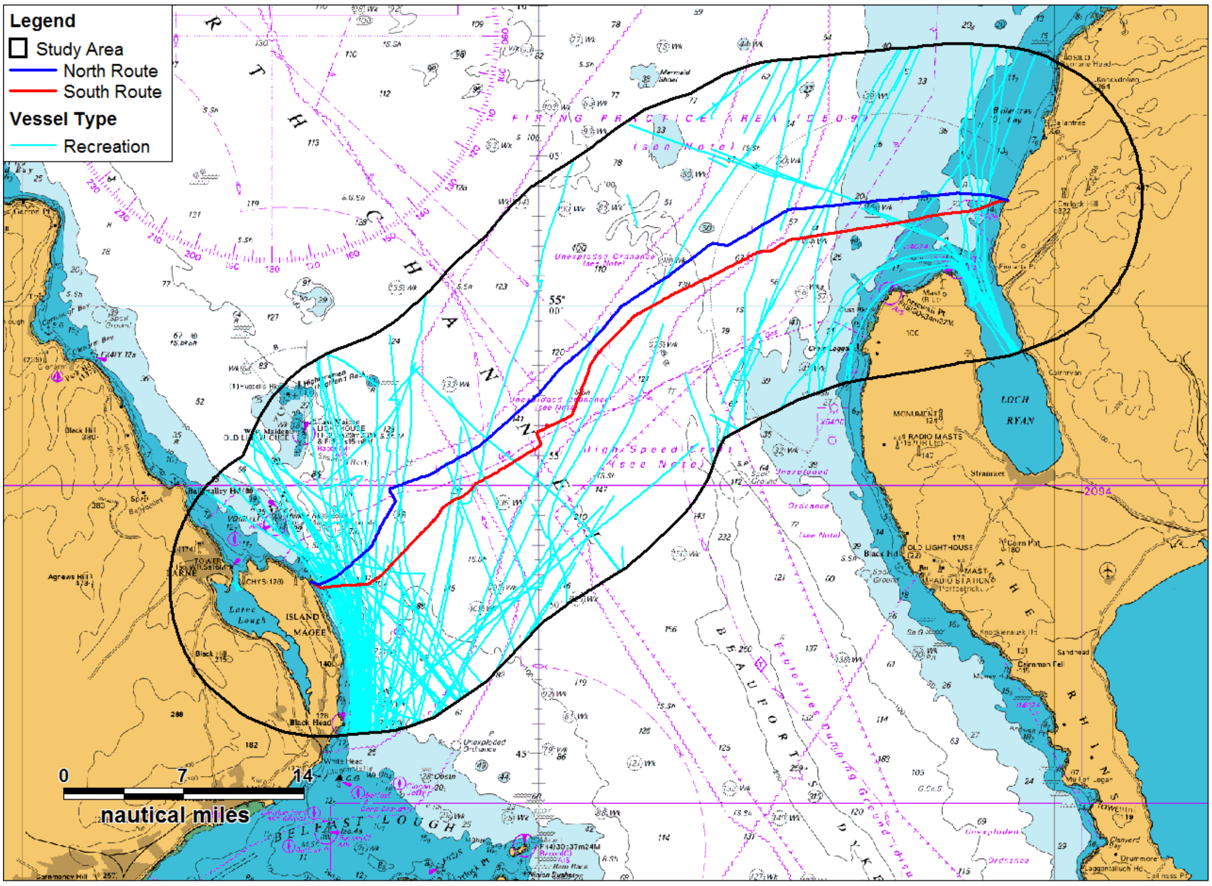


Figure 6.1 AIS Recreation Vessel Tracks

It is seen that the majority of recreational vessel activity over the cable corridors occurred near the Irish landfall point. Vessels associated with Loch Ryan were also seen in the mouth of the loch. Due to their small size, recreational vessels tend to remain close to the coast in water depths of less than 50m.

6.3 RYA Coastal Atlas

Information on recreational vessel activity in proximity to the area of interest has been obtained from the UK Coastal Atlas (Ref ii).

The Coastal Atlas presents a set of charts which define the cruising routes, general sailing and racing areas used by recreational craft around the UK coast.

Design and management of the Coastal Atlas project was conducted by the Royal Yachting Association (RYA) and supported by the Cruising Association (CA) and Trinity House. Primary data was sought from the UK Hydrographic Office, the RYA, the RYA affiliated clubs and associations, the CA Honorary Local Representatives and the RYA and CA specialist committees. Secondary sources include all relevant nautical almanacs, regional pilot books, sailing guides and similar publications.

The Coastal Atlas project developed a methodology and a set of maps that clearly:

- Plot the cruising routes used by recreational craft around the UK coast
- Indicate the intensity at which each route is used from local clubs, marinas and training centres
- Highlight the general sailing and racing areas used around the UK coast.

The Atlas notes that recreational boating, both under sail and power is highly seasonal and highly diurnal. The division of recreational craft routes into Heavy, Medium and Light Use is therefore based on the following classification:

- Heavy:- Very popular routes on which a minimum of 6 or more recreational vessels will probably be seen at all times during summer daylight hours. These also include the entrances to harbours, anchorages and places of refuge.
- Medium:- Popular routes on which some recreational craft will be seen at most times during summer daylight hours.
- Light:- Routes known to be in common use but which do not qualify for medium or heavy classification.

A plot of the RYA Coastal Atlas data in the North Channel is presented in Figure 6.2.

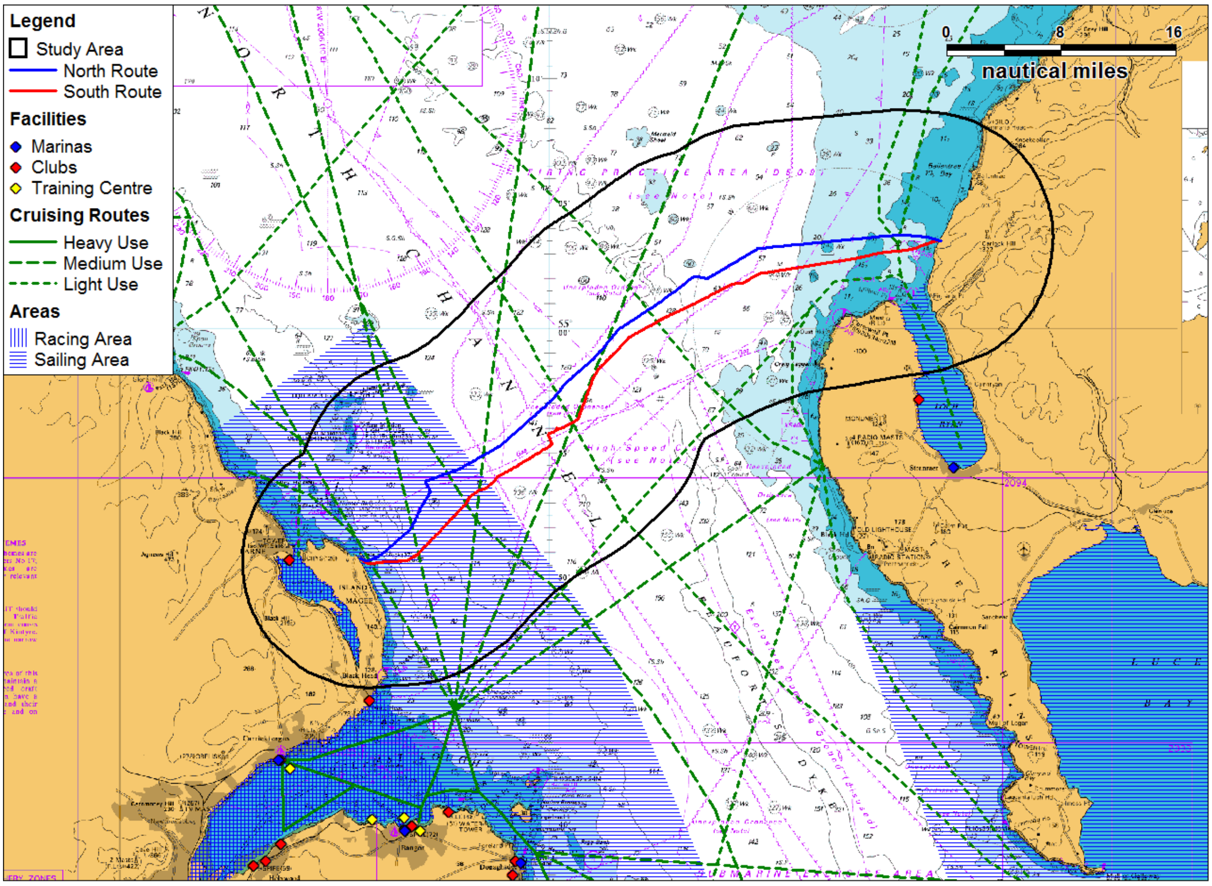


Figure 6.2 RYA Coastal Atlas

Overall, four light use and five medium use cruising routes crossed the two cable routes. A heavy use cruising route associated with Belfast passes approximately 1nm south of the study area. A sailing area extends 8nm into the study area from Islandmagee. The entirety of Loch Ryan is also a sailing area, part of which lies within the study area.

7. Historical Incident Review

7.1 Introduction

There have been a number of significant incidents involving vessels interacting with subsea equipment through anchoring and fishing. Incidents involving subsea pipelines have been included in addition to cable incidents, as these are more likely to be reported. This section presents details of these incidents

7.2 Anchoring

The following anchoring incidents have been extracted from industry research (presented in chronological order):

- **Philips-Ekofisk 1977:** On 14 March 1977, the tanker *Marion* (47,779 DWT) caught its anchor on the Philips Ekofisk pipeline when awaiting entry to Tees. On preparation for entering port, the vessel was unable to weigh anchor. It became evident that the anchor was fouled on the pipeline and the anchor plus two shackles of cable had to be slipped. Damage to the line resulted in mainly deep scratches. The chart on board the vessel had not been fully corrected and as a consequence the master was unaware of the pipeline.

- **BP Amethyst 1996**: The 47,000 tonne tanker *Kandilousa* dragged an anchor in bad weather off the Humber Estuary. The crew failed to note the charted Amethyst gas pipeline. While dragging, the windlass failed and the cable ran out to the bitter end. The anchor snagged the Amethyst pipeline, parted an ethylene feeder line and a power cable. The gas pipeline remained intact. The accident necessitated the shutdown of the supply platforms for several weeks.

- **BP Amethyst 1997**: The *Capella* (deadweight 32,936 tonnes), also dragged anchor in bad weather off the Humber Estuary. As the anchor was being recovered, the clutch disintegrated, but the cable was snubbed using the brake. The cable was observed to be leading aft, and it was assessed that the anchor had snagged on the Amethyst gas pipeline. Although the pipeline was not breached, a power cable was parted and production halted.

- **BP CATS 2007**: On 25 June 2007, the tanker *Young Lady* (105,528 DWT) dragged her anchor over the BP-operated CATS 36" concrete coated gas pipeline when awaiting entry to Teesport. The vessel was caught on the pipeline for about 10 minutes before a wide yaw caused the flukes to free themselves. A subsequent survey of the pipeline showed that *Young Lady's* anchor (approx. 9 tonnes) had lifted the pipeline out of its trench by about 1.5m, moved laterally at the point of contact by 6m and partially exposed over a length of about 170m. The concrete protection had been removed at the point of contact, and impact damage was identified on the steel pipe. Primary damage was to the concrete coating, but there was sufficient concern about the damage to the pipeline itself to require the installation of a repair sleeve to strengthen and protect the affected area of pipeline. The pipeline was shut down for approximately two months.

- **Vindö 2007 (near-miss):** This 4,516 tonnes cargo vessel suffered engine failure on 11 January 2007 near to several oil and gas fields in the southern North Sea. The vessel drifted towards gas installations in the area. The crew succeeded in reducing the vessel's speed by dropping the anchor. However, the order was given to slip its anchor as it threatened to damage gas pipelines in the area. Ultimately the vessel was taken in tow and brought to port for repair.

- **Falcon 2008:** On 1 February 2008, the Falcon telecom cable between Dubai and Oman was cut. An abandoned ships anchor weighing between 5 and 6 tonnes was found near the cable on the seabed, and was believed to be the cause of the cable cut. The vessel responsible for dropping the anchor is unknown.

7.3 Fishing

The following selection of fishing vessel snagging incidents has been extracted from Marine Accident Investigation Branch (MAIB) reports:

- **Case Number 0380/1997**: Incident involved a UK Stern trawler which capsized in high seas leaving all four in the boat dead. The vessel had a gross tonnage of 44.40 DWT and regulation length of 19.05m. The port trawl door caught on a Bruce to Forties Unity Pipeline which was operated by BP Exploration. Prior to this, the vessel was probably trawling along the pipeline. The vessel capsized as it tried to pull the trawl door free. As the boat sank, the liferafts floated free but remained attached to the vessel and were pulled down because they were badly sited and the weak links were installed incorrectly. The EPIRB signal was picked up but was attributed to another vessel previously registered with the same name. This vessel was also in the area and due to poor EPIRB registration documentation and the confusing labels; it was registered incorrectly with the EPIRB. The pipeline had free spans of up to 1.2m in height. The vessel was purchased by the skipper less than 3 months before the accident. The water depth at the location of incident is approximately 121m.

- **Case Number 1492/2006:** Incident occurred on 16th September 2006, when a UK fishing vessel reported that its gear had been fouled. The telecom company confirmed that the vessel was over an out of use cable. It was decided that the fishing vessel should slip her gear and make a claim via the fisheries office. The vessel was clear 40 minutes later.

- **Case Number 1115/2007:** This incident involved a small UK based trawler, and occurred on 28th September 2007. The trawler's gear snagged on a sub-surface cable. The vessel then waited for slack water in the hope that this would free the gear, however this did not prove successful. The gear was then buoyed and cut, and the vessel was able to return to port safely.

- **Case Number 0287/2009:** Incident occurred on the 9th March 2009. A stern trawler with four persons on board was towing its gear when in the Irish Sea when it snagged on a BT telephone cable. The skipper put the engine astern to avoid damaging the cable, then notified the coastguard, who in turn contacted the duty BT Submersible Cable representative in Southampton who confirmed ownership of the cable. BT then advised the skipper to cut and release the trawl gear and submit a compensation claim.

- **Case Number 0276/2010:** A UK based trawler snagged its gear on 6th March 2010. The skipper suspected the obstruction could be a cable that was supposed to be trenched, and notified the coastguard before jettisoning the gear. The owners of the telecommunications cables in the area were informed of the situation and told to contact the fisherman regarding retrieval of the gear and possible compensation.

8. Planned Anchoring Risk Assessment

8.1 Introduction

A dragged anchor incident occurs when the anchor of an anchored vessel fails and is subsequently dragged along the seabed. Should an anchor drag over a subsea cable it can cause damage to the cable. This section presents information on the anchoring activity of vessels recorded in the three months of AIS data and discusses the potential risk that they pose to the cables.

8.2 Anchoring Methodology

Vessels can transmit their navigation status via AIS, however they do not always do so accurately. There are therefore two steps taken to identify all anchored vessels within a data set. Firstly, all vessel tracks that transmitted their navigation status as "At Anchor" are examined to make sure their behaviour matches that of an anchored vessel. Any tracks that do not are removed. Secondly, all other tracks are used as input to Anatec's Speed Analysis program, which uses a set of predefined parameters to locate any tracks whose speed and course suggest possible anchoring activity. These tracks are then manually checked and any that can be confirmed as coming from an anchored vessel are added to the tracks from the first step.

8.3 Anchored Vessels

The three months of AIS data was examined to determine any anchored vessels. Vessels were seen to anchor frequently in Larne Lough over the three months. These vessels would be unable to interact with the cable routes as the Islandmagee peninsula lies between them and the corridors. Vessels were also seen to be anchoring outwith the study area in Belfast Lough. As these were approximately 6nm south of the south cable route it was considered extremely unlikely that they would have any interaction with either cable route.

Only one vessel was seen to be anchoring within the study area in a position that could lead to cable interaction. The passenger vessel *European Causeway* anchored approximately 2nm south of the southern cable route corridor in the mouth of Loch Ryan. The vessel's anchored tracks are presented in Figure 8.1.

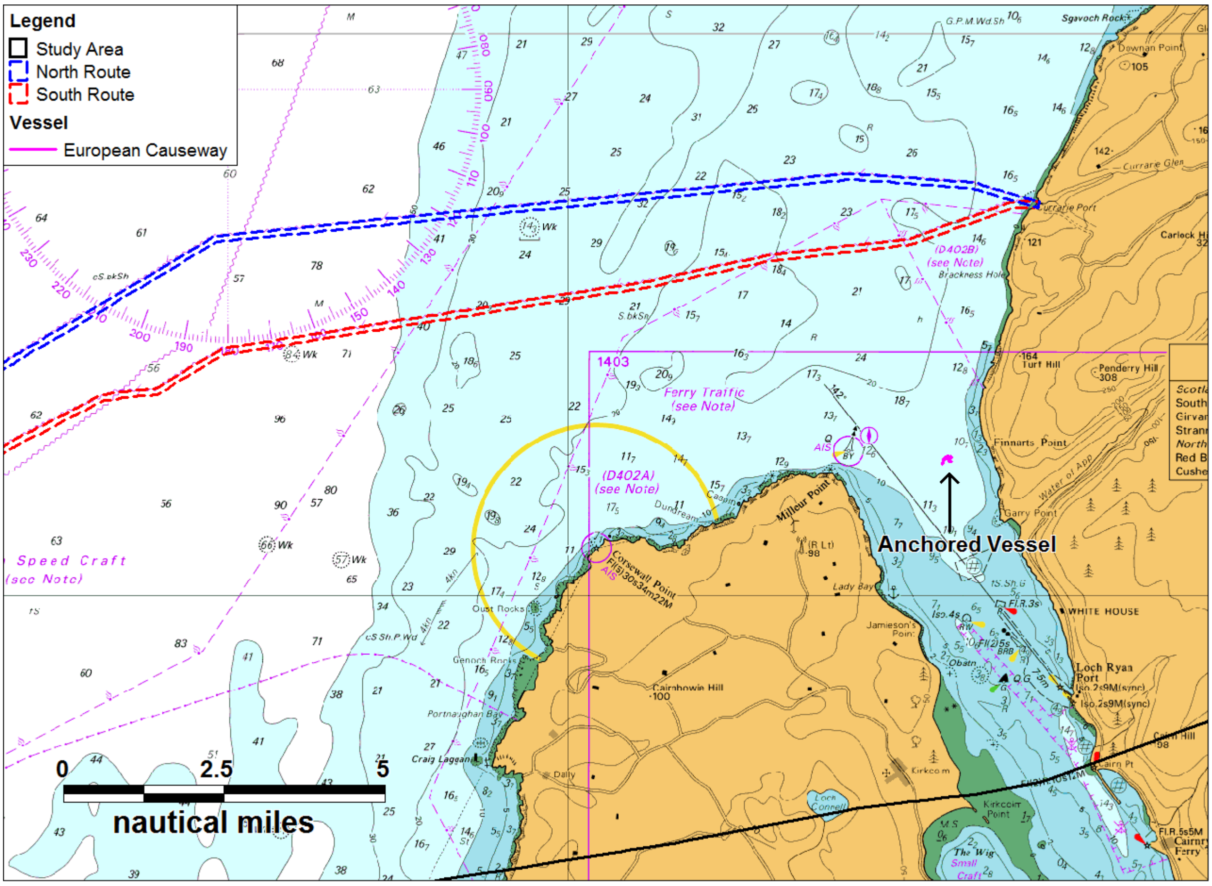


Figure 8.1 Tracks of Anchored Vessel *European Causeway*

The *European Causeway* anchored for six hours on the morning of the 19th January 2014. The vessel made daily trips between Cairnryan and Larne during the three months. It is 165m in length and has a DWT of 4,331.

The low level of anchoring activity seen within the study area is likely to be due to its location in the North Channel which is frequented by high levels of commercial shipping. It is also noted that the two existing cables are currently charted on the Admiralty charts, and this will discourage vessels from anchoring nearby.

It should be taken into consideration that vessels not carrying AIS could have anchored within the study area during the three months without being tracked, however these vessels are likely to be small and as such pose little risk to the cable.

8.4 Dragged Anchoring Risk

The risk to the marine cables from dragged anchoring is considered to be a very low frequency event, due to the very low level of anchoring seen in the study area. As a result, it is anticipated that the vast majority of the risk to the cable from vessel anchors would be due to emergency anchoring.

In the event that an anchor dragging incident does occur over the cable route, this could result in damage to the cable or, for smaller vessels in severe weather conditions, risk to the anchored vessel. The potential for damage depends on the likely penetration depths of the anchor and the burial depth of the cables. The likely penetration depths of the anchor vary according to vessel size and seabed type.

Although a snagged anchor could cause a small vessel to lose stability and capsize in severe weather conditions, the greater risk is considered to be to the cable and anchor rather than to the vessel and its crew. Vessels involved in dragged anchor incidents will usually slip anchor should a snagging incident occur and the anchor cannot be freed. The consequences of an interaction between a vessel anchor and the cable are discussed in more detail in Section 9.3.5.

9. Emergency Anchoring Risk Assessment

9.1 Introduction

Anatec's Emergency Anchoring model estimates the probability that a vessel sailing over a cable route suffers engine failure and subsequently drops anchor onto the cable. The model takes into consideration the density of vessels in the area, the probability that a vessel suffers engine failure and the probability that the vessel drops anchor in an emergency (based on water depth and distance from the shore).

9.2 Methodology

The Emergency Anchoring model combines the durations of vessels travelling near the cable route with the probability that a vessel suffers engine failure and the probability that the vessel drops anchor in an emergency (based on water depth and distance from the shore) to calculate the frequency of anchor drop due to emergency anchoring.

An overview of the emergency anchoring methodology, inputs and outputs is presented in Figure 9.1.

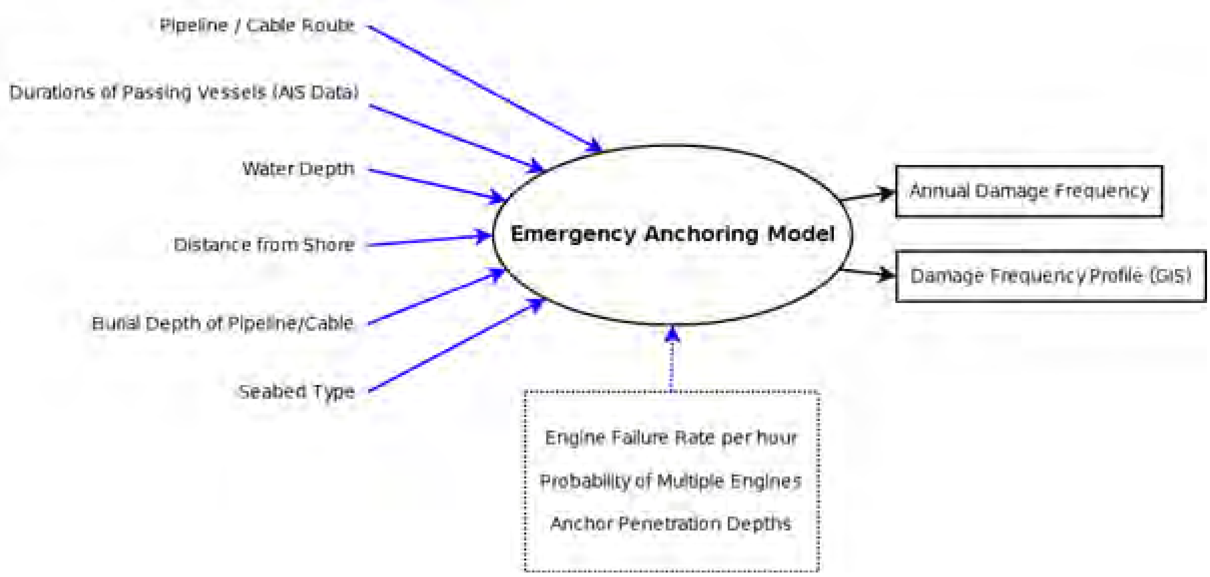


Figure 9.1 Emergency Anchoring Model Summary

9.3 *Emergency Anchoring Inputs*

9.3.1 Exposure Grid

It was considered that vessels travelling within 50m either side of the cable corridors could potentially interact with the cable by anchoring in an emergency. A 250m x 250m grid covering a 50m buffer around the cable corridors was populated with durations of vessels by type and size. The durations were then cropped to the 50m buffer and factored to an annual value.

The total annual durations of vessels within 50m of the two cable corridors is presented in Table 9.1.

Table 9.1 Annual Durations of Vessels on Routes

Route	Durations (Hours)
North	182
South	154

The durations were multiplied with the probability of engine failure taking into account the proportion of vessels with single and multiple engines, determined according to the AIS data.

9.3.2 Engine Failure Rate

The hourly engine breakdown probability is assumed to be 2×10^{-5} (Ref iii). This is combined with the likelihood that a vessel has more than one engine, based on vessel type and size, to give the probability that a vessel breaks down. The number of engines was assessed using vessel details for traffic travelling within 50m of the cable corridor, identified in the AIS data.

The frequency of emergency anchoring was then estimated by combining this information with the probability that the vessel drops anchor, based on the vessel type and size and the water depth and distance from the shore. This takes into account that, on drifting, the Master will take some time to assess the situation, including the location of any subsea structures identified on charts, and will only drop anchor if unavoidable or if unaware of the presence of the cable.

9.3.3 Water Depth

The probability that a vessel drops its anchor depends on the water depth. The probability that a vessel anchors in a particular water depth, depending on vessel size, is given in Table 9.2.

Table 9.2 Water Depth Factors

DWT	Water Depth Factor			
	< 20m	20 – 50m	50 – 100m	> 100m
0 – 1,500	1	0.5	0.1	0.01
1,500 – 5,000	1	0.6	0.25	0.05
5,000 – 15,000	1	0.75	0.4	0.1
15,000 – 40,000	1	0.9	0.5	0.25
40,000 – 60,000	1	1	0.67	0.33

9.3.4 Distance from Shore

A vessel is more likely to drop anchor in an emergency if it is closer to shore, to prevent damage from grounding. The probability of anchoring for each distance range used within the model is given in Table 9.3.

Table 9.3 Distance Factor

Distance from Shore	Distance Factor
0 – 2 nm	0.5
2 – 5 nm	0.25
5 – 10 nm	0.1
> 10 nm	0.05

9.3.5 Penetration Depths

Should a cable be buried, the probability of an anchor penetrating deep enough to make contact depends on the seabed composition the cable is buried in and the size of the anchor.

Anchor penetration depths vary depending on the type and mass of anchor. Anchor size requirements depend on regulations for the classification of ships, and broadly relate to vessel size. For small coastal vessels typical anchor masses would be 0.5-5 tonnes. However, vessels above 40,000 DWT could have anchors of 10 tonnes or more. Approximately 11% of vessel activity during the three months of AIS data was from vessels with greater than 40,000 DWT.

The anchor penetration depths used in the model were researched using a variety of sources. These are presented in Table 9.4 for 15 vessel size categories in an 'average' seabed type (e.g. medium dense sand).

Table 9.4 Anchor Penetration Depths

DWT	Anchor Penetration Depths (m)		
	Small	Medium	Large
0 - 1,500	0.8	0.8	0.9
1,500 - 5,000	0.9	1	1.1
5,00 - 15,000	1.2	1.3	1.4
15,000 - 40,000	1.5	1.6	1.7
40,000 – 60,000	1.8	1.9	2

Penetration depths also depend on the nature of the seabed (sediment type and mobility). Soft sand or mud will generally be penetrated very easily by anchors. An example anchor penetration curve is presented below.

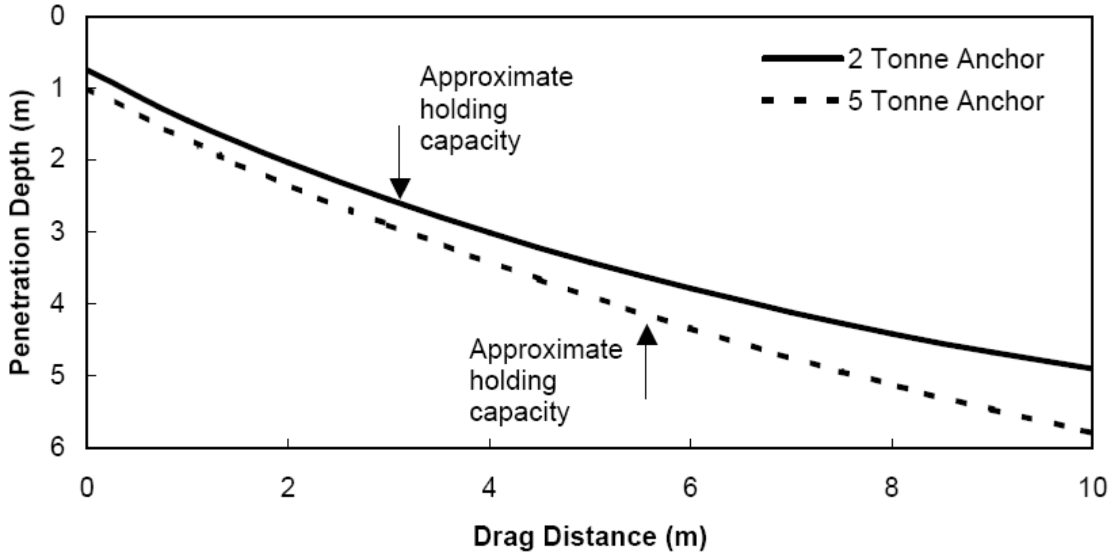


Figure 9.2 Typical Anchor Penetration Curve in Very Soft Clay

The penetration depths were therefore varied according to seabed type using the Seabed Factor, which was determined using seabed information provided by Intertek.

In addition to the risk to the cable, there is a risk to the vessel and crew in an emergency anchoring incident. Should an anchor snag on a cable, attempts to free it can result in the vessel capsizing, particularly for small vessels in bad weather. This is considered a very unlikely outcome however, as releasing an anchor is favourable to risking capsize, particularly for small vessels with easy replaceable anchors. The main risk is therefore considered to be to the cable.

9.4 *Emergency Anchoring Results*

9.4.1 Emergency Anchoring Frequency

The Emergency Anchoring Model was run using the input tables described in Section 9.3. The results are summarised in Table 9.5.

Table 9.5 Emergency Anchoring Results Summary

Route	Emergency Anchoring Frequency	Return Period (Years)
North	6.52×10^{-5}	15,347
South	6.57×10^{-5}	15,210
Total	$\mathbf{1.31 \times 10^{-4}}$	**7,639**

It is seen that the results were similar for both the north and south routes, each experiencing an estimated one emergency anchoring incident per 15,000 years. The results are plotted graphically in Figure 9.3.

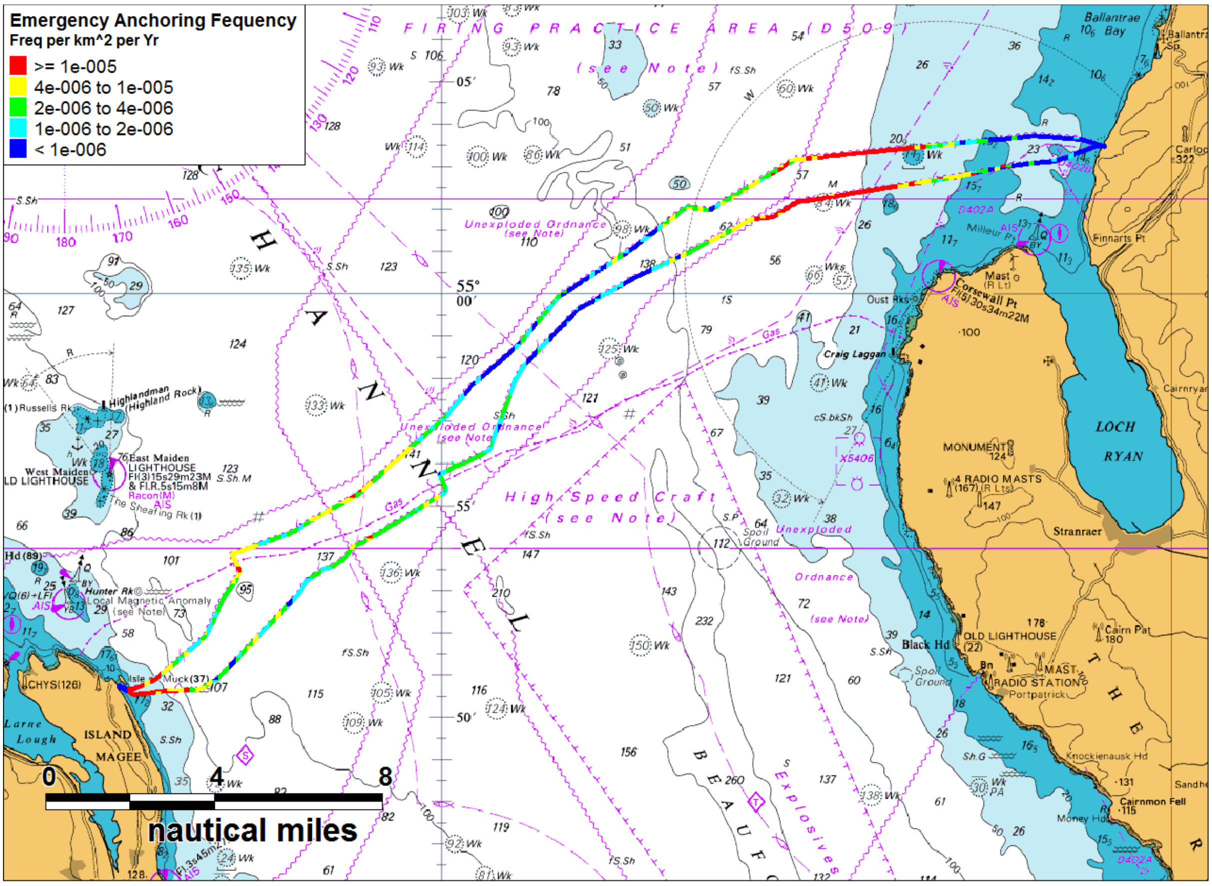


Figure 9.3 Emergency Anchoring Frequency Results

It can be seen that there is a significant area of risk to both cables northwest of Corsewall Point. This is due to a combination of high shipping durations (particularly from fishing vessels which are unlikely to have more than one engine), close proximity to land and shallower water depth. The highest shipping durations were seen in the commercial shipping routes through the North Channel but the distance to land and water depths exceeding 100m in this area led to a lower emergency anchoring risk. A high risk area is also seen near the Irish landfall point at Islandmagee.

The risk distribution by vessel size for both cable routes is presented in Table 9.6.

Table 9.6 Emergency Anchoring Risk Distribution by Vessel DWT

Route	< 1,500	1,500 – 5,000	5,000 – 15,000	15,000 – 40,000	>= 40,000
North	30%	38%	20%	4%	8%
South	31%	36%	22%	4%	6%

It is seen that the distributions were similar between the two routes with vessels between 1,500 and 5,000 DWT contributing approximately 30% of the total risk for both routes. Vessels between 1,500 and 5,000 DWT contributed 38% of the risk for the north route and 36% for the south route. The largest vessels (greater than 40,000 DWT) contributed 8% and 6% for the north and south route respectively. Larger vessels are likely to have larger anchors and are therefore capable of causing greater damage to cables.

As discussed above, an emergency anchoring incident is considered to pose more risk to the cable and anchor than to the vessel, although a snagged anchor could cause a small vessel to lose stability and capsize in severe weather conditions. In the event of a snagging, the vessel will usually slip its anchor if it cannot be freed.

9.4.2 Burial Depth Sensitivity Analysis

The proposed depth for the new cable is between 1 and 1.5m depending on seabed conditions. A sensitivity analysis was therefore performed to estimate the reduction in risk from burying the cable.

The Emergency Anchoring model was run assuming burial depths of 1m, 2m and 3m for the two cable routes. The results for the north and south routes are presented in Table 9.7 and Table 9.8 respectively. It is noted that contact refers to an anchor touching the cable route, the severity of any damage to the cable from anchor contact would depend on the type and size of the anchor and the point of contact.

Table 9.7 North Route Burial Depth Analysis Results

Burial Depth	Contact Frequency	Return Period (Years)
0m	6.52×10^{-5}	15,347
1m	3.95×10^{-5}	25,348
2m	1.03×10^{-5}	97,119
3m	3.99×10^{-6}	250,375

Table 9.8 South Route Burial Depth Analysis Results

Burial Depth	Contact Frequency	Return Period (Years)
0m	6.57×10^{-5}	15,210
1m	3.75×10^{-5}	26,700
2m	8.89×10^{-6}	109,280
3m	3.84×10^{-6}	260,326

Should the cables be buried to 1m it is estimated that anchor contact as a result of emergency anchoring would occur approximately once every 25,000 years for each route, thereby reducing the risk by approximately 41%. At 2m this fell to once every 100,000 years for each route, a reduction of 85% from the base case. At 3m, the frequency was less than once every 250,000 years for each route, a reduction of 94% from the base case.

10. Impact Review

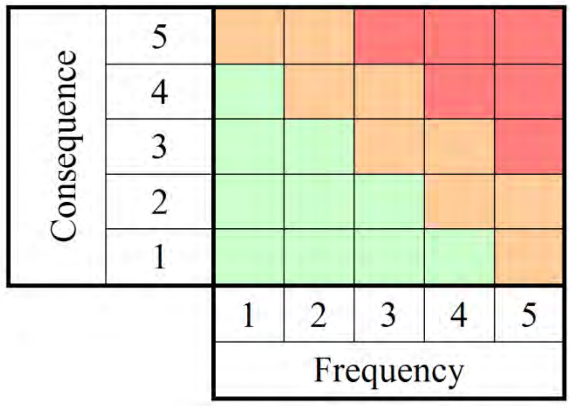
10.1 Introduction

The main hazards during cable installation and operation have been identified as follows:

- Anchor Dragging during Operational Phase: Ships that have planned to anchor in the vicinity of the cable subsequently dragging anchor over the cable.
- Emergency Anchoring during Operational Phase: Ships anchoring in an emergency due to breakdown impacting the cable.
- Ship Collision Risk with Work Vessel during Installation Phase: Ships colliding with the vessels carrying out the cable installation.
- Trawl Impact during Operational Phase: A fishing vessel using demersal (bottom) towed gear interacts with the cable.

A semi-quantitative risk ranking has been carried out using the following risk matrix.

Table 10.1 COLLRISK Risk Matrix



	Broadly Acceptable Region (Low Risk)
	Tolerable Region (Intermediate Risk)
	Unacceptable Region (High Risk)

The following definitions apply to the risk matrix.

Generally regarded as insignificant and adequately controlled. Nonetheless, the law still requires further risk reductions if it is reasonably practicable. However, at these levels the opportunity for further risk reduction is more limited.

Typical of the risks from activities which people are prepared to tolerate. There is however an expectation that these hazards are properly assessed, appropriate control measures are in place and that the residual risks are as low as is reasonably practicable (ALARP). These risks require periodic review to investigate whether further controls are appropriate.

Generally regarded as unacceptable whatever the level of benefit associated with the activity.

The following frequency and consequence definitions apply within the risk rankings.

Table 10.2 Frequency Bands

Rank	Description	Definition
1	Negligible	< 1 occurrence per 10,000 years
2	Extremely Unlikely	1 per 100 to 10,000 years
3	Remote	1 per 10 to 100 years
4	Reasonably Probable	1 per 1 to 10 years
5	Frequent	Yearly

Table 10.3 Consequence Bands

Rank	Description	Definition			
		People	Property	Environment	Business
1	Negligible	No injury	<£10k	<£10k	<10k
2	Minor	Slight injury(s)	£10k-£100k	Tier 1 Local assistance required	£10k-£100k
3	Moderate	Multiple moderate or single serious injury	£100k-£1M	Tier 2 Limited external assistance required	£100k-£1M Local publicity
4	Serious	Serious injury or single fatality	£1M-£10M	Tier 2 Regional assistance required	£1M-£10M National publicity
5	Major	More than 1 fatality	>£10M	Tier 3 National assistance required	>£10M International publicity

For risks associated with anchoring and fishing vessels, the main risks are considered to be to the property (i.e. the cable) and to crew onboard the vessels. For the ship collision risk with work vessels, the main risk is to personnel on the vessels.

10.2 Dragged Anchoring – Operational Phase

As discussed in Section 8, this hazard is that a ship routinely anchors in the vicinity of the cable but subsequently drags anchor towards and over the cable. This could result in the anchor penetrating, or snagging on, the cable.

The MAIB reported 20 incidents in United Kingdom territorial waters between 1992-2007 that involved merchant vessels of over 500 gross tonnes dragging their anchor and subsequently grounding.

Most of the incidents occurred in the vicinity of ports, and the ships involved were awaiting entry to port. This is the most common reason for a ship to anchor. In the case of the Moyle Interconnector, vessels were seen to be anchoring in Larne Lough near the ports of Larne, Ballylumford, and Magheramorne, however the cable corridors were shielded from these vessels by Islandmagee.

It is seen from Section 8 that only one vessel anchored in a position that could to lead to it dragging anchor over the cable corridors. The vessel was anchored in the mouth of Loch Ryan. For this reason the exposure of the cable corridors to anchor dragging is expected to be very low. As discussed in Sections 8.4 and 9.3.5, the likelihood of contact between the cable and the anchor depends on the penetration depth of the anchor and the burial depth of the cable. This varies according to the size of the anchor and the seabed type along the cable corridors.

If the anchor makes contact with the cable, it could inflict serious damage on the cable, particularly if the anchor belongs to a large vessel. In addition to the risk to the cable, there is a risk to the vessel and crew in a dragged anchor incident. Should a dragged anchor snag on a cable, attempts to free it can result in capsize, particularly for small vessels in bad weather. This is considered a very unlikely outcome however, as releasing an anchor is favourable to risking capsize, particularly for small vessels with easily replaceable anchors. The main risk is considered to be to the cable in a dragged anchoring incident.

The risk matrix developed for anchor dragging over the cable based on the discussion presented above is presented in Figure 10.1.

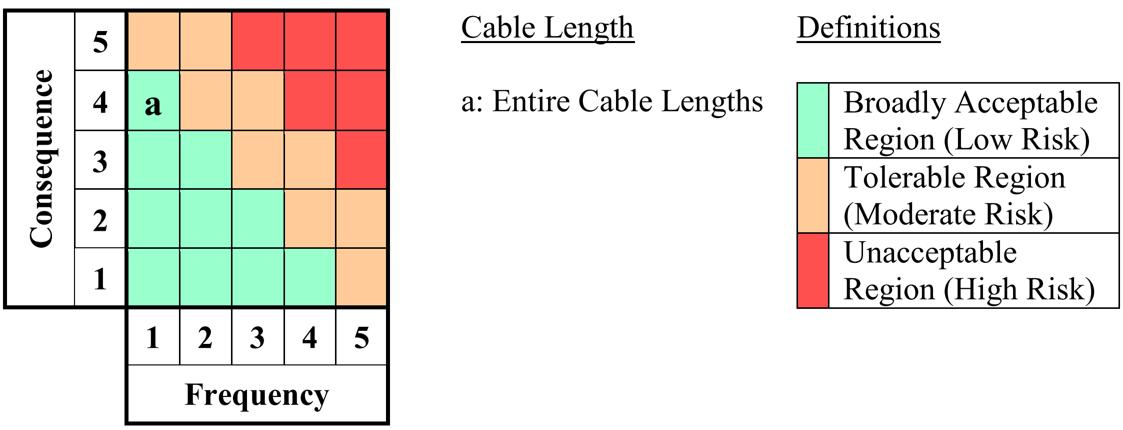


Figure 10.1 Dragged Anchoring Risk Results

The risk of dragged anchoring is considered to be **Broadly Acceptable.** Although the consequences of a dragged anchor incident can be serious due to potential damage to the cable, the frequency is negligible, due to the very low level of anchoring activity near the cables.

10.3 Emergency Anchoring – Operational Phase

This hazard is from a ship anchoring over the cable corridors in an emergency. A ship may anchor in an emergency to stop or slow down its rate of drift if it is heading towards a hazard, e.g., grounding risk or an offshore installation. The North Channel is a busy area for commercial shipping, and the cable corridors lie in an area frequented by passenger vessel routes between Scotland and Northern Ireland.

Whilst potential exists for a vessel to suffer a breakdown in the area and inadvertently drop or drag anchor over the cable corridor, mariners should be aware of cable locations and take this into account. The existing cables are clearly marked on Admiralty Charts, which alerts vessels to their presence.

From Section 9, an emergency anchoring incident was estimated to occur over the cable corridors once every 7,639 years, reducing to once every 12,987 years if the cable is buried to 1m. It was seen that the highest risk area was northwest of Corsewall Point. The majority of vessel activity in this area came from small fishing vessels, however large commercial vessels on routes between Scotland and England, and Scotland and mainland Europe were also seen. These large vessels will have large anchors, and as such have the capability to inflict severe damage to the cables in an emergency anchoring incident.

Should an anchor snag on the cable, there is a risk to the vessel and crew of capsize. As discussed in Section 10.2, capsize is more likely in small vessels and in bad weather. However, emergency anchoring in bad weather is considered a last resort, and will only be attempted if tidal currents in the area could send a vessel suffering engine failure into danger, most commonly shallow waters or land. In the vast majority of cases, a vessel unable to free itself from a snag on a cable will release the anchor rather than risk capsize. The main risk from an emergency anchoring incident is therefore considered to be to the cable.

The risk matrix developed for emergency anchoring over the cable corridors based on the discussion presented above is presented in Figure 10.2.

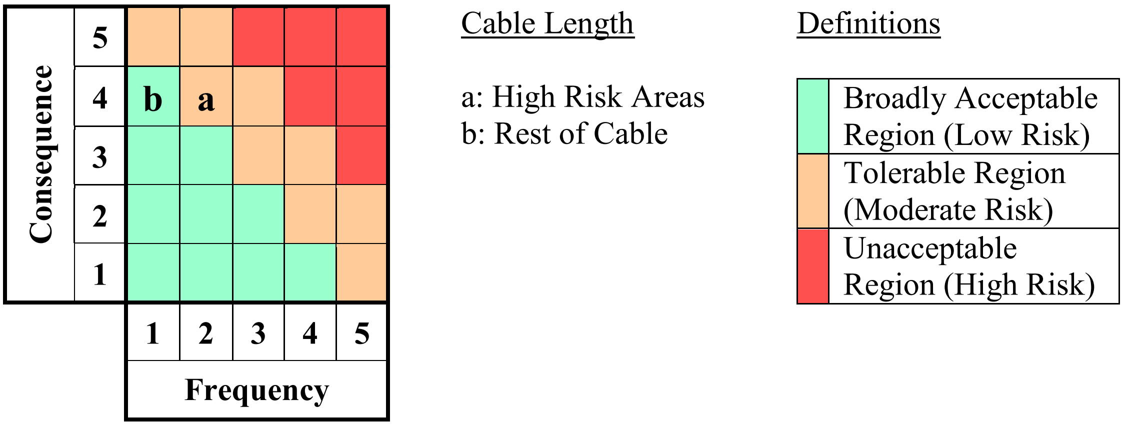


Figure 10.2 Emergency Anchoring Risk Results

The risk to the cable from emergency anchoring in the high risk areas of cable is considered to be **Tolerable.** The risk from emergency anchoring to the rest of the cable was considered to be **Broadly Acceptable.**

If the cable is buried to 1m, the frequency of anchor interaction with the cable reduces to negligible for the whole cable and the risk from emergency anchoring is **Broadly Acceptable.**

10.4 Ship Collision Risk – Installation Phase

There will be a temporary risk of ship-to-ship collision between 3rd party vessels and the vessels involved in the cable installation works.

The busiest parts of both cable corridors are the sections intersected by the passenger routes between Cairnryan and Larne, and Cairnryan and Belfast. These sections also lie in the busy commercial routes in the North Channel. These are the sections at most risk of a collision between passing vessels and the cable installation vessels.

To minimise traffic disruption, as well as the risk of collision, it is recommended to pre-warn mariners about the installation operations via Notices to Mariners, Navtex and NAVAREA warnings, liaison with ports, radio broadcasts during the operation, etc. The working vessels should have procedures regarding passage planning, holding positions (e.g., if waiting on weather), traffic monitoring (radar, AIS and visual), means of communications with 3rd party vessels and emergency response in the event of a vessel approaching on a collision course. A guard vessel could also be considered to communicate with any 3rd party vessels approaching close to the work site.

The risk matrix developed for ship collision risk during the installation phase is presented in Figure 10.3.

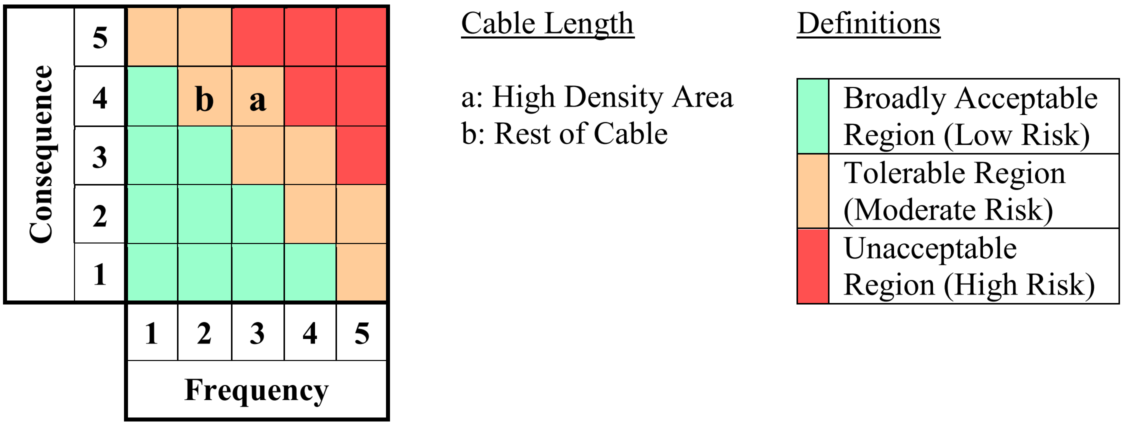


Figure 10.3 Ship Collision Risk Results

The risk of ship-to-ship collision whilst the cable is being installed is considered to be **Tolerable** for all sections of the cable corridors. It is noted that this impact is temporary.

10.5 Trawling – Operational Phase

The fishing review in Section 5 showed that the majority of fishing activity came from demersal trawlers. Demersal trawlers have the capacity to interact with subsea cables as they trawl the seabed. The consequences of interaction between fishing vessels and subsea equipment can be severe, with some historical incidents leading to capsize of the vessels and fatalities (see Section 7 for more information on historical fishing incidents). In less serious cases, damage can still be caused to the cable and to the gear. Upon consultation with the authorities and cable companies, vessels will often have to abandon their gear altogether.

The risk from fishing can be mitigated by using protection measures such as burial and trenching. Potential penetration depths for trawlers tend to be less than those of ship anchors (some studies have suggested penetration of up to 10cm in soft sediments).

In areas of sand waves, trawls may remove layers of sediment as they pass. Research has shown that in heavily fished areas, the same part of the seabed could be trawled more than once per year. This means even buried cables could become exposed in the worst case.

Historically, unlike anchor snagging incidents, a case of fishing gear snagging on a cable is considered to be a significant risk to both the cable and the vessel. There are recorded incidents of fishing vessels capsizing as they try to free their gear from a snagging. Fishing vessels are usually small, and are therefore prone to instability.

In the event of a snagging, vessels will initially try to free their gear. If this proves unsuccessful they will abandon the gear and can attempt to seek compensation from the cable operator. If a vessel suspects they are snagged on a cable, they are expected to contact the coastguard and cable operator before attempting action that might lead to damage to the cable. The safest option is always to release the gear, which vessels are being seen to be more inclined to do than in the past.

The highest area of fishing density was seen to be 5nm west of the cable's Scottish landfall point. As the activity here was from demersal trawlers, this was considered to be the area of greatest risk of a trawling incident.

The risk matrix developed for fishing vessel trawling risk is presented in Figure 10.4.

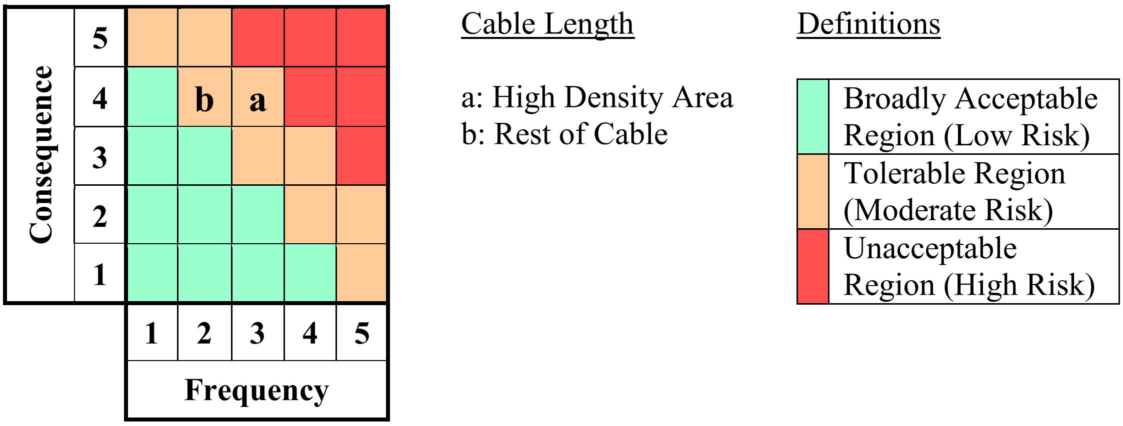


Figure 10.4 Trawling Risk Results

The risk from trawling is considered **Tolerable** for all sections of cable corridor.

However, the planned minimum burial depth of the cable is 1m, which should successfully protect the cable and the fishing vessel from a trawl gear snagging incident, due to the small penetration depths associated with fishing gear. This would reduce the frequency of trawling risk to negligible for the cable corridors, giving a **Broadly Acceptable** risk for fishing vessels.

11. Conclusions and Recommendations

11.1 Shipping Analysis

Three months of AIS data was analysed to assess the shipping activity in a study area comprising a 5nm buffer round the two cable corridors.

During summer there was an average of 30 unique vessels per day passing through the 5nm study area, with 40 vessels seen on the busiest day. The most common vessel type was cargo vessels, which made up 40% of all shipping, followed by passenger vessels with 18%. In terms of length 45% of vessels were less than 90m in length and 17% were greater than 200m.

In winter an average of 27 unique vessels per day was recorded, with 47 on the busiest day. As in summer, cargo vessels were the most common vessel type making up 45% of vessel activity, followed by fishing vessels with 19%. The length distribution was also similar to that of summer with 48% of vessels being less than 90m in length and 17% being greater than 200m.

The risk of collision between working vessels during the cable installation phase and passing traffic was considered to be **Tolerable**. It is noted that this risk is temporary.

11.2 Fishing

The fishing tracks from the three months of AIS data, sightings data from 2005 to 2009 and satellite data from 2009 was analysed to assess the fishing activity around the cable corridors. All three positional data sets agreed that the majority of fishing activity was from demersal trawlers. Demersal trawling activity was seen to occur near both cable corridors and particularly to the north of the northern cable corridor, approximately 6nm west of the Scottish coast. The satellite grid data from 2012 showed that this was the busiest area of fishing within the study area.

The risk from fishing was considered to be **Tolerable** if the cable is unburied. Assuming the planned minimum burial depth of 1m along the cables, the risk was considered **Broadly Acceptable**.

11.3 Recreation

The majority of recreational tracks from the three months of AIS data were close to the Irish Coast, though vessels were observed crossing the cable corrisors from Loch Ryan. The RYA Coastal Atlas showed that four light use cruising routes and five medium use cruising routes crossed the cable corridors, and that a sailing area extended 8nm into the study area from Islandmagee.

11.4 Anchoring Risk

Anatec's Emergency Anchoring Model was run using site specific inputs for the two cable corridors. The emergency anchoring frequency was estimated to be 6.52×10^{-5} for the north corridor and 6.57 x 10^{-5} for the south corridor. This equates to approximately one incident per 15,000 years for each corridor.

Should the cables be buried to a depth of 1m, it is estimated that there would be an approximate reduction of risk of 41%. A depth of 2m would see an estimated risk reduction of 85%, and a depth of 3m would see a reduction of 94%.

Only one vessel was seen to be anchoring within 5nm of the cable corridors over the three months of AIS data, a 165m passenger vessel with a DWT of 4,331. It anchored for six hours approximately 2nm south of the southern cable corridor. For this reason the risk of anchor dragging was considered to be negligible compared to that of emergency anchoring.

Assuming a 0m burial depth, the risk from dragged anchoring was considered to be **Broadly Acceptable,** and the risk from emergency anchoring was considered to be **Tolerable**. Assuming a minimum 1m burial depth as planned, the risk from both dragged and emergency anchoring was considered to be **Broadly Acceptable**.

11.5 Recommendations

It is recommended that the sections of cable identified in the impact review to be at high risk from vessel anchors and fishing gear be protected. The highest risk section was considered to be northwest of Corsewall Point, where significant trawling activity occurred. This was also estimated to be the area most at risk from an emergency anchoring incident. The preferred method of protection is by burying the cable, which is shown to significantly reduce the risk. It is currently planned that the cables be buried to a minimum depth of 1m. This would reduce the risk by an estimated 42%.

Alternative methods of cable protection include rock dumping or mattressing. In addition, the cables should be clearly marked on admiralty charts, which should discourage planned anchoring near the cable locations. Regular monitoring of the high risk areas of cable to check for damage is also recommended.

While the cable is being installed, it is recommended that mariners are warned in advance of the installation operations. All working vessels should have procedures in place to monitor and safely avoid passing traffic. Emergency response should be put in place in the event of a vessel approaching on a collision course.

12. References

i Admiralty Sailing Directions, 2011 – West Coast of Scotland Pilot, NP66, 17th Edition

ii UK Coastal Atlas of Recreational Boating – Recreational Cruising Routes, Sailing and Racing Areas around the UK Coast, RYA supported by CA and Trinity House, 2010.

iii "Identification of Marine Environmental High Risk Areas (MEHRA's) in the UK", Department of the Environment Transport and the Regions, 2001

A.2.10 – Intertidal Survey Report – Currarie Port

RPS

Intertek

Moyle Interconnector

Phase 1 Intertidal Survey Report - Currarie Port, South Ayrshire

Date:	*18th July 2014*
Project Ref:	*MGE0462*
Report No:	*MGE0462RP001*

Intertek

Moyle Interconnector

Phase 1 Intertidal Survey Report, Currarie Port, South Ayrshire

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File Location: O:\EOR0645 Moyle Interconnector\Reports\Intertidal Survey Report					

Table of Contents

1 Introduction

Background to the Project

1.1 The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland through submarine cables running between converter stations at Ballycronan More in Islandmagee, County Antrim and Auchencrosh in Ayrshire.

1.2 RPS was commissioned by Intertek to undertake a Phase 1 intertidal habitat survey at the landfall site at Currarie Port, South Ayrshire, southwest Scotland, where the cable comes ashore for connection at the Auchencrosh connector station. The onshore cable route is illustrated in Plate 1.1.

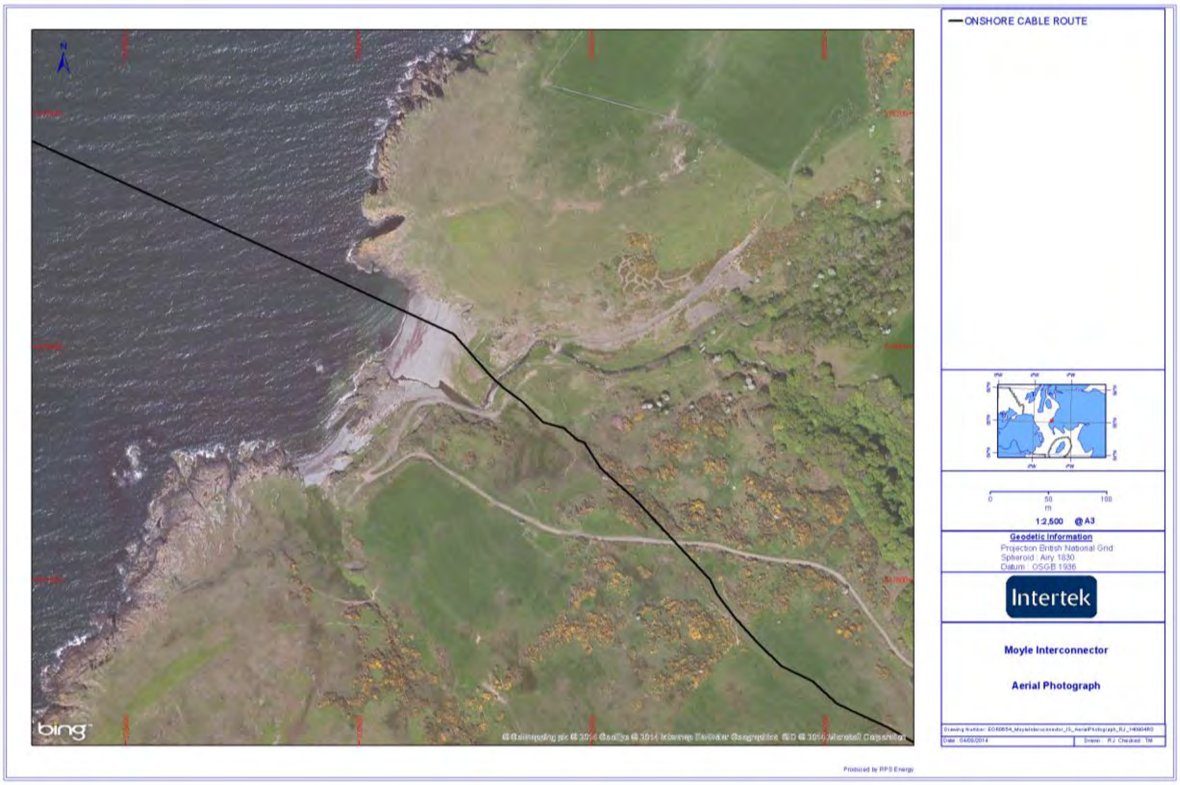

Plate 1.1: Location of the nearshore cable route and at Currarie Port, South Ayrshire.

1.3 This report presents the findings of the Phase 1 intertidal survey at the landfall site in order to characterise the intertidal baseline of the area that may be potentially affected by the installation of replacement cables.

2 Methodology

Survey Area

2.1 The area surveyed encompassed the cable route and the area within a minimum of 25 m either side of the cable route corridor. The survey area was extended to cover the area of the bay bounded by the edge of the rocky platform to the south and the vertical cliffs to the north.

Intertidal Phase 1 Survey

2.2 A Phase 1 intertidal walkover survey of the survey area between the mean low water spring (MLWS) tide and mean high water spring (MHWS) tide marks was undertaken on 17th June 2014 by RPS. The objective of the survey was to describe and map habitat and species complexes (known as biotopes) within the survey area.

2.3 The survey was conducted by a suitably qualified marine ecologist and followed guidance set out in the Joint Nature Conservation Committee (JNCC) Marine Monitoring Handbook (Davies *et al*., 2001), i.e. Procedural Guideline No. 3-1 In situ intertidal biotope recording, and in the Handbook for Marine Intertidal Phase 1 Biotope Mapping Survey (Wyn *et al*., 2006).

2.4 The survey was timed to coincide with spring tides and was conducted over a four hour period from low tide to ensure that as much of the intertidal zone as possible was surveyed. The survey was also undertaken during the optimal survey period for intertidal biotope mapping surveys of April to October (Wyn *et al*., 2006) to allow for macroalgal spring growth.

2.5 During the survey, notes were made on the shore type, wave exposure, sediments/substrates present, descriptions of species/biotopes present and the spatial relationships between these. All biotopes present were identified and their extents mapped with the aid of aerial photography and using a hand held GPS GARMIN recorder. Photographs were taken of each biotope present to provide a record of the survey. Biotopes were classified according to the JNCC Marine Habitat Classification for Britain and Ireland (v04.05) (Connor *et al*., 2004).

Survey Limitations

2.6 A Phase 1 habitat survey does not provide a full list of flora and fauna present at a site, but enables an experienced ecologist to attain sufficient understanding in order to broadly identify the habitat complexes present and the conservation value of the site to be determined. This information is used to confirm whether additional, more detailed surveys may be required.

2.7 The survey undertaken is a snapshot of the species present at that time and does not account for any seasonality where different species may be present at different times of the year. However, it is expected that most of the characteristic flora and fauna would be present during the survey in June.

2.8 Due to the nature of the substrate present (cobbles/boulders), on-site sediment sampling and analysis (i.e. digover samples) were not taken at this location.

3 Results

Site Overview

3.1 The site is situated at an exposed to moderately exposed location on the west coast of the peninsula, and the survey area was characterised by cobbles and boulders within the bay and bounded by a large rocky platform to the south and a vertical rock face to the north (Plate 3.1). There was a relatively steep incline from the adjacent farmland down into the bay and the profile of the intertidal area was marked by a notable gradient from MHWS to MLWS.

3.2 Along the southern edge of the survey area, a freshwater burn was recorded creating conditions of variable salinity and, therefore, influencing the species present in the lower shore within the zone of freshwater influx. A rocky platform extended south of this burn and dominated most of the coastline within visual range beyond this point (Plate 3.1). To the north of the survey area, rocky substrate was also dominant, but characterised by steeper cliffs dropping into the sea.

3.3 Above MHWS within the survey area, the beach levelled out to a grassy platform beyond which the burn cut through and then the land rose up relatively steeply onto grazed farmland (Plate 3.2).

Plate 3.1: Photographs showing an overview of the survey area and the rocky platform and cliffs either side of the beach.

Plate 3.2: Photograph showing burn running along the southern edge of the survey area and terrestrial habitat beyond MHWS.

Biotopes

3.4 A total of eight biotopes were identified during the Phase 1 intertidal survey (Table 3.1). The lower eulittoral zone (lower shore close to the subtidal zone) was characterised by cobbles and boulders of various sizes and a variety of brown, red and green algae were attached to the substrate. This zone is likely to be covered by seawater most of the time and exposed at low tide only during spring tides. Further up the eulittoral zone, there was a transition from cobbles and boulders dominated by the green algae *Enteromorpha* species, to species poor sandy gravel which then graded into similarly species poor cobbles and larger boulders in the upper part of the eulittoral zone. The biotopes present are shown in Figure 3.1 and described in detail in the following sections.

Table 3.1 Biotopes present in the study area (based on Connor *et al.* (2004)).

Biotope Code	Biotope Description
IR.MIR.KR.LhypT	*Laminaria hyperborea* on tide-swept, infralittoral rock
IR.MIR.KT.XKTX	Mixed kelp and red seaweeds on infralittoral boulders, cobbles and gravel in tidal rapids
LR.FLR.Eph.Ent	*Enteromorpha* spp. on freshwater influenced and/or unstable upper eulittoral rock (both variants present)
LR.MLR.BF.FspiB	*Fucus spiralis* on exposed to moderately exposed upper eulittoral rock
LR.FLR.Rkp.G	Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools
LR.HLR.MusB.Sem	*Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock
LS.LSa.MoSa.BarSa	Barren littoral coarse sediment
LS.LCS.Sh.BarSh	Barren littoral shingle

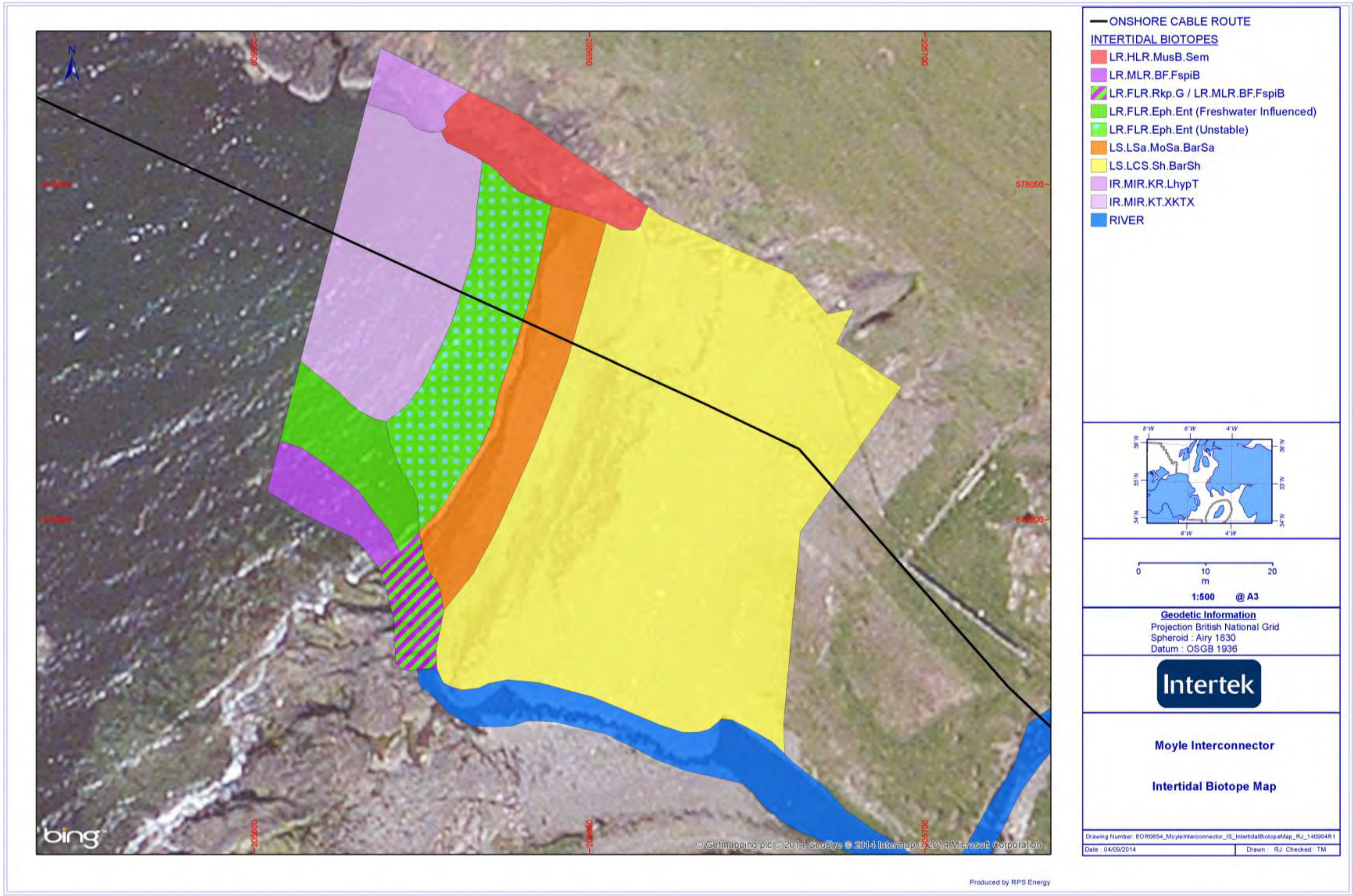

Figure 3.1 Intertidal biotopes present at the Kilantringan landfall survey area.

IR.MIR.KR.LhypT

3.5 The bedrock located to the north of the survey area was dominated by kelp *Laminaria hyperborea* with a rich understory of foliose red and brown seaweed typical of the IR.MIR.KR.LhypTL (*Laminaria hyperborea* on tide-swept, infralittoral rock) biotope (Figure 3.1). Towards the lower shore, this biotope was dominated by *L. hyperborea* whilst slightly further up the shore there was frequent sugar kelp *L. saccharina*. The bedrock was covered by high abundances of the barnacle *Semibalanus balanoides* and limpets *Patella vulgata*. Green seaweeds, including sea lettuce *Ulva lactuca* and *Enteromorpha* species were also recorded attached to the lower rock face (Plate 3.3).

Plate 3.3. Kelp *Laminaria hyperborea* dominated biotope IR.MIR.KR.LhypT in the lower shore.

IR.MIR.KT.XKTX

3.6 Within the bay, the lowermost part of the shore was dominated by the IR.MIR.KT.XKTX (Mixed kelp and red seaweeds on infralittoral boulders, cobbles and gravel in tidal rapids) biotope (Figure 3.1). This biotope was characterised by a mixed substrate of boulders, cobbles and gravel supporting communities of mixed seaweed species including sugar kelp *L. saccharina*, sea lettuce *U. lactuca*, *Enteromorpha* spp. (e.g. *E. linza* and *E. intestinalis*), the green tufted seaweed *Cladophora rupestris*, a brown tubular seaweed *Scytosiphon lomentaria,* dabberdocks *Alaria esculenta* and red seaweeds including false Irish moss *Mastocarpus stellatus,* purple laver *Porphyra umbilicalis*, carrageen *Chondrus crispus* and *Ceramium rubrum* present (Plate 3.4). Due to the unstable nature of the substrate in this part of the shore, kelp was not present in dense canopies, as is typical of stable tide-swept substrate. This biotope is representative of moderately exposed conditions that have strong tidal streams but may be relatively sheltered from wave exposure.

Plate 3.4. Mixed kelp and red seaweed communities of the IR.MIR.KT.XKTX biotope in the lower shore.

LR.FLR.Eph.Ent (freshwater influenced)

3.7 In the southwest corner of the survey area, in the lower shore region, the communities were influenced by freshwater running into the sea from the burn. As a result, the seaweed assemblage associated with the small boulder and cobble substrate in this area was dominated by sea lettuce *U. lactuca* and *Enteromorpha* spp. (Plate 3.5); no other floral or faunal species were noted here. Therefore, this community was assigned a 'freshwater influenced' variant of the LR.FLR.Eph.Ent biotope (*Enteromorpha* spp. on freshwater influenced and/or unstable upper eulittoral rock) which, although typically characteristic of the upper eulittoral zone or littoral fringe, was present in the lower eulittoral at this location, possibly due to the ingress of the burn into the lower eulittoral zone (Figure 3.1).

Plate 3.5. Small boulders and cobbles with ephemeral green algae associated with the LR.FLR.Eph.Ent (freshwater influenced) biotope.

LR.FLR.Eph.Ent (unstable substrate)

3.8 An 'unstable' variant of the LR.FLR.Eph.Ent biotope was recorded throughout much of the lower shore, adjacent to the IR.MIR.KT.XKTX biotope in the area where the hard substratum was relatively unstable and generally species poor (Figure 3.1). Characterising species were similar to those for the freshwater influenced variant with ephemeral green seaweeds on the lower shore and barnacles and limpets occasional towards the mid eulittoral zone (Plate 3.6).

Plate 3.6. Small boulders and cobbles with ephemeral green algae associated with the LR.FLR.Eph.Ent (unstable substrate) biotope in the lower shore.

LR.MLR.BF.FspiB

3.9 Along the southern edge of the survey area, a rocky platform in the lower shore extended due south from the bay. The small part of the platform included within the survey extent was characteristic of the LR.MLR.BF.FspiB (*Fucus spiralis* on exposed to moderately exposed upper eulittoral rock) biotope (Figure 3.1). The substrate comprised moderately exposed eulittoral bedrock with the characteristic spiral wrack *Fucus spiralis* abundant in some areas, however, due to the freshwater influence the green seaweeds *Enteromorpha* spp., *U. lactuca*, and *C. rupestris* were also abundant adjacent to the burn (Plate 3.7). *Ceramium* spp. and *P. umbilicalis* were also present occasionally. Underneath the fronds of spiral wrack the fauna frequently recorded included the barnacles *S. balanoides* and the limpet *P. vulgata*.

Plate 3.7. Ephemeral green algae in the zone of freshwater influx along the burn within the LR.MLR.BF.FspiB biotope.

LR.FLR.Rkp.G

3.10 Small rockpools, subject to fluctuating temperatures and variable salinity, dotted the bedrock associated with the rocky platform in the southwest part of the survey area and were assigned the LR.FLR.Rkp.G (Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools) biotope. Similar species were recorded in this biotope as were present within the LR.MLR.BF.FspiB biotope with ephemeral algae of the genus *Enteromorpha* dominant, along with *U. lactuca* and *C. rupestris*. *F. spiralis* was also present on the fringes of the rockpools (Plate 3.8). Fauna present included the barnacle *S. balanoides* and the limpet *P. vulgata*. Therefore, a mosaic biotope of LR.MLR.BF.FspiB and LR.FLR.Rkp.G was recorded in this area (i.e. mid shore) along the southern boundary of the survey area (Figure 3.1).

Plate 3.8. Small rockpool with ephemeral green algae and *Fucus spiralis* within the LR.MLR.BF.FspiB / LR.FLR.Rkp.G mosaic biotope.

LR.HLR.MusB.Sem

3.11 Along the northern boundary of the survey area, the substrate comprised moderately exposed bedrock in the mid to upper eulittoral zone characterised by the LR.HLR.MusB.Sem (*Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock) biotope (Figure 3.1). The barnacle *S. balanoides* was abundant and the limpet *P. vulgata* was also common on this substrate. Seaweeds were generally absent from this biotope although lower down in the rock face, small pools of ephemeral green seaweeds, such as *Enteromorpha* spp. were present (Plate 3.9).

Plate 3.9 Barnacles, limpets and ephemeral green algae in the LR.HLR.MusB.Sem biotope.

LS.LSa.MoSa.BarSa

3.12 A species poor habitat characterised by sandy gravel and cobbles and typical of the LS.LSa.MoSa.BarSa (Barren littoral coarse sediment) biotope, was found as a thin strip through the mid eulittoral zone (Figure 3.1). Due to the continual mobility of the sediments here and the steep profile, macrofaunal communities were generally absent in this biotope (Plate 3.10).

Plate 3.10 Sandy gravels and cobbles of the LS.LSa.MoSa.BarSa biotope.

LS.LCS.Sh.BarSh

3.13 The upper shore was dominated by a substrate comprising large cobbles and boulders with a steep gradient up to MHWS. No characterising species of flora or fauna were present and, as such, the LS.LCS.Sh.BarSh (Barren littoral shingle) biotope was assigned to this habitat (Figure 3.1); this biotope is characteristic of exposed/moderately exposed coastlines. This biotope and the LS.LSa.MoSa.BarSa biotope were distinguished based on the larger size of the sediment particles present within the LS.LCS.Sh.BarSh biotope (Plate 3.11).

Plate 3.11 Sparse cobbles and pebbles of the LS.LCS.Sh.BarSh biotope.

4 Summary

4.1 A Phase 1 habitat survey was carried out on 17th June 2014 during a spring tide. The survey area was generally characterised by cobbles and boulders with an abundant macrophyte community on the lower shore, and generally species poor communities present in the mid to upper eulittoral zone due to the mobility of the substrate and steep profile of the beach.

4.2 A freshwater burn entered the sea to the south of the bay and a rocky platform extended beyond this point.

4.3 The species present here were found to be typical of the biotopes identified and common around the coast of the British Isles.

5 References

Connor, D. W., Allen, J. H., Golding, N., Howell, K. L., Lieberknecht, L. M., Nothern, K. O. and Reker, J. B. (2004). The Marine Habitat Classification for Britain and Ireland Version 04.05. Joint Nature Conservation Committee.

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Joint Nature Conservation Committee (JNCC) (2010). The Handbook for Phase 1 habitat survey. Joint Nature Conservation Committee.

A.2.11 – Intertidal Survey Report – Portmuck South

RPS

Intertek

Moyle Interconnector

Phase 1 Intertidal Survey Report - Portmuck South, Islandmagee

Date:	*14July 2014*
Project Ref:	*MGE0462*
Report No:	*MGE0462RP002F01*

Intertek

Moyle Interconnector

Phase 1 Intertidal Survey Report - Portmuck South, Islandmagee

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RPS

PROJECT REF: MGe0462RP002F01		REPORT NUMBER: EOR0654-R-01	REPORT TITLE: Intertidal Survey Report		
DATE	VERSION	DESCRIPTION	PREPARED	CHECKED	APPROVED
14/07/14	A01	Client Approval	DM	JM	TAH
07/09/14	F01	Final	DM	JM	JM
File Location: O:\EOR0645 Moyle Interconnector\Reports\Intertidal Survey Report					

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1 Introduction

Background to the Project

1.1 The Moyle Interconnector links the electricity grids of Northern Ireland and Scotland through submarine cables running between converter stations at Ballycronan More in Islandmagee, County Antrim and Auchencrosh in Ayrshire.

1.2 RPS was commissioned by Intertek to undertake a Phase 1 intertidal habitat survey at the landfall site at Portmuck South, Islandmagee, Northern Ireland, where the cable comes ashore for connection The onshore cable route is illustrated in Plate 1.1.

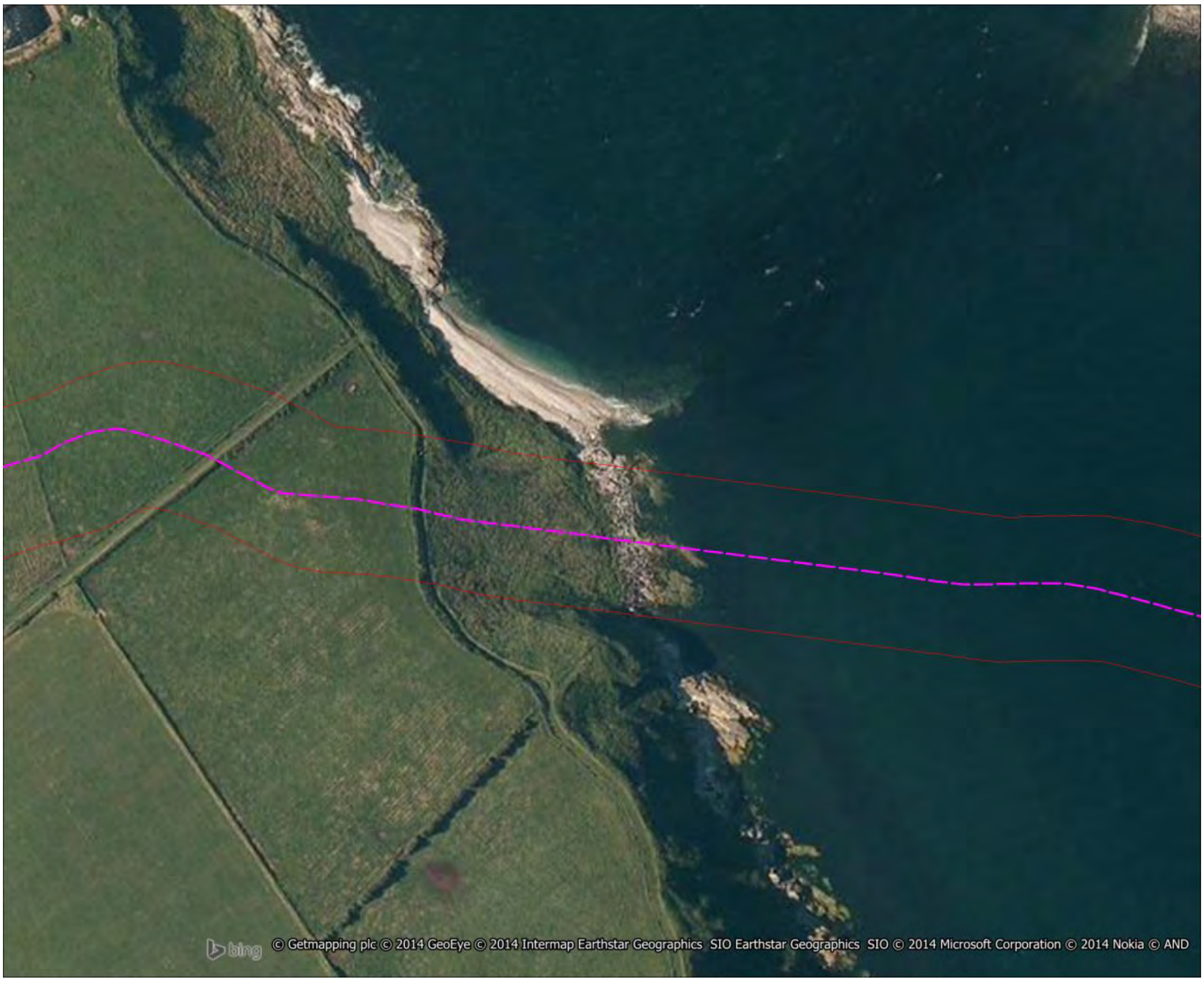

Plate 1.1: Location of the onshore nearshore cable route and the and landfall at Portmuck South, Islandmagee.

1.3 This report presents the findings of the Phase 1 intertidal survey at the landfall site in order to characterise the intertidal baseline of the area that may be potentially affected the installation of replacement cables.

2 Methodology

Survey Area

2.1 The area surveyed encompassed the cable route and the area within a minimum of 25 m either side of the cable route corridor (Plate 2.1). In addition notes of the surrounding area were recorded.

Plate 2.1: Location of the survey area.

Intertidal Phase 1 Survey

2.2 A Phase 1 intertidal walkover survey of the survey area between the mean low water spring (MLWS) tide and mean high water spring (MHWS) tide marks was undertaken on 2nd July 2014 by RPS. The objective of the survey was to describe and map habitat and species complexes (known as biotopes) within the survey area.

2.3 The survey was conducted by a suitably qualified ecologist and followed guidance set out in the Joint Nature Conservation Committee (JNCC) Marine Monitoring Handbook (Davies *et al*., 2001), i.e. Procedural Guideline No. 3-1 In situ intertidal biotope recording, and in the Handbook for Marine Intertidal Phase 1 Biotope Mapping Survey (Wyn *et al*., 2006).

2.4 The survey was timed to coincide with spring tides and was conducted over a four hour period from low tide to ensure that as much of the intertidal zone as possible was surveyed. The survey was also undertaken during the optimal survey period for intertidal biotope mapping surveys of April to October (Wyn *et al*., 2006) to allow for macroalgal spring growth.

2.5 During the survey, notes were made on the shore type, wave exposure, sediments/substrates present, descriptions of species/biotopes present and the spatial relationships between these. All biotopes present were identified and their extents mapped with the aid of aerial photography and using a hand held GPS GARMIN recorder. Photographs were taken of each biotope present to provide a record of the survey. Biotopes were classified according to the JNCC Marine Habitat Classification for Britain and Ireland (v04.05) (Connor *et al*., 2004).

Survey Limitations

2.6 A Phase 1 habitat survey does not provide a full list of flora and fauna present at a site, but enables an experienced ecologist to attain sufficient understanding in order to broadly identify the habitat complexes present and the conservation value of the site to be determined. This information is used to confirm whether additional, more detailed surveys may be required.

2.7 The survey undertaken is a snapshot of the species present at that time and does not account for any seasonality where different species may be present at different times of the year. However, it is expected that most of the characteristic flora and fauna would be present during the survey in July.

2.8 Due to the nature of the substrate present (intertidal rock and cobbles/boulders), on-site sediment sampling and analysis (i.e. digover samples) were not taken at this location.

3 Results

Site Overview

3.1 The site is situated at a moderately exposed location on the east coast of the peninsula, and the survey area was characterised by cobbles and boulders within the bay and bounded by brown and green algae covered rocks and cobbles to the north and rock to the south (Plate 3.1). There was a relatively steep incline from the adjacent farmland down into the bay and the profile of the intertidal area was marked by a notable gradient from MHWS to MLWS.

3.2 Above MHWS within the survey area, the beach levelled out to a grassy platform beyond which the land rose up relatively steeply onto grazed farmland (Plate 3.1).

Plate 3.1: Photographs showing an overview from the north of the survey area with rocky platform to the foreground and cobbles in the mid- and back-ground (left photo) and brown algae covered rock to the south.

Biotopes

3.3 A total of eight biotopes were identified during the Phase 1 intertidal survey (Table 3.1). The lower eulittoral zone (lower shore close to the subtidal zone) was characterised by cobbles and boulders of various sizes and a variety of brown, red and green algae were attached to the substrate. This zone is likely to be covered by seawater most of the time and exposed at low tide only during spring tides. Further up the eulittoral zone, there was a transition from cobbles and boulders dominated by the green algae *Enteromorpha* species, to species poor sandy gravel which then graded into similarly species poor cobbles and larger boulders in the upper part of the eulittoral zone. The biotopes present are shown in Figure 3.1 and described in detail in the following sections.

Table 3.1 Biotopes present in the study area (based on Connor *et al.* (2004)).

Biotope Code	Biotope Description
IR.MIR.KR.Ldig.Ldig	*Laminaria digitata* on moderately exposed sublittoral fringe bedrock
LR.LLR.F.FSerr	*Fucus serratus* on sheltered lower eulittoral rock (both rock and boulder variants present)
LR.FLR.Eph.Ent	*Enteromorpha* spp. on freshwater influenced and/or unstable upper eulittoral rock (both variants present)
LR.MLR.BF.FspiB	*Fucus spiralis* on exposed to moderately exposed upper eulittoral rock
LR.FLR.Rkp.G	Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools
LR.HLR.MusB.Sem	*Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock
LS.LCS.Sh.BarSh	Barren littoral shingle
LR.FLR.Lic	Lichens or small green algae on supralittoral and littoral fringe rock

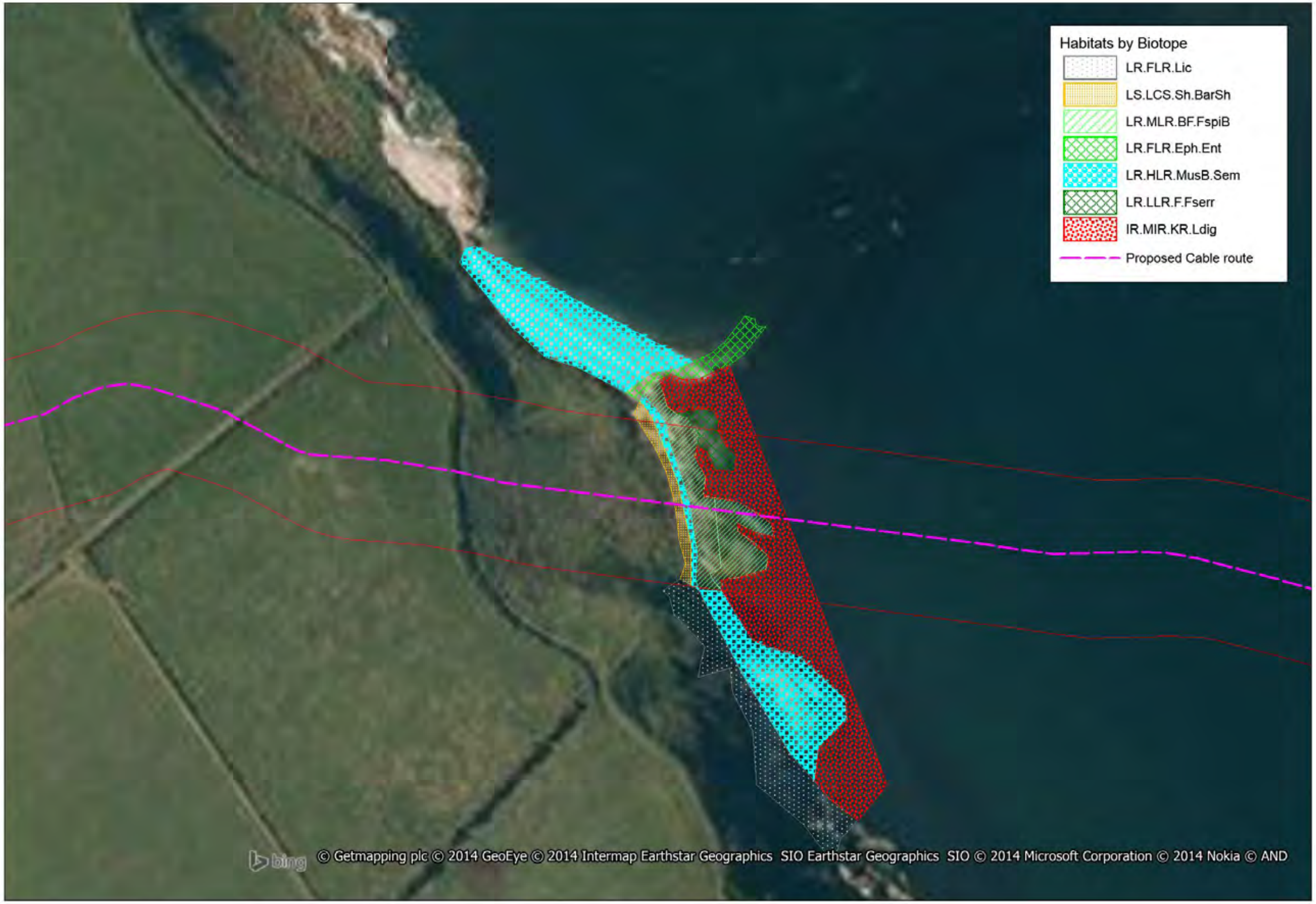

Figure 3.1 Intertidal biotopes present at the Islandmagee landfall survey area.

IR.MIR.KR.Ldig

3.4 In the lower shore, the biotope is characterised by exposed to moderately exposed sublittoral bedrock and boulders characterised by the kelp *Laminaria digitata* with coralline crusts covering the rock beneath the kelp canopy. Foliose red seaweeds such as *Palmaria palmata, , Chondrus crispus* and *Mastocarpus stellatus* were present the calcareous *Corallina officinalis*. Saw wrack, *Fucus serratus* and the green seaweeds *Cladophora rupestris* and *Ulva lactuca* were also present on the boulders and cobbles. The sponge *Halichondria panicea* was found under boulders with dog whelk *Nucella lapis*. polychaete *Pomatoceros triqueter*, and limpets *Patella vulgata.* (Figure 3.1).

3.5 In the lower midshore, especially in the middle of the survey area, *Enteromorpha* spp. (e.g. *E. linza* and *E. intestinalis*), the green tufted seaweed *Cladophora rupestris*, a thongweed *Himanthalia elongata* and *Ceramium rubrum* also occurred.. This biotope is representative of moderately exposed conditions. Whilst the channel is present the area is not thought to be subject to strong tidal streams but may be relatively sheltered from wave exposure by the island.

Plate 3.2. *Laminaria digitata* on moderately exposed sublittoral fringe bedrock and cobbles in the lower shore.

Plate 3.3. *Laminaria digitata* on moderately exposed sublittoral fringe bedrock with *Fucus serratus*.

LR.LLR.F.Fserr

3.6 Where the shoreline is sheltered by the cobble bank area, or raised patches of bedrock, these sheltered lower eulittoral rock areas are dominated by *Fucus serratus* occurring on boulders, cobbles and bedrock. The same species were recorded under the canopy as in the *Laminaria* dominated lower fringes above such as *Halichondria sp, Semibalanus balanoides, Carcinus maenas, Patella vulgate, Littorina littorea* and *Corallinaceae* . Patches of the biotope occur in any of the more sheltered areas of the shoreline, or as a complex with IR.MIR.KR.Ldig (Plate 3.3)

LR.FLR.Eph.Ent (freshwater influenced)

3.7 In patches across the lower mid shore, the communities were influenced by freshwater running into the sea in the area of lowest lying upper shore in the centre of the ebayment. As a result, the seaweed assemblage associated with the small boulder and cobble substrate in this area was dominated by sea lettuce *U. lactuca* and *Enteromorpha* spp. (Plate 3.4); no other floral or faunal species were noted here. At the fringes the boulder and cobbles had small amounts of purple laver *Porphyra umbilicalis* cover. Therefore, this community was assigned a 'freshwater influenced' variant of the LR.FLR.Eph.Ent biotope (*Enteromorpha* spp. on freshwater influenced and/or unstable upper eulittoral rock) which, although typically characteristic of the upper eulittoral zone or littoral fringe, was present in the lower eulittoral at this location, possibly due to the ingress of the freshwater from the much lower lying upper shore areas than the surrounding coastline into the lower eulittoral zone (Figure 3.1).

3.8 This habitat covers areas of low lying upper shore and the edge of the cobble spur to the north. This habitat is present for much of the central corridor area. Habitat either side of this area where the upper shore is elevated and there is less run off show less freshwater influence.

Plate 3.4. Small boulders and cobbles with ephemeral green algae associated with the LR.FLR.Eph.Ent (freshwater influenced) biotope.

LR.MLR.BF.FspiB

3.9 This habitat occurs on the bedrock at the edges of the site on exposed to moderately exposed upper eulittoral bedrock characterised by a band of the spiral wrack *Fucus spiralis* overlying the black lichen *Verrucaria maura* and the olive green lichen *Verrucaria mucosa*. Underneath the fronds of *F. spiralis* is a community consisting of the limpet *Patella vulgata*, the winkles *Littorina saxatilis* and *Littorina littorea*, and the barnacle *Semibalanus balanoides.*. During the summer months ephemeral green seaweeds such as *Enteromorpha intestinalis* can be common particularily in any surface pools on the rock. As a result the intertidal rock areas of the site were a complex of LR.MLR.BF.FspiB, LR.FLR.Rkp.G and LR.HLR.MusB.Sem.

Plate 3.5. Small boulders and cobbles with ephemeral green algae associated with the LR.FLR.Eph.Ent (freshwater influenced) biotope.

Plate 3.6. Close up of ephemeral green algae associated with the LR.FLR.Eph.Ent (freshwater influenced) biotope

LR.FLR.Rkp.G

3.10 Small rockpools, subject to fluctuating temperatures and variable salinity, dotted the bedrock associated with the rocky platform in the southwest part of the survey area and were assigned the LR.FLR.Rkp.G (Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools) biotope. Similar species were recorded in this biotope as were present within the LR.MLR.BF.FspiB biotope with ephemeral algae of the genus *Enteromorpha* dominant, along with *U. lactuca* and *C. rupestris. F. spiralis* was also present on the fringes of the rockpools (Plate 3.7). Fauna present included the barnacle *S. balanoides* and the limpet *P. vulgata*. Therefore, a mosaic biotope of LR.MLR.BF.FspiB and LR.FLR.Rkp.G was recorded in this area (i.e. mid shore) along the southern boundary of the survey area (Figure 3.1).

Plate 3.7. Small rockpool with ephemeral green algae and *Fucus spiralis* within the LR.MLR.BF.FspiB / LR.FLR.Rkp.G mosaic biotope.

LR.HLR.MusB.Sem

3.11 Along the two extremes of the survey corridor where the cliffs are higher the upper mid shore includes intertidal rock characterised by the LR.HLR.MusB.Sem (*Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock) biotope (Figure 3.1). The barnacle *S. balanoides* was abundant and the limpet *P. vulgata* was also common on this substrate. Seaweeds were generally absent from this biotope although where there were shelves and pools in the rock face, ephemeral green seaweeds, such as *Enteromorpha* spp. were present (Plate 3.8).

Plate 3.8 Barnacles, limpets and ephemeral green algae in the LR.HLR.MusB.Sem biotope.

LR.FLR.Lic

3.12 Above this zone in the splash zone above the main intertidal zone (i.e. that subject to regular covering by the tide) where upper shore rock was present, there were patchy lichens present . Low density yellow and grey lichens such as *Xanthoria parietina, Caloplaca marina, Caloplaca thallincola* and occasional *Ramalina sp*. were present with patches of *Verrucaria maura* occurring below in the littoral fringe .

LS.LCS.Sh.BarSh

3.13 The upper shore was dominated by a substrate comprising large cobbles and boulders with a steep gradient up to MHWS. No characterising species of flora or fauna were present and, as such, the LS.LCS.Sh.BarSh (Barren littoral shingle) biotope was assigned to this habitat (Figure 3.1); this biotope is characteristic of exposed/moderately exposed coastlines. This biotope occurred to the north of the site. Due to the continual mobility of the gravels in the upper shore macrofaunal communities were generally absent in this biotope and they formed a band behind a low ridge of infralittoral bedrock and the terrestrial habitats. (Plate 3.9)

Plate 3.9 Sparse cobbles and pebbles of the LS.LCS.Sh.BarSh biotope.

4 Summary

4.1 A Phase 1 habitat survey was carried out on 2nd July 2014 during a spring tide. The survey area was generally characterised by cobbles and boulders with an abundant macrophyte community on the lower shore, and generally species poor communities present in the mid to upper eulittoral zone due to the mobility of the substrate and steep profile of the beach.

4.2 The species present here were found to be typical of the biotopes identified and common around the coast of the British Isles.

4.3 No specific species or habitats of outstanding conservational importance were recorded.

5 References

Connor, D. W., Allen, J. H., Golding, N., Howell, K. L., Lieberknecht, L. M., Nothern, K. O. and Reker, J. B. (2004). The Marine Habitat Classification for Britain and Ireland Version 04.05. Joint Nature Conservation Committee.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. and Vincent, M. (2001). Marine Monitoring Handbook. UK Marine SACs Project, Joint Nature Conservation Committee.

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A.2.12 – Explosive Ordnance Desktop Study

Project 14182

EOD CONTRACTS LTD

INTERNATIONAL UNEXPLODED ORDNANCE RISK MITIGATION

EXPLOSIVE ORDNANCE DESK TOP STUDY FOR MOYLE INTERCONNECTOR, NORTH AND SOUTH CABLES

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EXPLOSIVE ORDNANCE DESK TOP STUDY

of

Moyle Interconnector, North and South Cables

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PREFACE

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CONTENTS

Annexes

TERMS AND DEFINITIONS

Anti Aircraft Shells (AA)
Small HE shells ranging up to 100mm in diameter.

Battlefield Area Clearance (BAC)
The systematic clearance of munitions from military property or old battle sites e.g. ranges, airfields etc.

Borehole Search
The placing of boreholes in a set pattern, then using a magnetometer to take readings at specific depths along each borehole. When used with a geophysical survey system this will give a magnetic signature of the area. The depth of the borehole and the pattern will depend upon the type of UXB and the geology of the ground.

Doodle Bug (See Pilotless Aircraft)

Explosive Ordnance (EO)
All munitions containing **explosives**, nuclear fission or fusion materials and biological and chemical agents. This includes bombs and warheads; guided and ballistic missiles; artillery, mortar, rocket and **small arms ammunition**; all mines, torpedoes and depth charges; pyrotechnics; clusters and dispensers; cartridge and propellant actuated devices; electro-explosive devices; clandestine and improvised explosive devices; and all similar or related items or components explosive in nature.

Explosive Ordnance Clearance (EOC)
See BAC.

Explosive Ordnance Disposal (EOD)
The detection, identification, field evaluation, render safe, recovery and disposal of **UXO**.

Geophysical Survey
The survey of an area using a Magnetometer and geophysical gathering device, after interpretation, this will produce a geophysical map and an object list for any metallic hotspots.

High Explosive (HE)
High explosives burn/detonate at rates of up to 9,000 m/per second.

Incendiary Bomb (IB)
Incendiary bombs ranged from 1kg in size to 500kg the larger sizes were sometimes called Oil Bombs. Fills range from thermite mixtures, phosphorus to kerosene.

Intrusive Survey
The use of a cone pentrometer (MagCone) or drilled boreholes (MagDrill) to take magnetometer test in a set pattern (see borehole search) or to prove pile positions.

Land Service Ammunition (LSA)
LSA is defined as “All items containing explosives or pyrotechnic compounds which are placed, thrown or projected so as to cause damage to men and equipment during land warfare.

Long Range Rocket (LRR)

The long range rocket sometimes codenamed Big Ben is the V2 rocket designed to deliver an approximate payload of 1000 kg.

Oil Bomb (OB)

A bomb containing a flammable liquid normally the KC 250 Flam or the C 500 flam.

Pilot less Aircraft (PAC)

A flying bomb (Fly) or doodlebug is the V1 rocket or predecessors designed to deliver an explosive payload of approximately 500kg - 800kg.

Parachute Mine (PM)

Air dropped mine may have been used as a blast effect bomb maximum explosive content 1600lb always fitted with anti-handling and anti-stripping equipment.

Unexploded Bomb (UXB)

Any air dropped bomb that has failed to operate.

Unexploded Ordnance (UXO)

Explosive ordnance that has been primed, fused, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other cause.

Vengeance Weapons (V)

V1 see Pilot less Aircraft.
V2 see Long Range Rocket.

WWI

World War 1.

WWII

World War 2.

EXECUTIVE SUMMARY

1 **Instruction**

EOD Contracts Ltd, have been commissioned by Intertek to undertake a desktop study for potential historic Explosive Ordnance (EO) and Unexploded Ordnance (UXO) contamination along the route of the Moyle Interconnector, north and south cables.

2 **Scope Of Work**

The scope of this EO Risk Assessment/Desk Study is to identify all possible sources of UXO contamination and assess an overall level of risk that UXO may pose to the project works to permit the proposed works to be completed in the safest possible manner.

3 **Selected Marine Cable Routes**

3.1 The plan is to install two new separated LV return conductors between existing converter stations at Ballycronan More on Islandmagee, County Antrim, Northern Ireland and Auchencrosh in Ayrshire, Scotland.

3.2 The new marine cables will be installed within 100m corridors to the south of the existing Interconnector north and south cable routes.

3.3 The proposed landfall sites for the new cables will at the location of the existing landfalls at Portmuck South, Islandmagee and Currarie, Ayrshire.cccccc

Annex A shows the UXO study area.

4 **Sources of UXO Contamination**

4.1 The main sources of UXO contamination are:

4.1.1 Sea Dumping of Munitions
4.1.2 Naval Action
4.1.3 Air delivered ordnance bombs and sub-munitions/incendiaries.
4.1.4 Anti Aircraft Ammunition (AA).

5 **Key Findings**

5.1 Based on the information researched by EOD Contracts Ltd for the study area in that the cable route corridors:

5.1.1 Pass through a firing range (paragraph 4.10).

5.1.2 Pass over Beaufort Dyke Munitions dumping area paragraph 5.3, this assessment appears to indicate this is within the high target area.

5.1.3 A singular Naval vessel appears to be on southern corridor, as indicated in Annex C.

5.2 The risk level along the cable route corridors is generally **medium** and specific areas are **high**, which are shown in Annex G Risk map, given that some UXO retains the potential to detonate if disturbed with possible severe consequences, it is concluded that it would be prudent to ensure that basic precautions are taken to ensure that the project can proceed in the safest possible manner and that any residual risk posed by UXO is as low as it is reasonably practical to achieve (ALARP).

5 RECOMMENDATIONS

5.3 It is recommended that the following risk mitigation strategy is executed during the project:

5.3.1 Communicating the risks, all stakeholders should be made aware of the UXO situation on the cable route corridors and the possible impact it may have on the project works. Clients have a legal duty under the Construction Design & Management Regulations (CDM) and Health & Safety at Work legislation to provide Designers and Contractors with project specific information needed to identify hazards and risks associated with the design and construction work. The possibility that UXO may be encountered along the cable routes falls within the category of a significant risk and as such it should be addressed as early as possible in the lifecycle of the project.

5.3.2 Further Planning; the risks posed by UXO should be brought to the attention of the Project CDM/Safety Coordinators and other individuals with a responsibility for project safety and cable installation operations. The matter of UXO should be considered critical to project safety and one requiring high priority action.

5.3.3 Safety Training; UXO safety awareness training should be given at all levels of cable installation works, personnel and selected individuals on the project staff with relevant responsibilities. The training should be provided by a competent person as part of the project safety induction course. It should be reinforced with specific safety briefings and tool box talks to individuals involved in conducting intrusive seabed works. The training should cover the following topics to a level commensurate with the audience's responsibilities and duties:

5.3.3.1 Project overview and the responsibilities of those working on the cable routes with regard to duty of care and public safety.

5.3.3.2 UXO recognition and safety procedures to be followed on discovery of a suspicious object or the alarm being sounded.

5.3.3.3 Emergency procedures to be followed in the event of an explosion. Evacuation routes, muster stations and accounting for personnel.

5.3.3.4 Work permits, works methodology and specific UXO risk mitigation methods. Post incident inspections and returning to normal works.

5.3.4 UXO safety monitoring of all "at risk" operations. This should be provided by a UK Home Office Authorised EOD/UXO Contractor using qualified EOD Engineer with specialist locators and detectors to scan the seabed ahead of the cable installation corridors wherever possible.

5.3.5 **Essential:** The cable route and working area is surveyed using magnetometer and side scan sonar. Due to the depths requiring survey the following specifications are recommended:

5.3.5.1 Depth 5m to 50m marine gradiometers at 5m line spacing.

5.3.5.2 Depth 50m plus: Single Magnetometer piggy backed to a side scan sonar, best line spacing 10m plus, this would be acceptable for medium threat areas. High Threat sections of the route ROV with magnetometers.

5.3.6 **Essential:** The signatures of large ferromagnetic anomalies detected by the survey are avoided, where possible when cable laying. If this proves impracticable then the ferromagnetic anomalies will have to be investigated to ascertain the status of the anomaly as EO or not, this will have to be carried out by ROV or diver.

5.3.7 An onboard EOD Supervisor is recommended for the entire route, the EOD Supervisor will carryout inspection of the cutting head for possible small items of EO. This will be essential if the cutting head becomes jammed. The supervisor will also give an EO Safety Briefing to all the crew. When an EO item is discovered the supervisor will carryout a risk assessment of the item and inform the ships master of the required mitigation actions, this will depend on the status/condition of the EO item, e.g.:

- Inert: No explosive content, no further action required.
- Live No fuzing system: Safe to move or handle.
- Blind fired or fuzed:Unsafe to move or a hazard to the ship.

5.4 The magnetometer survey is carried out just prior to the cable laying operation, this will mitigate the requirement for a second survey on the chance that munitions may migrate into the cable laying area.

1 INTRODUCTION

1.1 Instruction

EOD Contracts Ltd, have been commissioned by Intertek to undertake a desktop study for potential historic Explosive Ordnance (EO) and Unexploded Ordnance (UXO) contamination along 100m corridors to the south of the existing Moyle Interconnector north and south cable routes within which new LV cables will be installed.

1.2 Scope Of Work

The scope of this EO Risk Assessment/Desk Study is to identify all possible sources of UXO contamination and assess an overall level of risk that UXO may pose to the project works to permit the proposed works to be completed in the safest possible manner.

1.3 Restrictions

It must be emphasized that a desk study can only indicate the potential for UXO to be present on the cable route. A geophysical survey and investigation is fundamentally important to provide proof that the cable route is free of the UXO threat.

This study was written with the cable route conditions prevailing at the time of the study and no liability can be accepted for any change in the condition of the area.

Please note that our appraisal relies on the accuracy of the information contained in the documents consulted and that EOD Contacts Ltd will in no circumstances be held responsible for the accuracy of such information or data supplied.

1.4 Sensitive Documentation

Information may be classified, restricted or deemed to be confidential in nature to EOD Contracts Limited, where such material has been gained a summary of the documentation has been approved.

1.5 Objective

The objective of this document is to define the UXO contamination routes as defined in Unexploded ordnance (UXO) A guide for the construction industry (C681) dated July 2009 and offer remediation methodologies if required.

2 SOURCES OF INFORMATION

2.1 Research of the study area's history, with regard to military usage, bombing raids and bomb impacts has been undertaken to establish the following:

- Frequency and intensity of enemy bombing raids along for the cable route corridors and immediate vicinity up to 500m.
- Sea dumping most notably Beaufort Dyke.
- The potential for UXO to remain along the cable route corridors and in the vicinity.
- Records of UXO removal activities for the cable route corridors and immediate vicinity.

2.2 The main sources of information consulted include:

- EOD Contracts Ltd company records
- Ministry of Defence records
- Central and Local Government Records
- Public Records Office (Kew)
- Historic Maps and Air Photography
- Open Source information (Internet)

2.3 **Ministry of Defence (MOD) Records**. 33 Engineer Regiment (Explosive Ordnance Disposal) Royal Engineers is the unit responsible for maintaining the records concerning conventional Bomb incidents, reports, clearances and related UXO matters. These records are known to be incomplete and are no longer supplied.

2.4 **Attack Record Keeping**. In general, the quality and accuracy of bombing and shelling records prior to 1939 varied greatly from one region to another. Records relating to the limited air attacks on the United Kingdom are considered to be sufficiently accurate in urban areas to provide a reasonable level of confidence in determining the likelihood that an area was or was not bombed during this period. Wartime records, maps etc held within the civil archives are considerably more comprehensive than those still in existence within the MOD, where it is acknowledged that large numbers of records have been disposed of since 1945. Records from some areas, particularly rural districts or near large bodies of water should still be regarded as an incomplete picture of the extent and effect of the bombing campaign.

2.5 **Attack Record Accuracy**. While an Air Raid was in progress it was inevitable that mistakes would be made in the transcription of rushed verbal reports into the written records. Discrepancies did occur between the total of bombs dropped against detonations witnessed. In some cases records were made several hours after the event and mistakes were inevitable. Some reports were drafted before the full extent of the raid had been determined which has led to significant omissions in the records. Reports of raids on rural areas were often witnessed and submitted by untrained individuals and passed through third parties before being recorded. Suspect UXBs occasionally went unreported by local farmers and freeholders who saw the event as insignificant, or were reluctant to report their findings for fear of valuable land or crops being destroyed by the authorities in their attempts to find the UXB. It should also be noted that bomb strikes in water were notoriously difficult to spot, particularly if the bomb had failed to detonate. As a result bomb record accuracy in areas containing large bodies of water or marshland is considered to be questionable.

2.6 **Errors and Omissions**. The accuracy of records has been shown to vary greatly; this may have been a result of the individual record keeper's expertise. Additionally, in some cases, errors occurred as a result of poor or incomplete transcription and copying. Some "errors and omissions" were intentional, designed to serve as dis-information to confuse German intelligence. So long after the event, official verification of such incidents has often proven to be impossible to obtain. At present, UXBs are found on construction cable routes and other locations where there had been no documentary evidence to suggest their presence. These events, although infrequent, do serve as confirmation that records cannot be considered definitive.

2.7 **Bibliography**

The significant published documents referred to during this study are listed below:

Publications	OSPAR Commission Assessment Of The Impact of Dumped Conventional & Chemical Munitions (Update 2009). DTI Strategic Environmental Assessment Area 6, Irish Sea, Seabed & Geological Survey Commissioned Report CR/05/057 May 2005. Imperial College London Consultants Ltd Munitions Dumped At Sea A literature review June 2005. German air raids on Britain 1914-18 Capt J Morris 1925 & 93. Military Engineering volume XII, WO 1956. Dangerous Energy W D Cocroft, 2000. Guide for assessing risk on UXO sites, CIRIA RP732 2008. United Nations International Mine Action Standards (IMAS). Dealing with Munitions in Marine Aggregates. UMA 2008. Fisheries Research Services Report No 15/96 Surveys Of The Beaufort's Dyke Explosives Disposal Site, November 1995 -July 1996
Archive Record	HO192/J These papers at the National Archives deal with observation of and research into allied and enemy bombs, bombing methods and effects, fire prevention and air raid damage both in the United Kingdom and in enemy occupied territories. HO196 & 199/.... Additional Bomb Papers Held in the National Archives. 33 Engineer Regt (EOD). Royal Navy. Admiralty Office (Wrecks)
Supplied	Moyle Interconnector Submarine Power Cable 2012 Subsea Power Cables Inspection Document Number NSS-12540-01-RR3-R02 UXO IDENTIFICATION SURVEY MEC (Munitions and Explosives of Concern) SURVEY Dated 2012 The Moyle, Interconnector -New LV Cables Environmental Scoping Report

3 CABLE ROUTE DESCRIPTION AND DETAILS

3.1 Selected Marine Cable Routes

3.1.1 The plan is to install the two new separated LV return conductors between existing converter stations at Ballycronan More on Islandmagee, County Antrim, Northern Ireland and Auchencrosh in Ayrshire, Scotland.

3.1.2 The preferred option is for each LV cable to be installed parallel to and offset between 50m and 100m south of each existing north and south cable.

3.1.3 For the purposes of this report the project area is defined as the northern and southern limits of the existing and new cable locations i.e. the existing north cable represents the northern limit of the project area and 100m south of the existing south cable represents the southern limit of the project area (see Annex A).

3.2 Landing Options

3.2.1 The proposed landfall sites for the new cables will be at the location of the existing landfalls at Portmuck South, Islandmagee and Currarie Port, Ayrshire.

3.2.1.1 **Portmuck South Landfall:** The landfall site at Portmuck South comprises a stone covered approach over sand to a rocky shore and a small beach, rising to a steep grass covered plateau. The slope may be used for horizontal directional drilling (HDD) into the shore approach or an open cut cable installation method maybe used.

3.2.1.2 **Currarie Port Landfall:** The landing site at Currarie Port is approached via a narrow inlet onto a shingle and boulder plateau. The upper part of the shingle shore could be a suitable location for a transition joint pit. Documentation supplied anticipates that a direct landing option would be the most suitable at this landing site, with the cable floated ashore by means of buoys from the main installation vessel which would be standing some way off. This method has advantages over HDD which would be complicated by constraints including the presence of bedrock and potential high seas.

3.3 Future Works

Therefore it is assumed that the following intrusive works will be carried out:

- PreLay Grapnel Run (PLGR)
- Cable Burial to 1.5m by:
  - Ploughing
  - Jetting
- Further details of the construction methodology are provided in Annex B

4 HISTORICAL REVIEW

4.1 Military / Naval Action:

4.1.1 WWI

4.1.1.1 WWI saw the first major actions for U-Boats, the majority of this action was seen in the North Sea, Atlantic and English Channel, some action did occur in the early part of the war in the Irish Sea. This was curtailed by the construction of the barrier minefield across St Georges Channel.

4.1.1.2 The only known U-Boat to be sunk in the Irish Sea is **UB 82** (Walter Gustav Becker). 17 Apr 1918. Severely damaged in a D/C attack by 2 trawlers, surfaced but sank at 5513N 05.55W (Torr Head Antrim NI).

4.1.1.3 U-80 carried out several missions around the Hebrides and in the Irish Sea. Commanded by Oberleutnant von Glasenapp, she laid a minefield off the Isle of Man –11 miles south-east of Chicken Rock Lighthouse –on 18 December, 1916, to catch shipping using Liverpool.

4.1.2 WWII

The loss of shipping from direct action on or near the project area, the following details for Allied ships known to have been lost:

4.1.3 There are 4 known U-boats sunk in the Irish sea they are:

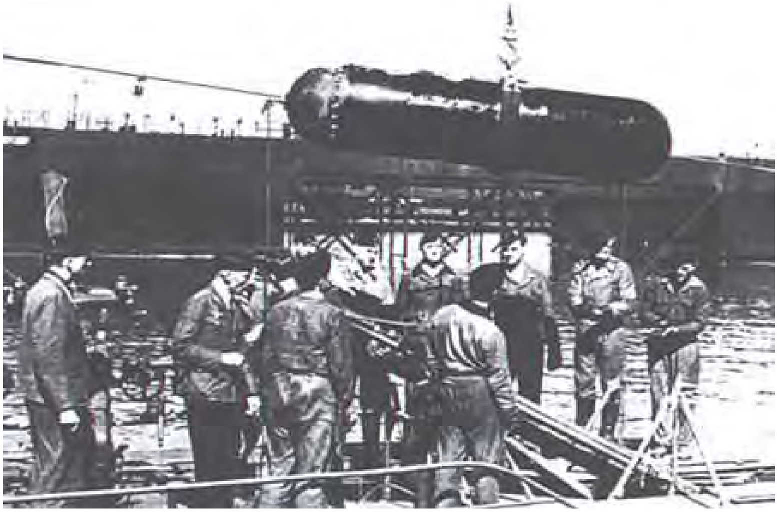
- **U-33** (Kptlt. Hans-Wilhelm von Dresky). Sunk 12 Feb, 1940 in the Firth of Clyde, in position 55.25N, 05.07W, by depth charges from the British minesweeper HMS Gleaner
- **U-1051** (Oblt. Heinrich von Holleben). Sunk 26 Jan, 1945 in the Irish Sea south of the Isle of Man, in position 53.39N, 05.23W, by ramming and depth charges from the British frigates HMS Aylmer, HMS Calder, HMS Bentinck and HMS Manners
- **U-1024** (Kptlt. Hans-Joachim Gutteck). Captured on 12 April, 1945 in the Irish Sea south of Isle of Man, in position 53.39N, 05.03W by the British frigates HMS Loch Glendhu and HMS Loch More. The frigates attempted to tow her to port but the boat sank while underway on 13 April, 1945
- **U-246** (Kptlt. Ernst Raabe). Lost during April 1945 in the Irish Sea south of the Isle of Man, in position 53.40N, 04.53,5W. Listed as missing on 5 April, 1945. No explanation exists for its loss

4.2 A map and list of the known sunken vessels along the route of the cable are in Annex C, this comprises of a list of the type, only one Naval vessels appears on the list.

4.3 German Mine Laying Operations

The submarine mine during World War Two was a very efficient and dangerous weapon if properly used. Minesweeping was expensive and time-consuming for the defenders, diverting men and equipment from other duties.

In the period prior to WWII the German Navy developed in secrecy a series of mines that were superior to those used in the previous conflict. They were laid in hundreds of operations although Admiral Donitz did not favour them as they were not quite as effective as the torpedo.



A type TMB mine being loaded on the U-373 in 1942.

Types of mines used

TMA was a big submarine floating mine. It was redesigned as the TMC in late 1939.

TMB was designed especially for submarine use. This was an unearthed "seabed" that utilized a magnetic pistol. It was 7.5 feet long and carried an explosive charge of 1,276 pounds (567kg) which was twice that of the torpedoes of the time. It was laid on the bottom in shallow seaways and was detonated when a big ship passed over its position. Not many ships survived such a blast under their keel.

The mines were originally laid at the depth of 30m but after reliability questions and testing it was established that 25m was much more lethal depth. The mines were also overly sensitive, sinking smaller ships than intended. The U-boat crews thus started laying them in even shallower waters and de-magnetizing them to reduce their sensitivity. This improved their score.

TMC was a ground variant of the floating TMA mine. It was designed after Admiral Dönitz worried that the 1,276 pound warhead of the TMB might not be powerful enough against really big ships (British battleships and aircraft carriers). Unlike the torpedo directorate that acted super-slow on reliability complaints the mine designers were quite willing to improve their work. They delivered the TMC with a massive explosive charge of 2,200 pounds believed to be lethal of up to depth of 36 meters.

This mine was probably used for the first time by U-32 in Firth of Clyde in December 1939. They were laid in an unfavourable position and failed, the commander being sacked for disobeying orders.

SMC – Very little information on this type of mine except that it was believed to be unsuited for U-boat operations.

Mine laying could be extremely effective but it was not a popular task for the U-boat crews. Traditionally the mines were laid close to shore in very hostile waters where, if discovered, the submarine was in great danger of being destroyed. Secondly the mines did not cause any immediate damage to shipping and thus was often not credited fairly and did not give the men any feeling of achievement like torpedoes did. Many of the men also felt this was somehow "sneaky" or unfair.

4.3.1 **Air Dropped Mines**

The use of airdropped mine throughout British coastal waters, has been documented, (1,000, were dropped in the period April to June 1940), specific areas are not defined, however docks and channelled waterways were targeted.

4.4 **BRITISH MINE LAYING**

4.4.1 British mine laying operations were carried out from the day that hostilities commenced until 10 May 1945. They were carried out in all types of weather and ships deployed in coastal waters had the additional hazard of enemy mines as well as encounters with hostile warships and aircraft.

4.4.2 Two types of mine laying can be easily identified. Defensive minefields, as laid in the Dover Straits, along the East Coast of UK and in the North Atlantic, including the Denmark Strait. Anti-submarine traps as placed in both the NW and SW Approaches, the Irish Sea and English Channel.

4.4.3 **Anti Submarine Traps:** No known minefields have been mapped for the route.

4.5 **Mine Types:** The two main types of mines that may be encountered are:

4.5.1 Ground mines, these mines are laid on the seabed and are instigated by magnetic, acoustic or water pressure influence creating an air bubble.

4.5.2 Buoyant mine, these are tethered mines mostly initiated on contact. These do become un-tethered and become floating mines, or sink.

Buoyant Mine

4.6 **Summary on Mines:** Mines were laid by both the Allies and Axis forces during both wars in the Irish Sea though confirmed positions have not been identified. The types of mines would have been ground and tethered. The post wars cleanup would have removed known mines. Therefore there is a limited probability of mines being on the route. The likely areas are in shallow water (25m).

4.7 **Air Raids in and Around the Cable Route**

4.7.1 A review of air raids and bombing incidents has been carried out however no recorded bombing raids have been noted for the cable route corridors.

4.8 **Anti Aircraft Artillery (AAA):** The 1 known site on the Irish Coast is:

4.8.1 Dundresan 4km east of Larne, these will have been fired over the sea and a low possibility of encountering AA ammunition is expected.

4.9 **Defence Works:** All port areas had sea defences, however the laying of anti invasion minefields was limited to the south and east coasts of the UK, therefore no land mines are expected. The nearest Coast Artillery Battery is:

4.9.1 300m S of Finnarts Bridge, Finnarts Bay, Loch Ryan. In September 1940, two 4Einch naval guns were installed, to be replaced by two 5.5Einch MkI/I guns, numbered 57 (Adm 40) and 16 (Adm 46). The battery was placed on care and maintenance in January 1945 and the guns removed in September 1945.

4.10 **Military Ranges:** The Northern Irish Sea, (see Figure 1) is a training ground for the Royal Navy Submarine Warfare School, information supplied by the Royal Navy indicates this has been used as "Tactical" training, in so far as escape and detection exercises, live firing of main armaments have not been carried out. However a firing area in red was indicated along the cable route corridors.

4.11 The nearest Historical Range is the bombing range in Luce Bay indicated in yellow in Figure 1.

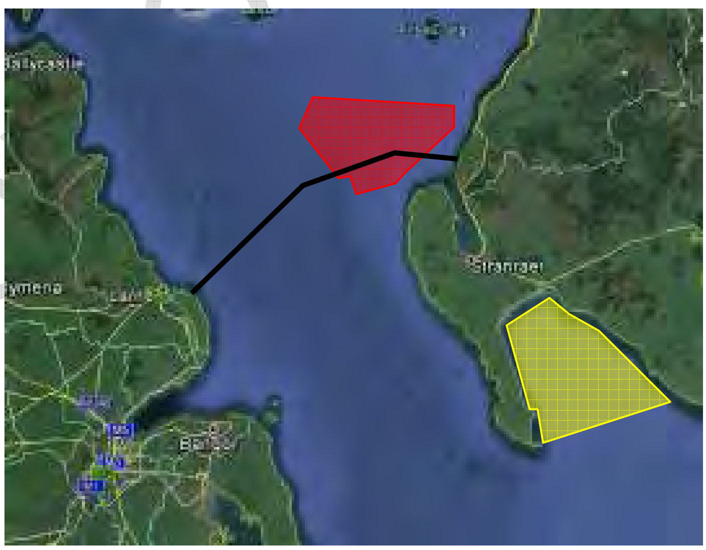


Figure 1 Military Areas in the vicinity of the proposed Cable Route Corridors

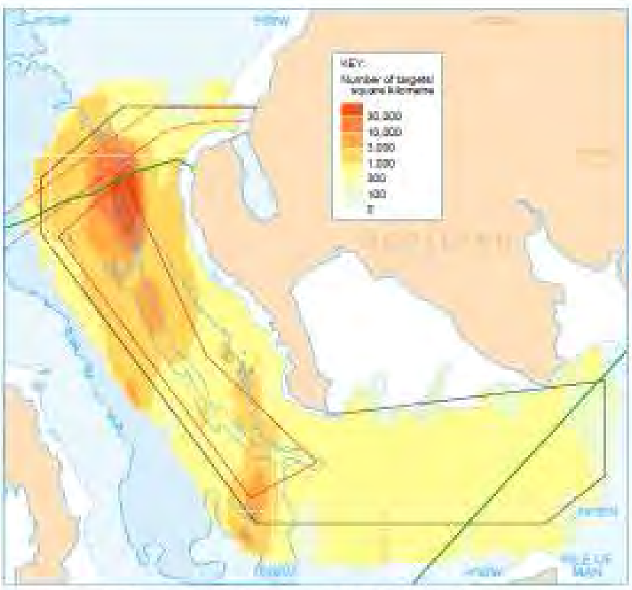
5 **SEA DUMPING**

The main ammunition dumping ground is called Beaufort's Dyke in the North Channel of the Irish Sea.

5.1 **Beaufort's Dyke** a long narrow trough between the Rhins of Galloway and Northern Ireland. Disposal of munitions was restricted to the area defined by Notice to Mariners No 4095 issued in 1945. There are no records which refer to dumping of munitions prior to 1945. In some cases the location and types of munitions dumped is well known, although the full extent of dumped munitions will never be known. This is due to inadequate documentation of operations at the time of dumping and the subsequent destruction of records. Best estimates indicate that in excess of one million tonnes were dumped in Beaufort's Dyke alone. The materials dumped range from conventional munitions to phosphorous incendiary devices as well as chemical munitions containing phosgene gases and other substances. Below is a map of the known munitions dump site, Figure 2.

5.2 The transhipping of the munitions to the dump site at Beaufort's Dyke was from Cairn Ryan. A short video from Pathe News showing the dumping of EO in Beaufort's Dyke is on an attached VLC Media File.

5.3 In 1995 a submarine gas pipeline was laid across the area of Beaufort's Dyke, this caused incendiary items being washed up on the Forth of Clyde coastline and the coastline of Northern and Southern Ireland. A survey was commissioned and carried out by the Fisheries Research Service (FRS) the research looked into the density and spread of munitions on the seabed, Figure 2 shows the munitions distribution. The cable route corridors appear to be passaging through high density target areas.



Map of North Channel and northern Irish Sea, showing the distribution and densities of larger munitions, munitions-related materials and unidentified man-made debris derived from combination of the side-scan sonar, underwater television and pulse induction data (number of targets/square kilometre).

Figure 2 – Beaufort's Dyke Dump Site

5.4 **Possible Migratory Factors**. The migration of UXO from the known munitions dump sites can be attributed to tidal action, fishing vessels dragging items of ordnance or rereleasing them back into the sea where they hauled in their nets. It has been recorded that underwater explosions from munitions have taken place in Beaufort's Dyke. These explosions have been reported to have caused damage to fishing boats and sometimes death to members of their crews. Not only are these explosions dangerous to shipping, but may also be a contributory factor in the migration of UXO. The explosion could possibly dislodge unexploded munitions enabling them to be influenced by the tide. The locations and magnitude of the recorded explosions, measured on the Richter Scale ML, in the Beaufort's Dyke area between 1992 and 2004 are shown on Figure 3 below.

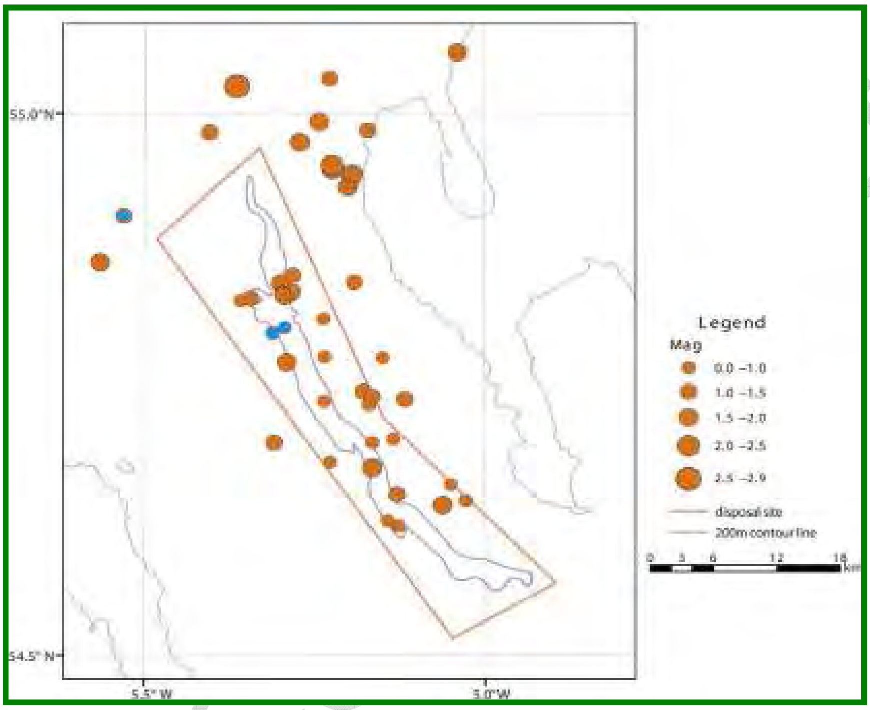


Figure 3 ERecorded Explosions in Beaufort's Dyke

5.5 **Encounter of Munitions**. The OSPAR Commission Assessment of 2009 reported that a study was carried out over the period April 1999 to October 2008, to record encounters with munitions. The results seem to show that there was no clear relationship between the location of dumpsites and encounters with munitions. Of the 1821 encounters with known locations, 7% were within 5km of reported dumpsites, whereas 31% occurred at a distance greater than 50km and 5% occurred more than 100km away from known dumpsites.. This would seem to suggest that migration through tidal action may be a factor responsible for the movement of the UXO.

5.6 **Activity on Encountering UXO**. The study on encounters with UXO also focussed on the activity being carried out at the time of the find and the majority of the reports received were from the fishing industry; the second largest amount of reports were UXO found on the shore line. The pie chart below shows these details, Figure 4.

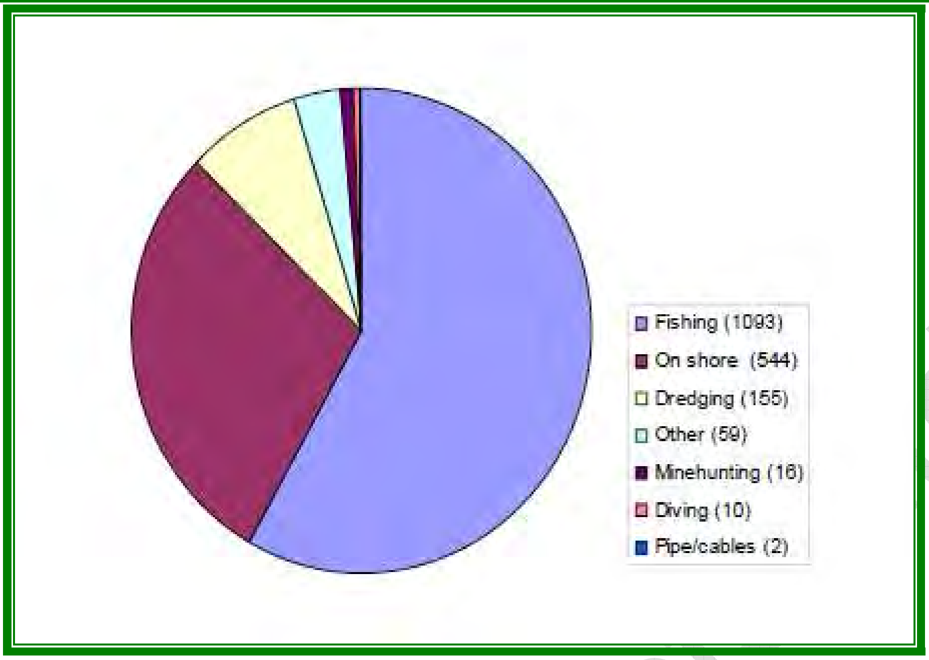


Figure 4 – Pie Chart for Activity on Encountering UXO

(58%) Fishing activity
(29%) Found on shore
(8%) Dredging activity
(3%) Non specific activity
(10%) Diving, mine hunting
(2%) Pipe and Cable Laying.

5.7 **Errors and Omissions**. In some cases the location and types of munitions dumped is well known, although the full extent of dumped munitions will never be known. This is due to inadequate documentation of operations at the time of dumping and the subsequent destruction of records. The standard response from the MOD in regard to sea dumping is shown in Annex D.

5.8 **Effect of Seawater on Munitions**

5.8.1 The munitions dumped in Beaufort's Dyke are 1,000,000 tons of all types of munitions including 14,500 tons of phosgene artillery shells. The period of dumping is known, and therefore the effect by seawater has to take into consideration the following:

5.8.1.1 Munitions in storage/transit packaging, this would prevent the water gaining egress and therefore no degradation would be expected.

5.8.1.2 Munitions items not packaged, may still be sealed units, however, if not then the date of dumping would indicate the explosive fill.

5.8.1.3 The effect of seawater on the explosive fill depends on the type, an extract from EOD Database, "Chemical Sheets for Explosive" of the three most common explosives, showing solubility and stability is detailed in the following:

5.8.1.3.1 HMX (High Melting eXplosive, Her Majesty's eXplosive, High‐velocity Military eXplosive Also known as cyclotetramethylene‐tetranitramine) WWII, **Solubility**: Practically insoluble in water; solubility in other solvents is comparable with that of RDX.

5.8.1.3.2 RDX (Research Department Explosive or Cyclotrimethylenetrinitrarnine) WWII, **Solubility**: Moderately soluble in hot acetone; readily soluble in hot phenol. **Stability**: Stability in storage is very good. Nonhygroscopic and not adversely affected by moisture. Reacts slightly with copper‐plated steel. Mixtures of RDX with oxides of copper or iron may ignite at temperatures only slightly above 212° F (100° C). Does not react with common metals or nitric acid.

5.8.1.3.3 (RDX/HMX are TNT based explosives, with additives for stability.

5.8.1.3.4 **Picric Acid (Lydiite)** WWI, **Solubility**: Slightly soluble in water and in ether; moderately soluble in ethyl alcohol, isopropyl alcohol, and benzene. Soluble in toluene, methyl alcohol, and baking soda solution. Very soluble in acetone. **Stability**: Stability in storage is good. Has no tendency to decompose at temperatures normally encountered in storage. Slightly hygroscopic; presence of moisture increases reactivity, especially with metals. Excessive moisture content decreases reliability of detonation. Reacts with all metals except aluminium and tin to form dangerously sensitive compounds. Is highly acidic and corrosive. Forms very dangerous mixtures with lead or lead compounds.

5.8.2 Therefore most likely case no effect on munitions viability is expected, worst case, items with a Picric Acid fill could become dangerously sensitive.

5.8.3 Chemical Munitions, dependant on the integrity of the container, if egress of seawater has taken place then the chemical will either have broken down Phosgene or dispersed, (Note Mustard Gas's solubility in water is deemed Negligible) if the container's integrity has not been breached then the chemical will still be viable. Therefore at best case chemical weapons will have broken down/dispersed.

5.9 **Prior Clearance Operations**

5.9.1 No prior clearance operations have been carried out for the area along the cable route corridors, paragraph 5.3 notes a previous gas pipeline was placed in 1995, which caused Munition items to be discovered on the Forth of Clyde.

5.9.2 Seabed surveys have been carried out along these routes for prior cable corridor works, and where possible, these should be obtained and reviewed.

6 SOURCES OF UXO CONTAMINATION

6.1 The main sources of UXO contamination are:

6.1.1 Sea Dumping of Munitions

6.1.2 Naval Action

6.1.3 Air delivered ordnance bombs and sub-munitions/incendiaries.

6.1.4 Anti Aircraft Ammunition (AA).

6.2 General

6.2.1 The cable route corridors pass through the northern section of Beaufort Dykes Munition Dumping Ground.

6.2.2 A sunken Naval Ship is noted along the southern cable corridor.

6.2.3 Munitions/UXO are essentially dangerous; therefore further information on Munitions/UXO and Safety is detailed in Annex E.

7 RISK ASSESSMENT

7.1 **Risk Assessment**. The overall risk for the cable route from unexploded ordnance has been derived by assessing both the likelihood of occurrence and the consequences of the encounter whilst on board a vessel and whilst laying the seabed cable. Shown at Annex F, Table 4 .

7.2 **Likelihood of Encounter**. Given the results of the research and other criteria it is considered that there is a **High** risk of encountering UXO in proximity of Beaufort's Dyke. and in the Clyde and the remainder of the Route is **moderate**. This is based on assessment of all of the available information.

7.3 **Encounter Factors**. This likelihood of encounter is based on assessment of all of the available information and taking into account the tides and currents which may have dispersed and or migrated items of UXO.

7.4 **Consequence of Encounter**. The consequence (See Annex F table 4) of an uncontrolled encounter with UXO, given its lethal design and its unpredictable nature could be catastrophic and normally warrants a severity factor of five (5)E Fatality. Given that all vessel operations are being conducted in deep waters greater than 8 metres a severity factor of one (1) – Minor injury has been assessed. With regards to the consequences, the following factors were considered.

7.4.1 Items of UXO will have been subjected to current and tidal forces over a number of years, imparting some degree of external force to the items.

7.4.2 The project works been identified as cable laying to a depth of 1m to 1.5m.

7.4.3 Deep water (10m plus) munitions items will have sunk through the light sediment and settled on the seabed

7.4.4 Shallow water munitions items dropped from height may have penetrated the seabed.

7.4.5 In addition to the dangers of explosion, many common chemicals used in the manufacture of explosive ordnance fillings are in sufficient quantity, and level of exposure, toxic or poisonous. Although it is unlikely that such chemicals would be encountered in significant quantity to represent a significant risk to personnel, leakage or venting could pose a risk to the local marine environment. In addition to heavy metals; copper, lead, zinc etc used in the weapon body and fuze, hydrocarbon propellants such as Kerosene may also be present..

7.4.6 In addition to the dangers of explosion, many common chemicals used in the manufacture of explosive ordnance fillings are in sufficient quantity, and level of exposure, toxic or poisonous. Although it is unlikely that such chemicals would be encountered in significant quantity to represent a significant risk to personnel, leakage or venting could pose a risk to the local marine environment. In addition to heavy metals; copper, lead, zinc etc used in the weapon body and fuze, hydrocarbon propellants such as Kerosene may also be present.

7.4.7 Chemical munitions such as mustard gas and phosgene were sea dumped; therefore it is conceivable, however unlikely that such a munitions is present within the site footprint.

7.5 The consequence from UXO is dependent on proximity and quantity of explosive content (NEQ).

7.5.1 **NEQ:** The NEQ for the possible UXO in the Irish Sea ranges from <1kg to 600kg per item.

7.5.2 **Proximity:** The proximity of the works with respect to UXO, will range from "in contact" (Pre-Lay Grapnel Run (PLGR) trenching and cable laying-intrusive works) to remote as in the ships position at the end of the drag cable.

7.5.3 Cables will be buried either by means of ploughing or trenching either simultaneously with, or after, cable laying. These techniques can be summarised briefly as below:

7.5.3.1 Underwater cable plough that executes a simultaneous lay and burial technique by lifting a wedge of sediment, allowing the cable to fall into this trench and then folds the sediment back on top of the cables. This mobilises relatively little sediment.

7.5.3.2 Trenching (jetting) equipment that uses high-pressure water jets to fluidise a narrow trench into which the cables are located. The displaced sediments settle back into the trench and with typical tidal conditions the trench coverage is naturally reinstated over several tidal cycles.

7.5.3.3 Mechanical trenching equipment use a series of hardened picks mounted on a revolving chain or wheel and theoretically have the capability to cut through strong (very stiff to hard) soils and even relatively strong rocks. Typical seabed conditions in which chain cutters are used include weak rock, coarse granular soils (e.g. gravels) and stiff to hard clays.

7.5.4 The equipment laying cables may have UXO becoming entangled in the equipment.

7.6 **Sandwaves:** Sandwaves may be dredged or clipped, this methodology has not been confirmed.

7.7 **At Risk Activities**

7.7.1 Contact may initiate an Explosive Ordnance (EO) item on the seabed Table 2 below denotes the consequence from EO detonating. The following consequences are:

7.7.1.1 **Minor:** Little or no damage from an unintended explosion.

7.7.1.2 **Major:** Moderate likelihood of damage being caused.

7.7.1.3 **Catastrophic (Cata):** Serious loss of equipment, damage to ship, personnel injury/death.

Action	**Item**	**NEQ Consequence**			
		<1kg	**1kg to 9.9kg**	**10kg to 99kg**	**100kg plus**
Trenching Deep Water	Trenching Equipment	Minor	Major	Major	Cata
	Cable	Major	Major	Major	Cata
	Ship	NA	Minor	Major	Cata
	Personnel	NA	Minor	Major	Cata
Trenching Shallow Water	Trenching Equipment	Minor	Cata	Cata	Cata

	Cable	Major	Cata	Cata	Cata
	Ship	Minor	Major	Cata	Cata
	Personnel	Minor	Major	Cata	Cata

7.8 **Risk Level**. Information pertaining to the offshore component of the project is considered to be of great value in relation to tidal influence resulting in the migration of items of UXO. Account has been taken of the anticipated scope and methodology of the project works. The study has found that the possibility of an encounter with UXO is **High** near the Beaufort's Dyke and **Medium** along the remainder of the cable route corridors project area. All of the known or anticipated prevailing factors were given due consideration when applied to the likelihood verses consequence scenario. It is acknowledged that the possible consequence of such an encounter could be catastrophic, however due to the nature of the works the risk assessment of 1 has been given. As a consequence the study has identified a **Medium or High** UXO risk, as applied to the following operations:

7.9 Surface vessel transiting through the **high** risk area laying cable. The risk to this operation is **high** to the cable not the ship.

7.10 Pre-Lay Grapnel Run (PLGR) is deemed **high** risk to the operation and the potential for snagged items to be brought back on board the vessel.

7.11 Surface vessel transiting through the **Medium** risk area laying cable. The risk to this operation is **Medium.**

7.12 A map showing risk areas is provided in Annex G.

8 CONCLUSIONS

8.1 Based on the information researched by EOD Contracts Ltd for the cable route, in that the cable route corridors:

8.1.1 Pass through a firing range (paragraph 4.10).

8.1.2 Pass over Beaufort Dyke Munitions dumping area paragraph 5.3, this assessment appears to indicate this is within the high target area.

8.1.3 A singular Naval vessel appears to be on the southern corridor, as indicated in Annex C.

8.2 The risk level on the cable route corridors is generally **medium** and specific areas are **high**, which are shown in Annex G Risk map, given that some UXO retains the potential to detonate if disturbed with possible severe consequences, it is concluded that it would be prudent to ensure that basic precautions are taken to ensure that the project can proceed in the safest possible manner and that any residual risk posed by UXO is as low as it is reasonably practical to achieve (ALARP).

9 RECOMMENDATIONS

9.1 It is recommended that the following risk mitigation strategy is executed during the project:

9.1.1 Communicating the risks, all stakeholders should be made aware of the UXO situation on the cable route and the possible impact it may have on the project works and day to day running of the district. Clients have a legal duty under the Construction Design & Management Regulations (CDM) and Health & Safety at Work legislation to provide Designers and Contractors with project specific information needed to identify hazards and risks associated with the design and construction work. The possibility that UXO may be encountered on cable route falls within the category of a significant risk and as such it should be addressed as early as possible in the lifecycle of the project.

9.1.2 Further Planning; the risks posed by UXO should be brought to the attention of the Project CDM/Safety Coordinators and other individuals with a responsibility for project safety and operations at the cable route. The matter of UXO should be considered critical to project safety and one requiring high priority action.

9.1.3 Safety Training; UXO safety awareness training should be given at all levels of cable route personnel and selected individuals on the project staff with relevant responsibilities. The training should be provided by a competent person as part of the project safety induction course. It should be reinforced with specific safety briefings and tool box talks to individuals involved in conducting intrusive earthworks. The training should cover the following topics to a level commensurate with the audience's responsibilities and duties:

9.1.3.1 Project overview and the responsibilities of those working on cable route with regard to duty of care and public safety.

9.1.3.2 UXO recognition and safety procedures to be followed on discovery of a suspicious object or the alarm being sounded.

9.1.3.3 Emergency procedures to be followed in the event of an explosion. Evacuation routes, muster stations and accounting for personnel.

9.1.3.4 Work permits, works methodology and specific UXO risk mitigation methods. Post incident inspections and returning to normal works.

9.1.4 UXO safety monitoring of all "at risk" operations. This should be provided by a UK Home Office Authorised EOD/UXO Contractor using qualified EOD Engineer with specialist locators and detectors to scan the ground ahead of the excavation wherever possible.

9.1.5 **Essential:** The cable route and working area is surveyed using magnetometer and side scan sonar. Due to the depths requiring survey the following specifications are recommended:

9.1.5.1 Depth 5m to 50m marine gradiometers at 5m line spacing.

9.1.5.2 Depth 50m plus: Single Magnetometer piggy backed to a side scan sonar, best line spacing 10m plus, this would be acceptable for medium threat areas. High Threat sections of the route ROV with magnetometers.

9.1.6 **Essential:** The signatures of large ferromagnetic anomalies detected by the survey are avoided, where possible when cable laying. If this proves impracticable then the ferromagnetic anomalies will have to be investigated to ascertain the status of the anomaly as EO or not, this will have to be carried out by ROV or diver.

9.1.7 An onboard EOD Supervisor is recommended for the entire route, the EOD Supervisor will carryout inspection of the cutting head for possible small items of EO. This will be essential if the cutting head becomes jammed. The supervisor will also give an EO Safety Briefing to all the crew. When an EO item is discovered the supervisor will carryout a risk assessment of the item and inform the ships master of the required mitigation actions, this will depend on the status/condition of the EO item, e.g.:

10 Inert: No explosive content, no further action required.
11 Live No fuzing system: Safe to move or handle.
12 Blind fired or fuzed: Unsafe to move or a hazard to the ship.

12.1 The magnetometer survey is carried out just prior to the cable laying operation, this will mitigate the requirement for a second survey on the chance that munitions may migrate into the cable laying area.

Annex A

SITE LOCATION (Overview Supplied)

Annex B

CONSTRUCTION METHODOLOGY

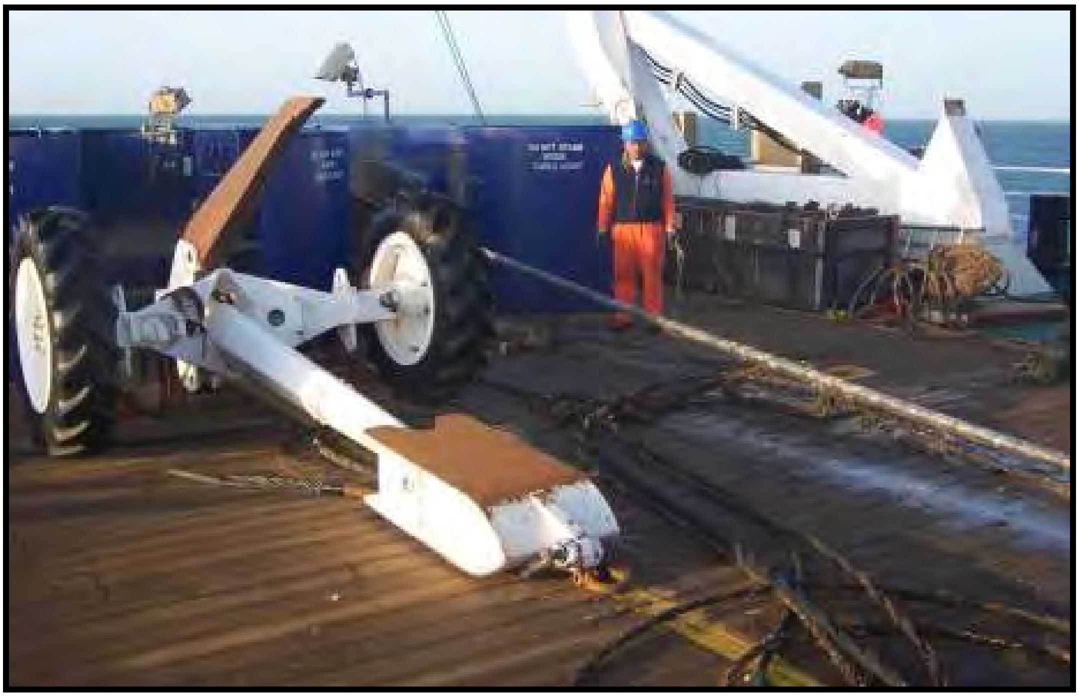
Extracted from: The Moyle, Interconnector - New LV Cables Environmental Scoping Report

It is intended to bury the cables along their entire length apart from where this is not possible, for example at crossings with existing cables or pipelines, or where the seabed characteristics are inappropriate for burial. The exact details of the installation technique will be confirmed when the contract for installation is awarded taking into account the prevailing ground conditions. It is envisaged that a variety of installation and burial techniques will be required due to the variable nature of the seabed along the cable route. A „rolling box" technique will be employed for installation so that only the area required by the installation vessel, its attendant tugs and support vessels will be restricted to other marine traffic. The remainder of the route will remain open to normal marine activities.

Seabed Preparations

Prior to offshore cable installation the contractor will undertake a Pre-Lay Grapnel Run (PLGR) operation to ensure that all obstacles are removed from the path of the planned cables. A grapnel (often on wheels, see Figure 1) is towed along the seabed along the route to try to snag undetected objects. This is primarily to ensure that objects and debris do not interfere with the trenching equipment.

Figure 1: Wheeled Grapnel Onboard a Cable Ship



Along the routes areas of sandwaves will be avoided where possible. Where sandwaves cannot be avoided, they will be crossed at a perpendicular angle by the cable route.

Cable Burial

The cables will be buried as the primary means of protection. This will ensure that the cables are protected from external aggressive forces and that surface sediment transportation does not de-bury the cable over time. The target depth for burial is 1.5m below mean seabed level, although this may vary depending on the nature of the substrate: in areas where there is evidence of trawling activity or areas of mobile seabed this may be increased. It may be necessary to use rock protection or "mattresses" over some parts of the routes to protect the cables in areas of hard bedrock, areas of potential scouring by tidal currents and at cable/pipeline crossing locations. The cables will be buried using a combination of the methods described in Table 2-1.

Burial Method Description

Ploughing: Ploughing is suitable for most types of seabed material, with the exception of rock and some glacial material. The cable is fed from the vessel, through the plough share into the seabed. The forward blades of the plough cuts a narrow trench into the seabed and holds it open long enough to depress the cable into the bottom of the trench. The seabed then closes behind the plough.

Jetting: Jetting is most effective in sandy sediment, and may not be capable of burying cable in more cohesive sediment. Two methods of jetting are typically available:

Fluidising the seabed: the cable is laid on the seabed, where a jetting sledge flushes water below it, fluidising the sand. The cable sinks by its own weight to the depth set by the operator.
This will result in increased suspended sediment compared to ploughing or forward jetting.

Forward jetting a trench: Water jets are used to jet a trench ahead of the cable lay. The cable can typically be laid into the trench behind the jetting tool.

Using either of the methods described above the cable will be directly buried in the bottom of the trench created by the plough or jetting trencher. The cable is depressed into the bottom of the trench allowing the sediment to cover the cable in one operation. This method allows the cable to be protected in the seabed in one direct burial operation. Where cable burial is not possible (e.g. pipeline/cable crossings), mechanical protection will be required using concrete mattresses or rock placement. The exact specification of the installation burial tool will be determined in the detailed design phase, the sediment type along the route and also the availability of suitable equipment will be among the factors considered. It is expected that both a jetting trencher and cable plough will be required based on existing understanding of the seabed conditions along the routes. Typical cable installation equipment is shown in Figure 2 below.

Jetting Trencher (right), Mechanical Trencher (upper left) and Cable Plough (bottom left)

Cable Landfalls

The land cables will be connected with the marine cables in a transition jointing pit (TJP) buried in the ground above the high water mark. In all areas the cables will be buried below surface.
The construction vessels will locate offshore as close as possible to the landfall.

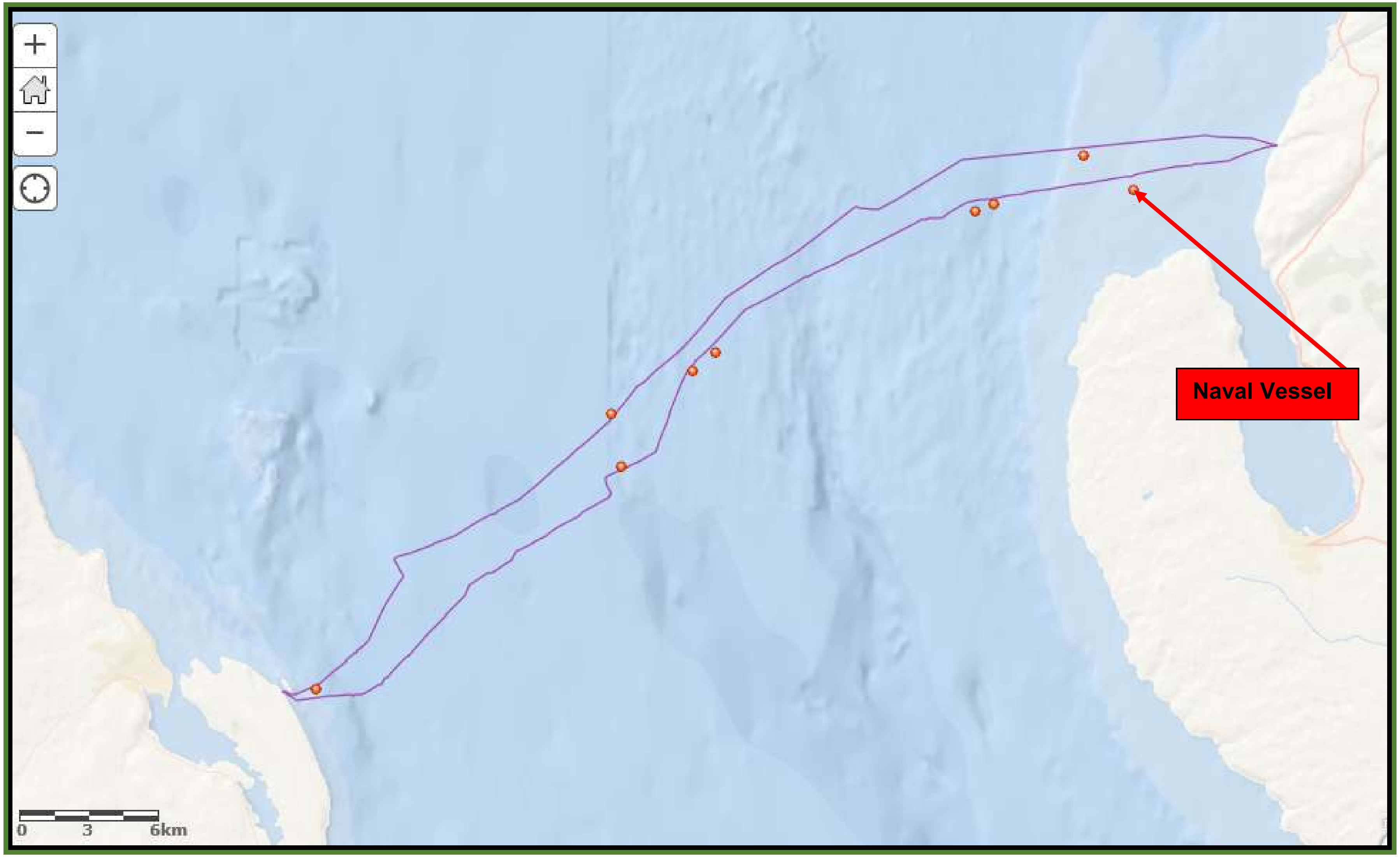
The "open cut" installation method may be used in the intertidal area of the landing site. This will involve using mechanical diggers to construct a trench across the beach from low to high water and floating the cable from the ship to the lower end of the trench. The cable will then be attached to a wire that ispull ed by an onshore winch through the rest of the trench, to the onshore end.
Mechanical diggers will be used to fill in the trench, ensuring the cable is buried to a predetermined depth.
Alternatively conduits will be installed beneath the beach using HDD or another boring technique. The bore entrance area will be inland and comprise a site approximately 20m by 20m. This site(s) will be used to bore seaward, to install the conduits for cables, to pull the cables inland and to join the land cables with the marine cables. On completion of jointing, excavations will be backfilled and the surface reinstated.

The cables will be landed from a vessel which will approach as far inshore as is possible considering the water depths and vessel draught. A pulling rope will be attached to each cable end and passed through the cable conduits. Floats will be attached to the cables which will be floated ashore at high tide and guided into the conduits. When sufficient cable is ashore the floats will be progressively removed to allow the cable to sink to the seabed.

Once the cable pulls have been completed, with the cable ends at the jointing chamber, the cables on the beach will be progressively buried using land based excavators as the tidal conditions permit. The cables will be buried across the beach to a depth of approximately 1m in order to protect the cable.

Annex C

POSITION OF SUNKEN VESSELS WITHIN 500m OF CABLES



DETAILS OF SUNKEN VESSELS

OBJECTID	SZLABEL	LATITUDE	LONGITUDE	WRECK_CATE	POSITION_Q	NAME	FLAG	CARGO
848		54.84694	-5.69833		unreliable			
820		54.93365	-5.49106	non-dangerous wreck	unreliable			
843		54.95421	-5.49802	non-dangerous wreck	unreliable			
847		54.97116	-5.44303	non-dangerous wreck	unreliable			
855		54.97838	-5.42664	non-dangerous wreck	unreliable			
537	MORAG GLEN	55.03337	-5.2511	non-dangerous wreck	unreliable	MORAG GLEN	BRITISH	
335	EMPRESS OF JAPAN (POSSIBLY)	55.03587	-5.23832	non-dangerous wreck	surveyed	EMPRESS OF JAPAN (POSSIBLY)		
341	LONGWY	55.05475	-5.17666	dangerous wreck	surveyed	LONGWY	FRENCH	IRON ORE
337	Obstruction	55.0417	-5.14279		precisely known	Naval		

Annex D

COPY OF UK GOVERNMENT STANDARD REPLY ON SEA DUMPING

STANDARD REPLY TO ENQUIRES RE SEA DUMPING OF MUNITIONS

It is important first of all to set the issue of marine munitions disposal in its historical context. At the end of World War II, Britain was faced with the need to dispose of an enormous quantity of surplus munitions. This process had to be completed quickly and safely. However, given the technological limitations of the time, it soon became clear that sea dumping was likely to be the only practicable method of disposing of the bulk of the munitions. Other nations arrived at the same conclusion and sea dumping became the internationally accepted method of munitions disposal during the 1940s. The main disposal site for the United Kingdom was Beaufort's Dyke, a long narrow trench in the Northern Channel between South West Scotland and Northern Ireland. Beaufort's Dyke may have been used for sea dumping of munitions as early as 1920. It is estimated that a million tons of conventional munitions ranging from small arms ammunition to heavy aircraft bombs were dumped there between 1945 and 1973. Surviving records also show that some 14,500 tons of 5 inch artillery rockets filled with phosgene gas were dumped in Beaufort's Dyke in July 1945. However, phosgene is destroyed by hydrolysis on contact with seawater. A further emergency dump of two cases of heavily corroded 40mm shells took place at Beaufort's Dyke in 1976.

Sea dumping at Beaufort's Dyke had effectively ceased in 1973, however, as, in 1972, the United Kingdom adopted the London Convention on the Disposal of Wastes at Sea and the Oslo Convention on the Prevention of Marine Pollution in the North East Atlantic. These Conventions ended munitions disposal on the United Kingdom continental shelf. By 1973, the sole approved MoD dump site was the Atlantic Deep which was a circular area of 15 miles' radius, centred on a position 48 degrees 20 minutes North, 13 degrees 40 minutes West, and located some 400 miles south west of Land's End. More information on the Atlantic Deep is given below in respect of sea dumping of radioactive waste.

I should add that, in late 1995 and mid 1996, the Scottish Office Marine Laboratory carried out two detailed surveys of Beaufort's Dyke to find out if the area had been polluted by the munitions, which had been dumped there. Samples of sediment and the edible flesh of fish and shellfish taken from the area were examined for a range of contaminants but laboratory tests confirmed that none were present. Laboratory tests of the samples also revealed no trace of explosives.

Turning to the disposal of chemical weapons (cw), these were partially disposed of by MOD between 1945 and 1957 through deep sea dumping at a number of locations in the Atlantic. The process involved loading surplus cw in sealed containers on to redundant merchant ships and then scuttling these vessels at pre-selected deepwater sites in the Atlantic. Munitions were dumped in water between 500 and 4,200 metres deep.

Wreck dumping of cw in the Atlantic took place in four distinct phases. Phases 1 (1945 – 48), 2 (1949 –51) and 4(1956) involved the disposal of some 120,000 tons of mustard and phosgene charged munitions. Records for Phase 4 are incomplete and there is no clear evidence that the usual practice of sealing cw into containers and dumping it in scuttled merchant ships was followed during this Phase.

Phase 3 (Operation SANDCASTLE (1955 – 56)) involved the disposal of 14,000 tons of Tabun-charged munitions confiscated from Germany after World War Two. Additionally, 300 tons of arsenical compounds and 3 tons of toxic seed dressings were dumped on behalf of other Government Departments during this operation.

The inert arsenical compounds were in powder form and sealed in drums from a Ministry of Supply depot. The 3 tons of toxic seed dressings were in 50 containers, and came from HM Norfolk Flax Establishment.

Tabun and phosgene become ineffective through dilution and hydrolysis. Mustard gas being heavier than water would stay on the seabed. Furthermore, at the depths where the ships were scuttled, seawater movement is very slow. Any chemicals released at these depths would not present a health hazard.

None of the three cw agents (tabun, phosgene, mustard gas) were the “Nazi Death-Camp gas”. The Nazis used carbon monoxide from internal combustion engines and “Zyklon-B” as their lethal agents in the gas chambers.

In addition, the allied nations undertook dumping of confiscated German chemical munitions into the Baltic and Skagerrak between 1945 and 1947. The total tonnage of cw dumped at sea in the Skaggerak by the UK was in the region of 120 – 130,000 tons. Although we have no contemporary material that confirms the exact scuttling locations of the majority of the vessels believed to have been used in the UK cw dumping programme, all the available evidence indicates that the Skaggerak was used as the UK’s sole scuttling site. A contemporary document records the location of the site as between 53 degrees 14 minutes North (53 14 N) 09 27 E; 53 19N 09 40E; 53 17N 09 40 E.

The cw covered a wide range of types, primarily the more common vesicants and blood agents. However, it should be noted that some shells from the French Zone dumped by the UK in the Skaggerak contained nerve agent.

Many records of past sea dumpings of conventional munitions and chemical weapons were destroyed as a matter of custom and practice after World War II. Those records, which remain in existence, are held at The National Archives at Kew. Should you wish to find out more, you can access details of the National Archives at http://www.nationalarchives.gov.uk/

For your information, however, I am attaching as an Annex to this letter a list of the sites used for the disposal of conventional munitions and details of past dumping of chemical weapons in the Atlantic. This information has also been made available to the UK Parliament, and, in 1998, to the Oslo-Paris (OSPAR) Convention. The OSPAR website contains information on sea dumping by all other countries who have signed the Convention, with the exception of Portugal, which has still to supply such information. The OSPAR website is at: http://www.ospar.org/

Details of sea dumpings of cw in the Skaggerak were made available to the Helsinki Commission in 1993.

Turning to the disposal of radioactive waste, I can confirm that, in the past, some MoD radioactive waste has been dumped at sea. From 1946 to 1993, the United Kingdom disposed of amounts of both civilian and radioactive waste at sea, in accordance with national policy and legislation, and with later international agreements regulating such disposals. These disposals were seen at the time as routine and uncontroversial. The dumpings were carried out as part of the national programme of radioactive waste disposal at sea, run by the United Kingdom Atomic Energy Authority (UKAEA) as the UK's competent national authority..

Dumping at sea of radioactive waste was carried out after World War Two into two sites: the Atlantic Deep and the Hurd Deep. Arrangements for such dumping were subject to approval by the then Ministry of Agriculture Fisheries and Food (MAFF) Approval Committee, whose procedures included careful checks on the containment and transport of the waste. Dumping areas were chosen at least fifty miles seaward of the Continental Shelf, well away from fishing grounds or cable routes where there might be a risk of accidental retrieval or other contact.

The Atlantic Deep dumpsite is located 48 degrees 20 minutes North, 13 degrees 40 minutes West, approximately 400 miles south west of Land's End. It was used to dump up to 1,500 tons per year of highly active radioactive waste at a depth of not less than 1,500 fathoms. Between 1949 and 1968, approximately 53,800 containers, with a gross weight of 29,000 tons, were dumped at this site. Records show that the estimated total activity in curies for these dumpings was:

Alpha activity:	4,000 curies;
Beta-Gamma activity:	117,200 curies.

Approved containers used for radioactive waste dumped in the Atlantic were designed to sink quickly to the seabed and remain intact for a number of years. The containers were steel drums with concrete linings, with provision for permitting pressures to equalise during descent so as to avoid implosion at depth. Such activity as may emerge when the drums break up would be harmless in the conditions of dilution and dispersion afforded by the ocean. Even if activity escaped immediately, it would present no hazard in these conditions.

The other approved dumpsite, Hurd Deep, is located in the English Channel north west of the Channel Islands at position 49 degrees 30 minutes North, 3 degrees 34 minutes West. It was used after World War One for dumping of chemical and some conventional weapons, and from 13 July 1945 to 31 July 1946 for the dumping of conventional munitions. Further routine dumpings took place there until 1973, with an emergency dump of munitions in 1973 – 74.

Dumping of radioactive waste into the Hurd Deep took place after World War Two until 1973. After this date, when the dumping of high level radioactive waste was banned under the London Convention, the sole approved UK dumpsite for radioactive waste was the Atlantic Deep.

Hurd Deep was used to dump up to 5,000 tons a year of low activity waste, which was not to exceed 200 curies of alpha, and 4,000 curies of beta-gamma, radiation. Between 1950 and 1963, approximately 61,550 containers, with a gross weight of 16,300 tons, were dumped in Hurd Deep. Records show that the total estimated activity in curies for these dumpings was:

Alpha activity: 400 curies.

Beta-Gamma activity: 1,200 curies.

The very low active waste (mainly sludges) dumped into the Hurd Deep was packed in approved light metal drums to permit rapid dispersion of the contents.

It may be helpful to explain the activity of types of radioactive waste. Alpha contaminated waste is characterised by less penetrating radiation, which is easily absorbed by matter. It is not dangerous to living organisms unless inhaled or ingested. It only requires secure containment in transportation. Reliance on natural decay for alpha wastes is not usually profitable since half lives may be very long. In this context, the most important alpha active isotopes are plutonium 239 and americium 241.

Beta and Gamma wastes are characterised by much more penetrating radiation and must be transported in containers designed to provide adequate shielding from such radiation, if necessary. This radiation penetrates matter more strongly and is dangerous to living organisms whether or not ingested. In a typical mix of beta and gamma radioactive waste only 10% of the original activity may remain after 25 years and only 1% after seventy years. The important beta isotopes are ruthenium 106, zirconium 95 and niobium 95.

Details of the disposal programme of radioactive wastes were contained in a Department of the Environment report entitled "Report of the Independent Review of Disposal of Radioactive Waste in the Northeast Atlantic". The report was published in 1984; it is available to members of the public. Sea dumping of high level radioactive waste was banned globally under the London Convention of 1972, although this did not cover the disposal of intermediate and low level waste.

In 1993, the Ministry of Defence agreed to an indefinite ban on the disposal at sea of intermediate and low level radioactive waste, although in practice such dumpings had been discontinued by the UK in 1983.

I should add that the Ministry of Defence is not aware of any dumping of defence radioactive waste in Beaufort's Dyke. However, the Government is aware of the dumping of small quantities of low or intermediate level radioactive waste in Beaufort's Dyke between 1953 and 1957. This was prior to the making of any legislation controlling such disposal operations. The material was mainly contaminated laboratory waste and radioactive luminous paint. MAFF was consulted about these dumpings and provided subsequently with details of the dates and positions of the dumping operations. Levels of contamination resulting from these dumpings are likely to have been low. Monitoring by MAFF (now Department for Environment Food and Rural Affairs – Defra) of radioactivity levels in Beaufort's Dyke has never detected any localised increase in radioactivity.

R.BOWLES

MOD - DSC-Env1

Annex E

EXPLOSIVE ORDNANCE SAFETY AND INFORMATION

1 UNEXPLODED ORDNANCE

Since the end of WWII, there have been a limited number of recorded incidents in the UK where bombs have detonated during engineering works, though a significant number of bombs have been discovered.

The threat to any proposed investigation or development on the site may arise from the effects of a partial or full detonation of a bomb or ordnance item. The major effects usually being shock, blast, heat and shrapnel damage. It should be noted that the detonation of a 50kg buried bomb could damage brick/concrete structures up to 16m away and unprotected personnel on the surface up to 70m away from the blast. Larger ordnance is obviously more destructive. Table 2 denotes recommended safe distance for UXO.

Table 1 Safety Distances for Personnel

UXO (Kg)	Safety Distances (m)			
	Surface UXO		Buried UXO	
	Protected	Unprotected	Protected	Unprotected
2	2O	200	10	20
10	50	400	20	50
50	70	900	40	70
250	185	1100	120	185
500	200	1250	140	200
1000	275	1375	185	275
3000	450	1750	300	450
5000	575	1850	400	575

Explosives rarely become inert or lose effectiveness with age. Over time, fuzing mechanisms can become more sensitive and therefore more prone to detonation.

This applies equally to items that have been submersed in water or embedded in silt, clay, peat or similar materials.

Once initiated, the effects of the detonation of the explosive ordnance such as shells or bombs are usually extremely fast, often catastrophic and invariably traumatic to the personnel involved.

The degradation of a shell or bomb may also offer a source of explosive contamination into the underlying soils. Although this contamination may still present an explosion hazard, it is not generally recognised that explosives offer a significant toxicological risk at concentrations well below that at which a detonation risk exists.

2 TYPES OF ORDNANCE

2.1 **German Air Delivered Ordnance**. Technical information on the nature and characteristics of the ordnance used by the German Air Force during both world wars has been available for a number of years. Assessment that began during the 1930's has continued to the present day. Research has been conducted in many countries by experts as part of national research programmes and as individual research projects. Consequently a well informed assessment of the threat posed by unexploded ordnance, and the hazards that they represent, can be made with a high degree of confidence.

3 **Terminology**. It should be noted that two terms used in bomb records can lead to some confusion as to their meaning and therefore significance. The term Unexploded Bomb (UXB) refers to a bomb that has fallen, failed to function and has been subsequently dealt with and removed from the site. The term Abandoned Bomb (A/UXB) refers to a UXB that could not be found or recovered, or the decision was taken not to pursue the matter further. Consequently the unexploded bomb remains where it came to rest when it was dropped or fell to the present day. It should also be noted the word 'bomb' can be used to describe an airdropped bomb or a shell as in some cases no differentiation was made and the term was interchangeable.

4 **Abandoned Bombs**. The records of known abandoned unexploded bomb locations in the London area were released in response to a written Parliamentary Question from Simon Hughes. (Hansard: Volume; 282. Dated 15th October 1996). The information was provided by the Ministry of Defence (MOD) and supplied under an indemnity.

5 **Explosive Ordnance Failure Rates**. Over the course of both World Wars a considerable quantity of ordnance dropped on UK targets failed to function as designed and subsequently penetrated the ground without exploding. Information gathered during the war by the MOD and its research partners provide typical failure rates for different types of ordnance. Figures significant to this study are:

5.1 10% of all German airdropped bombs failed to function as intended.

5.2 30% of all anti-aircraft and other types of shells failed to function as intended.

6 **Deductions & Considerations**. The following points were considered as part of the assessment and have been given due consideration:

6.1 Records were found that indicated that the general area was subjected to heavy bombing.

6.2 Bombs which struck previously hit or burned out targets and did not function; consequently their impact was unseen and therefore no report was ever made.

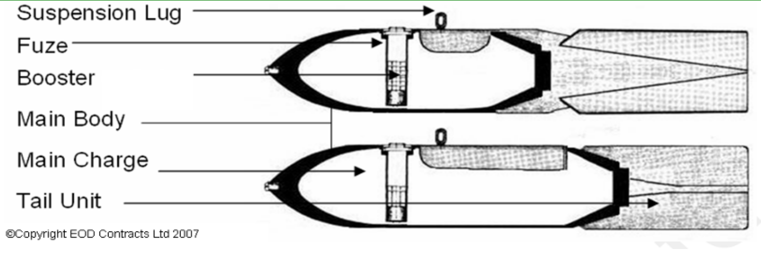
6.3 In all likelihood, the local anti-aircraft battery would have fired a far higher number of shells than the bombers dropped HE bombs. Contamination by anti aircraft shells can not be rules out.

7 **Generic German Bomb Types**. The majority of German bombs dropped were 50kg in weight, accounting for approximately 16% of the total bombs dropped. The range of common bombs increased in weight to a maximum of 1700kg. Regardless of size, German bombs were fitted with one or more Electrical Condenser Resistance (ECR) fuzes many of which included a mechanical component. The fuzes were mounted transversely in the bomb body with the booster directly below, and in contact with, the fuze. The booster; sometimes referred to as the Gaine, is composed of a sensitive explosive material (Picric Acid). Picric Acid is known to deteriorate over time becoming

increasingly unstable. The internal layout of two common German bombs and a German fuze is shown in Figures 6.1 & 6.2.

FIGURE 6.1 Generic German Bomb Design.

Graphic Cross Section through the most common German bombs (50kg)



Note; the diagram shows that there can be a significant difference in the quantity of High Explosive contained within bombs of similar size and shape; the Grade 1 bomb on the bottom having 30% more HE than the Grade 2 shown at the top. This serves to demonstrate the importance of an accurate identification of any item of UXO.

FIGURE 6.2 Generic German Bomb Fuze Design.

Graphic Cross Section through a typical German fuze (ECR)

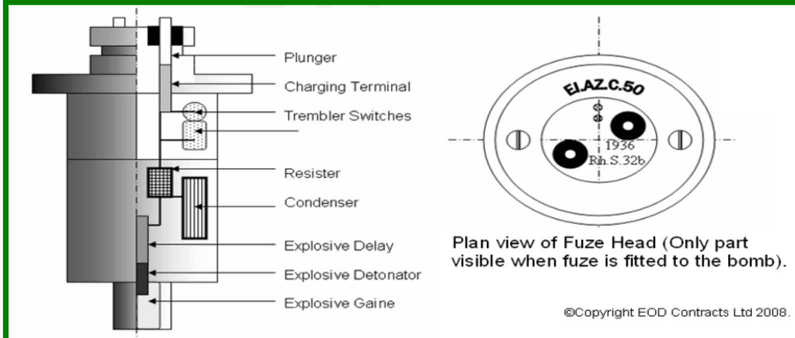


FIGURE 6.3 Range of HE bombs dropped on the United Kingdom.

German bombs

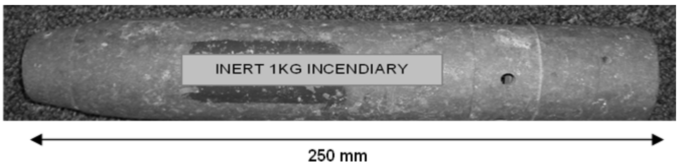
The smaller sub-munitions (Bomblets) seen to the right, ranged in size between 1 and 3kg, were dropped in large numbers and were intended as incendiary bombs, anti-personnel bombs or as bombs filling both roles. The smaller bomblets were dropped in larger container bombs designed to hold between 360 and 620 of the bomblets. The containers were designed to burst open at a predetermined height above ground level, dispersing the bomblets over a wide area. Air raid damage was far greater by using both incendiary, and HE bombs on a single raid. The fires started by the incendiaries being rapidly spread by the blast waves from the HE bomb. This scenario was shown to devastating effect on the 14th February 1945 in the German city of Dresden. Where fires started and spread by the bombing increased to a point where the oxygen was being sucked into the flames at such a high speed that the fire became a "Fire Storm". At the time the city's population had increased due to a high number of refugees fleeing the Russian advance to the east, the exact civilian death toll from fire and suffocation will never be known, but is considered to be somewhere between 25,000 and 100,000.

7.1 High Explosive (HE) Bomb. Some of the most common type of ordnance to be dropped on the United Kingdom, HE bombs are often the type encountered as UXBs. Relatively thick cased, they are still recovered in remarkably good condition. Ranging in size from 50 to 1700 kg, their typical release height (1,500m) allowed them to penetrate deep into the ground as a result of design or flaw. Towards the end of the bombing campaign, as steel became scarce the German Engineers produced a range of bombs that used steel reinforced concrete as the bomb body. Figure 6.3 shows the range of steel HE bombs dropped on the UK.

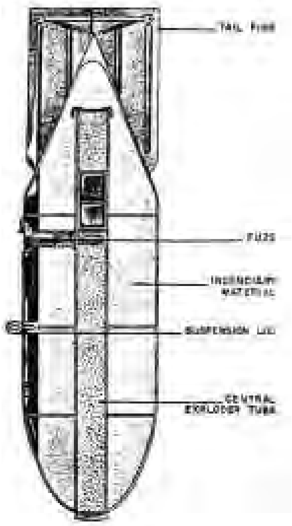
7.2 Incendiary Bomb. The larger incendiary bombs, containing bottles of white phosphorus and an incendiary mixture contained within a thin steel case were designed to burst on contact with the ground. The smaller type of bomb or 'Bomblet' was delivered to the target area in container bombs or by a fixed dispenser on the aircraft; both types of container would open dispersing the smaller Incendiary bombs. Relatively small and light they were unlikely to penetrate the ground to any significant depth. However, once concealed in bomb damage rubble or below water they were easily missed and are still unearthed today from in-fill and drained land. Later versions of the incendiary bomb contained an additional explosive charge used as a short delay "Booby Trap" device that contained a significant amount of high explosive. The Booby Trap component was designed to kill or injure fire fighters and hinder the damage control. See Figure 6.4.

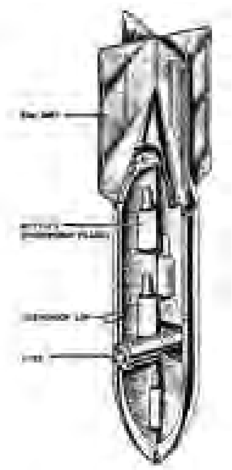
FIGURE 6.4 Incendiary Bombs.

Common German Incendiary Bombs



Above 1kg incendiary bomblet, below left the larger 500kg incendiary bomb
Below right a 50kg incendiary bomb containing bottles of white phosphorus.



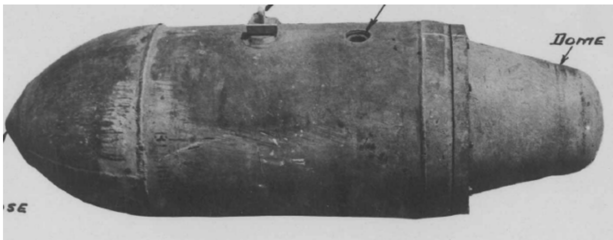


Note; Incendiary bomblets were made of a flammable alloy similar in appearance to aluminium, which resists corrosion well. The tail unit was made of thin tin-plate steel and is more prone to have rusted away. Some Incendiary models were fitted with a High Explosive (HE) steel nose. With the tail and explosive nose attached the bomb was 480mm long.

7.3 Blast Bomb / Parachute Mine. The parachute mine was extensively used on land and at sea and was fitted with specialist fuzes designed to trigger the weapon at a predetermined altitude, water depth or to switch on other magnetic influence mechanisms to trigger the weapon when a ship approached (Magnetic or Acoustic influence). While early versions were based on the standard 1000kg SD Bomb case others were specially designed and manufactured with an aluminium body, making them extremely difficult to detect using magnetometers. The thin cased versions would normally disintegrate on impact on land and are normally considered to pose little threat to work on land based projects, but the risk increases significantly on projects over water or in marshland. Thicker cased versions however will survive impact and pose a significant risk regardless of the local ground conditions. (See Figure 6.5)

FIGURE 6.5 Common Airdropped Mines.

Parachute & Ground Mines



Note; all mine fuzes were designed to arm after deployment from the ship, submarine or aircraft, some fuze designs incorporated anti-removal booby traps. Unexploded mines found today are the result of a failure within the arming mechanism or procedure whereby the mine never fully armed. Sudden shock or jarring of a weapon in this state has the potential to complete the arming sequence and could result in the mine detonating with lethal consequences.

7.4 Non Steel Cased Bombs. Used primarily in the construction of training or practice bombs, some high explosive variants were introduced towards the end of the war. With resources running scarce, German Engineers produced a small number of blast bombs with a concrete body. The design utilised a steel framework onto which concrete was cast. The explosive filling was also contained within a thin steel container within the bomb body. Very few "concrete" bombs were dropped on the UK. In common with standard steel cased weapons, this type of bomb can be detected using standard magnetometer detection techniques (albeit; providing a smaller ferromagnetic signature than its all steel counterparts). This type of bomb represents a very small percentage of the total number of bombs dropped worldwide and are not considered a significant threat, particularly when viewed from an overall bomb threat in the UK.

7.5 Anti-Personnel Bomb. Generally these were small weapons of 1-3 kilograms in weight and are often referred to as ‘Bomblets’ and possessing similar ground penetration ability as the Incendiary Bomblets. They were often located during the post-raid searches. This type of bomb has been recovered within the bomb rubble being cleared or used as in-fill on construction projects and poses the same potential to function as the Incendiary bomb with a greater potential to cause localised casualties.

7.6 Specialist Bomb. These types of bombs were designed to meet a specific mission requirement. Typically, this would be a design modification or special fusing to enable the bomb to destroy hardened/armoured targets or deep buried and sub-marine targets. Similar to the more common HE bombs, they differ in that they rarely contain large amounts of high explosive. Therefore the consequence of a detonation is reduced but remains a significant risk, particularly when the detonation occurs on or near the surface.

7.7 Depth Bombs & Depth Charges. These types of weapons were designed to meet a specific mission requirement. Typically, the modifications would include the type of explosive filling and special fusing to enable the bomb to penetrate to a significant depth into the ground or water before detonating. Depth bombs intended for maritime attack and sub-marine targets would be fitted with one or more fuzes, one of which would be a hydrostatic fuze designed to detonate the bomb at a predetermined depth. The bomb would be fitted with an anti skip ring to reduce the deflection of the bomb as it entered the water. Similar in many ways to Depth Bombs, Depth Charges were exclusively designed to detonate at a predetermined depth. This was achieved by fitting the Charge with a short time delay or hydrostatic fuze. Depth bombs; having a similar configuration to general purpose bombs had the potential to penetrate deeply into the sea bed where an attack occurred in the relatively shallower water of a dock.

7.8 Unmanned Rocket Bombs & Missiles. The most famous in this category of weapons were the V1 (Fi103 flying bomb) commonly known as the Doodlebug and the Larger V2 (A4 missile). Both V1 & V2 with high explosive warheads containing 850kg & 1000kg (respectively) represent some of the largest weapons to land in the United Kingdom. Both types were built in a similar manner to an aircraft and would generally disintegrate on impact even if the warhead failed to detonate. The impact would spread debris over a wide area which was difficult to miss and any resulting unexploded ‘V’ weapons were comprehensively dealt with at the time. For this reason they are rarely encountered on land. However, where a ‘V’ weapon landed in water the opportunity for the event to have been missed and/or follow-up action abandoned was greater and they continue to pose a significant risk. Other, less well known rocket bombs were also produced by the Luftwaffe to attack maritime targets. Some were equipped with TV/Radio guidance from the parent bomber. Two of the most common were the Fritz X which consisted of an adapted SD1400kg bomb and the Henschel Hs293 which was based on a smaller 500kg bomb. No record of one having been recovered on land as a UXB can be found but these large HE bombs are considered to pose a significant risk, particularly to maritime projects. No records were found to indicate this type of bomb was ever used on targets in the area.

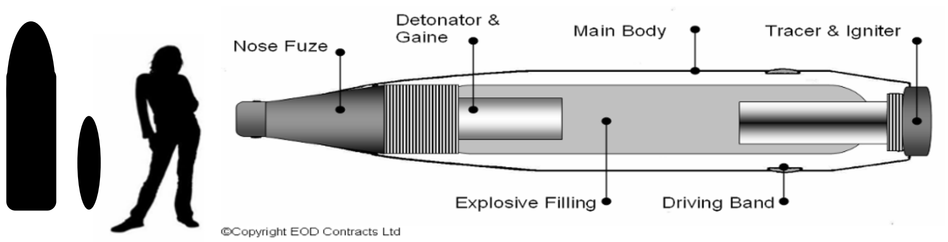
7.9 Photoflash Bomb. This type of bomb was dropped by specialist “Pathfinder” aircraft and although this type of bomb can be included with the category of specialist bombs, it is worthy of specific comment due to the danger it may still pose. Photoflash bombs were designed to explode with a blinding flash, rather like a camera flashbulb. They were used to enable photographs to be taken of targets at night and also served to identify ground targets for other aircraft to attack. The speed at which the highly energetic filling detonated, and energy it produced in doing so, was significant. Although these bombs were thin skinned and are prone to corrosion the functioning of one can be compared to a high explosive bomb detonation.

8 **High Explosive Shells & Projectiles**. As mentioned previously, one of the most common sources of UXO contamination encountered in the United Kingdom is High Explosive Shells and Projectiles. This is most commonly found to be as the result of firing practice ranges, bombardment and anti-aircraft defence, the latter often positioned to defend Major cities and Strategic installations and ports from German Bombing. Anti Aircraft Shells and projectiles are generally smaller (Up to 4.7" inch diameter) than the airdropped bombs and as a consequence were more easily missed amongst the bomb rubble. However, coastal bombardment guns could fire a shell weighing 1000kg, (larger than most common airdropped bombs) and capable of significant ground penetration. The generic layout of a projectile can be found at Figure 6.6. It should be noted that the fatal incident on the German autobahn in 2006 was thought to be the result of a shell or projectile detonating, not an airdropped bomb as first reported.

8.1 The Fuzes used in Anti-Aircraft Ammunition were designed to ensure the projectile would detonate in contact with the target, or at a pre-set altitude, or in close proximity to the target. The fuzes employed different means to achieve this, including; direct impact, or indirect impact, Barometric, Delay and Electro-magnetic influence. Some were fitted with more than one fuze, which served to reduce the chance of the projectile falling to earth and detonating. Artillery fuzes are activated during the firing process, using the projectile's acceleration or spin within the gun barrel to switch off the safety mechanisms. For this reason fired projectiles are considered more dangerous than unfired ones.

FIGURE 6.6 Generic Shell Design

Scale & Graphic Cross Section of a typical High Explosive (HE) Shell



Approximate size of a large shell used by battleships and coastal bombardment guns (Left) and Anti-aircraft shell (Right)

9 **Other Types of Ordnance**. The following additional sources of ordnance types have been considered, and inherent risks taken account of:

9.1 Flares and Pyrotechnics. Flares and pyrotechnics were used for a variety of reasons throughout the war and continue to be found today in the most unlikely places. However, due to the thin casings of these weapons a high level of corrosion is likely to have occurred since manufacture. Depending on the specific nature of the weapon, this effectively renders them inert with the exception of any white phosphorous content or explosive gaine.

9.2 Land Service Ammunition (LSA). While as the name implies this type of ammunition was designed for use on land, it was also issued to naval personnel for close protection of vessels and their crew and to provide a limited offensive capability even to relatively small craft. This type of ammunition includes some shells and projectiles such as those covered previously. Other natures of LSA range from Small Arms Ammunition (SAA), having little or no high explosive content to Grenades, Mortars and Rockets which may pose a risk of detonation due to their explosive content and the design of their fuzes (impact) which; if subjected to sufficient shock or friction may result in the weapon functioning. (See Figure 6.7)

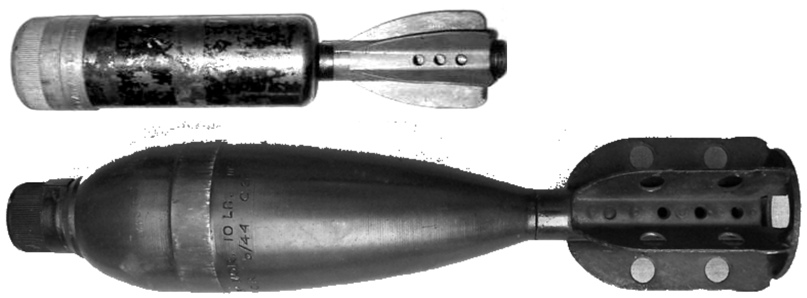
FIGURE 6.7 Common Categories of Land Service Ammunition

Land Service Ammunition

Small Arms Ammunition

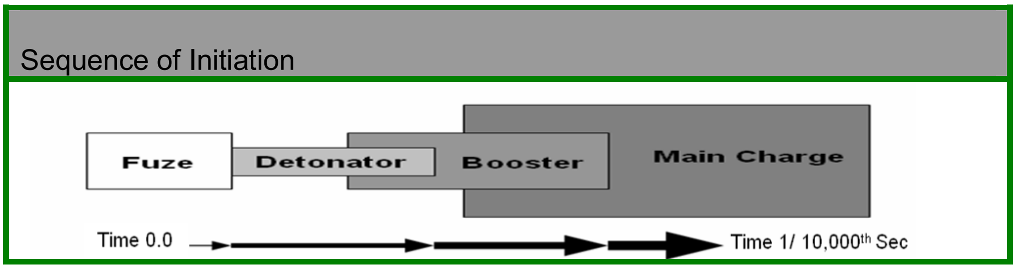
Grenades

Mortar Bombs



10 **Initiation of Unexploded Ordnance**. Explosive Ordnance is highly unlikely to spontaneously explode. The energetic chemical compounds, (Explosives) used in weapon manufacture are chosen to be as stable as possible and they all require a significant application of additional energy to create the right conditions for detonation to occur. If stored correctly, most explosive materials are designed to remain stable for the duration of their expected lifespan (typically 20 years). During this time, the correct functioning of the weapon is achieved by means of the ‘Initiation Train’ (See Figure 6.8).

FIGURE 6.8 Explosive Ordnance Initiation Train.



11 **Initiation Train**. This is a means by which, once the safety features have been switched off or removed, a chain reaction occurs through the weapon. Starting within the fusing system as a small ignition or spark, causing a detonator to explode, which in turn causes the booster charge to detonate with a greater energy and ending in the full detonation of the main explosive filling. Each part of the process has in-built safety features to prevent an unintended detonation. A failure in any of the components within the Initiation Train can result in a UXO. In the case of a UXB; the chain reaction has broken down and the Initiation Train is brought to a halt, albeit, a temporary one. There are a number of ways that sufficient energy could be introduced to the otherwise stable UXB / UXO that may allow the Initiation Train to set off once more, overcoming the initial reason for failure. In addition to subjecting the weapon to excessive heat, such as a fire, the most common methods to bring about an explosive detonation in such items are considered to be:

11.1 Direct impact onto the main body of the bomb by mechanical excavation or pile driving: Such an occurrence can cause the bomb to detonate, should the point of impact be on the bomb fuze; less force would be required to bring about a full or partial explosive detonation.

11.2 Re-starting the clock timer in the bomb fuze. Only a small percentage of bombs were fitted with clockwork fuzes. It is likely that corrosion has taken place within the fuze that may prevent the clockwork mechanism from functioning. However, the restarting of the clock is by no means a scenario that can be completely ruled out. This is considered to be one of the two most credible mechanisms by which sufficient energy could be introduced to the bomb and result in a detonation.

11.3 Induction of a static charge or exposure to an external power source (Electrical Services), causing a current in an electrical fuze. The majority of German bombs employed an electrical component within the fuzes, it is likely that corrosion would have taken place within the fuze mechanism and that it would no longer contain, or conduct sufficient electrical charge to initiate the bomb.

11.4 Friction initiating the sensitive fuze explosive. Some chemical constituents may have deteriorated, due to oxidisation. Components designed with a high degree of stability at the time of manufacture may no longer be as safe. **This is considered to be the most likely mechanism by which sufficient energy could be introduced to the bomb and result in a detonation.**

Annex F

Risk Assessment Tables

Table 1 Summary of Potential Contamination Sources

Summary of Potential Contamination Sources		
Source	**Applicable**	**Not Applicable**
Enemy Attack & Counter Measures		
Bombing WW1		☒
Bombing WW2		☒
V1 & V2 Rockets		☒
Shelling or Bombardment		☒
Anti-Shipping Mines & Depth Charges	☒	
Anti-Aircraft Shells & Rockets Larne only	☒	☒
Beach Mines & Coastal Defences		☒
Airfield/Key Point Defensive Mines/Charges		☒
Abandoned Unexploded Bomb (A/UXB)		☒
Migration of UXO		
UXO Migration in Rubble & Infill		☒
UXO Migration by Tide & River Current	☒	
UXO Migration by Marine Dredging	☒	
Ship Wrecks	☒	
Dispersal by Explosion, Fire & Accident		☒
Aeroplane Crash		☒
Private Collections		☒
MOD Facilities		
Bombing Range		☒
Artillery, Mortar & Tank Range		☒
Grenade Range		☒
Small Arms Firing Range		☒
Weapon Research & Development Facilities		☒
Ammunition Burial Grounds		☒
Offshore Ammunition Dumping Grounds	☒	
Ammunition Storage & Manufacture Sites		☒
Airfields & Air Stations		☒
Bombing Decoy Site		☒
Army Barracks & Camps		☒
MOD Training / Concentration Areas		☒
Home Guard & SOE Weapon Caches		☒

Table 2 Potential UXB Density Assessment

Item	Strikes Within 100ht	Size of Site (ht)	Estimated Failure Rate	*Potential UXO Present
	(a)	(b)	(c)	(d)
UXO Migration	**Indeterminate due to unknown number of quantities**			

Table 3 Construction Activities Encounter Indicators

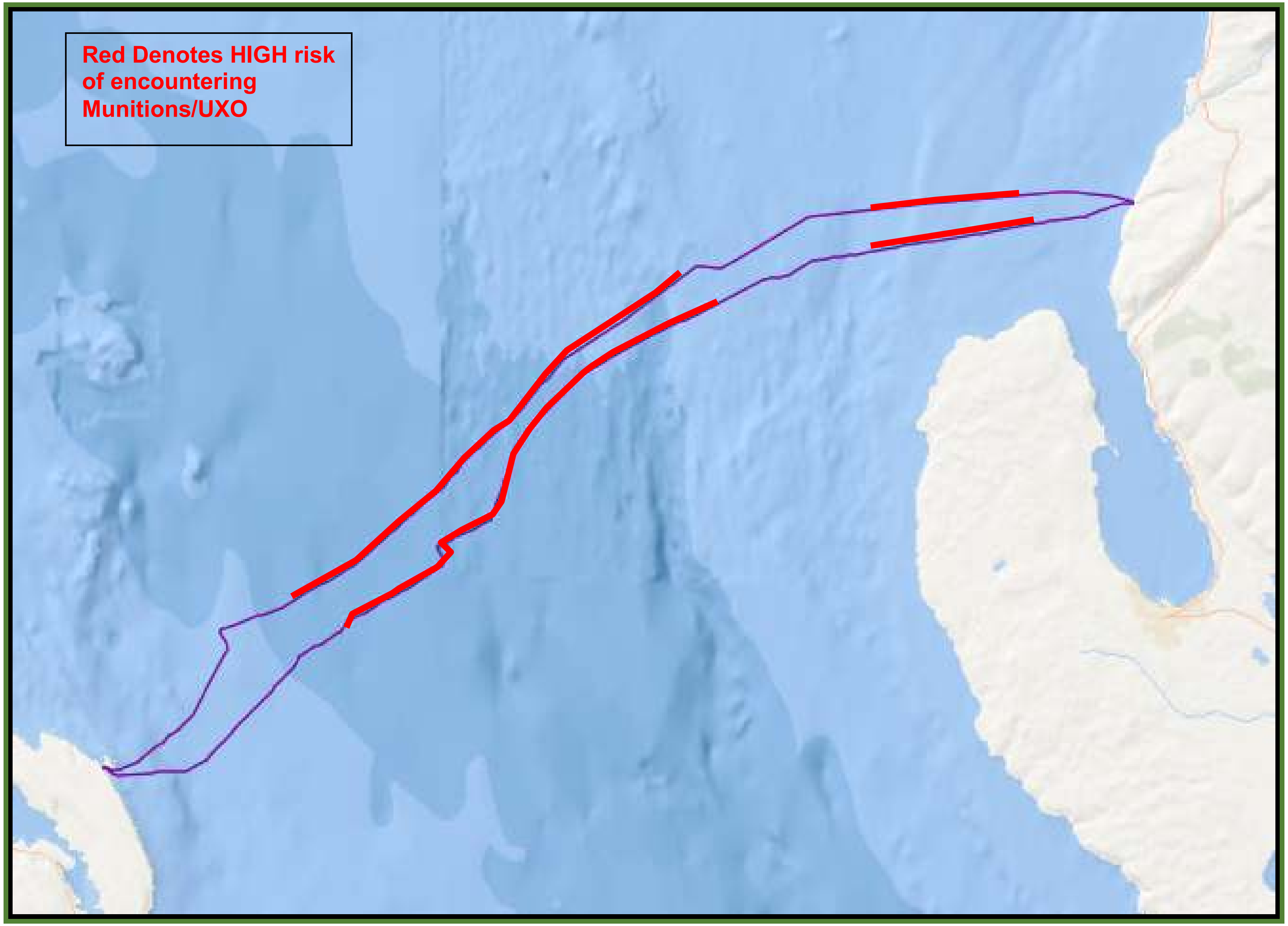
	Increasing Potential level ⇨
	Cable Laying at Depth
	Jetting
	Ploughing
Activities	Pre-Lay Grapnel Run (PLGR)

Table 4 Consequences of an Encounter.

Description	Code	Definition
Fatality	5	Immediate or subsequent death due to injuries sustained or through drowning.
Severe Injury	4	Fracture of major bone or skull. Amputation of Limb. Loss of eye and / or sight. Unconsciousness requiring resuscitation. Any illness or injury requiring medical treatment and/or 12 months work absence.
Major Injury	3	Fracture of joint. Unconsciousness. Extensive or deep burn. Amputation of hand or foot. Any illness or injury requiring medical treatment and/or 1-12 months work absence.
Serious Injury	2	Severe cuts, scratches abrasions and lacerations. Severe bruising, sprains and strains. Minor burns Dislocation or fracture of digits. Minor head injury including temporary loss of hearing or sight. Any illness or injury requiring medical treatment and/or 3 days to 1 month work absence.
Minor Injury	1	Minor muscle or eye strain. Prolonged discomfort or minor ill health. Any illness or injury resulting in up to 3 days work absence.

Annex G

RISK MAP



A.2.13 – Compass Deviation Risk Assessment

MOYLE INTERCONNECTOR PROJECT

COMPASS DEVIATION RISK ASSESSMENT

NAVIGATION AND SAFETY RISK TO VESSELS OPERATING WITH A MAGNETIC COMPASS

Report Reference. P1796_R3608_Rev1

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SUMMARY

Moyle Interconnector Ltd, a subsidiary of Mutual Energy Ltd own and operate the existing HVDC interconnector between Northern Ireland and Scotland. The system is currently running at half capacity due to cable faults with the integrated return conductor. Installation of two new separate metallic return conductor (MRC) cables is planned to return the system to full capacity.

DC currents along cables induce magnetic fields. In the original cable configuration, the current in the return conductor generated a magnetic field equal and opposite to that generated by the main conductor such that the two opposing fields cancel out. However with the new, separate MRC cables there will be areas in the immediate vicinity of the cable where the two fields no longer cancel. The resultant field can interact with the earth's magnetic field and cause magnetic compasses to deviate.

Theoretical modelling, validated through trials, was conducted by DNV KEMA to calculate potential magnetic compass anomalies. The results demonstrated that a small proportion of the route (between 3% and 6% of approx. 53 km) had results above 3°. Depending on cable separation distance, deviations in nearshore route can be substantial, up to 180°.

Intertek Energy & Water Consultancy Services was commissioned to assess the potential risks associated with the predicted magnetic anomalies and to identify mitigation options both to ensure that the residual risks are tolerable and that the installation design for the new MRC cables has reduced risk to as low as reasonably practicable (ALARP).

This report firstly presents the results of a quantitative risk assessment (QRA) that was conducted to determine the potential risks to vessels operating in the vicinity of the nearshore sections of the system. Based on the risk assessment, the report then defines and justifies a nearshore design for the cable route that is judged to be ALARP.

Both ends of the cable (Northern Ireland and Scotland) were considered. However vessel numbers on the Northern Ireland side are considerably higher, such that the QRA was based on Northern Ireland only.

The QRA concluded that:

i. Risk to safe navigation associated with position fixing errors is negligible, as the time taken to take a fix would exceed that of the time the compass was subject to magnetic anomalies. Furthermore, most vessels will use GPS as a means of verifying position and course.

ii. The magnetic anomalies generated have potential to pose a risk only to vessels under sail using a fluxgate-controlled autopilot in shallow water. The potential risk stems from a sudden and unexpected course change by an autopilot.

iii. Vessels taking a nearshore passage are extremely unlikely to transit the cable at less than 10m water depths. At the Northern Ireland side, any which do will be piloting through a course change to avoid the Isle of Muck and are far less likely to be vulnerable to an unexpected autopilot course deviation.

iv. For vessels under sail in waters of depth less than 22m (termed nearshore), the QRA indicates that substantial risk mitigation will be achieved by laying the new MRC cables closer to the existing cables such that the interaction of both serves to reduce deviation to 20° or less.

The ALARP assessment balanced compass deviation risk against risks to safety and the cable integrity associated with installing the MRC cables too close to the existing cables.

It is concluded that an ALARP solution is provided by cable route design and installation in the nearshore zones, whereby:

- At water depths between 10m and 22m LAT the MRC cables are laid close enough to the existing HVDC cables to limit compass deviation to less than 20°.
- At water depths shallower than 10m LAT, the MRC cables are laid as close as reasonably practicable to the existing HVDC cables but without disturbance to the existing cable protection; i.e. alongside the edge of any existing rock berm protection or approximately 4m separation.

CONTENTS

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FIGURES

GLOSSARY

ALARP	As Low As Reasonably Practicable
DC	Direct Current
F3	Beaufort Force 3 (similar for F4, F6 AND F7)
GPS	Global Positioning System
HVDC	High Voltage Direct Current
IRC	Integrated Return Conductor
KP	Kilometre Point (marking distance along the cable).
LAT	Lowest Astronomical Tide
LV	Low Voltage
MRC	Metallic Return Conductor
RYA	Royal Yachting Association

NAUTICAL TERMS

Broach: A boat can broach if its heading suddenly changes resulting in a steering imbalance for which the rudder cannot then compensate.

Drying Obstruction: A charted underwater hazard (such as a rock) that is exposed during low water.

Gybe: a manoeuver by which a sailing vessel (usually sailing with the wind behind the vessel) turns so that the wind passes behind the boat and the sails move to the other side of the boat. An involuntary gybe occurs when the wind shift changes such that the balance of the wind and sails changes sufficiently to cause all the sails to move to the opposite side without warning.

Short-handed: Depending on the size of the vessel, a practical number of crew will be required.

Transects: A straight line or narrow section through an object or natural feature, or across the earth's surface, along which observations are made or measurements taken.

1 INTRODUCTION

Moyle Interconnector Ltd, a subsidiary of Mutual Energy Ltd own and operate the existing HVDC interconnector between Northern Ireland and Scotland. The system is currently running at half capacity due to faults with the integrated return conductor (IRC) cable. Moyle Interconnector Ltd is planning to install two new metallic return conductor (MRC) cables to return the system to full capacity. The new cables are to be installed along a similar route to the existing cables.

Direct current (DC) in a cable induces a magnetic field. In the original cable configuration, the current in the return conductor generates a magnetic field equal and opposite to that generated by the main conductor such that the two opposing fields cancel out. However in the new configuration, with separate MRC cables there will be areas in the immediate vicinity of the existing IRC cable and new MRC cable where the two fields are separated sufficiently so that their interaction with one another does not cancel the overall field effect. The field diminishes rapidly with distance such that this will only be noticeable to vessels on the surface in shallow water. The resultant field can interact with the earth's magnetic field and cause magnetic compasses to deviate.

Theoretical modelling was conducted by DNV KEMA to calculate potential magnetic compass anomalies and resulting compass deviation effects for a number of cable configurations, including the installation of the new MRC cables. The results demonstrated that the majority of the route (more than 97%) had results below 3° deviation. However deviations in the shallow nearshore sections of the route were up to 180°. For the purposes of this report, 'nearshore' is defined as areas with water depths of less than 22 m.

Intertek Energy & Water Consultancy Services (Intertek) was commissioned to conduct a risk assessment of the potential impact of compass deviations predicted by DNV KEMA, their predictions having been validated by ground-truthing survey.

This report presents the results of a quantitative risk assessment (QRA) conducted by Intertek to determine the potential risks to vessels operating in the vicinity of the nearshore sections of the Moyle Interconnector system, once operating with the new MRC cables. Based on the risk assessment, this report defines and justifies a nearshore design for the cable route that reduces the risk to be as low as reasonably practicable (ALARP).

1.1 COMPASS DEVIATION RISK

HVDC cables induce a static magnetic field that, when combined with the Earth's natural magnetic field, can significantly alter values observed by magnetic compasses. In the marine environment where cables are laid on top of or buried within the seabed such alterations will be observed at surface level in shallower waters.

To counteract this effect, HVDC cables are typically installed as a bundle such that the opposing currents in the cables cancel out the effect. For Moyle, in its new configuration with the new MRC cable, the currents which oppose each other will run in the existing IRC and new MRC cables. Laying the new and existing cables in a bundle is not a viable option so there will be a finite separation.

There is, therefore, potential for an induced magnetic field in the vicinity of the cables. The magnitude of the effect reduces rapidly with distance from the cable. In the marine environment, as any effect will be detected at sea level, it is only noticeable in shallow water. In the case of Moyle, it can be shown to have minimal effect in water depths greater than 22m.

The magnitude also depends on[1]:

- Distance between the conductors of a cable pair;
- Magnitude of the DC current;
- Vertical distance between cable pair and compass (i.e. water depth dependent);
- Magnitude and orientation of the local geomagnetic field; and
- Cable route heading (e.g. an cable aligned at 90° to the earth's magnetic field will add or subtract to the field, but not alter the direction – unless the change was sufficient to reverse the direction.

The corridors of influence of the effect at surface level are directly centred over the cables, are relatively narrow (meters) even in shallow waters and tend to narrow further in proportion to the reduction in magnitude.

The effects of compass deviation within these corridors of influence pose two potential risks for vessels which, in this report, are termed:

- Navigational risk – associated with position fixing, or potentially for a vessel running on autopilot in a direction similar to the cable to be 'captured' by a deviation which adjusts the course to run along the cable, and
- Safety risk – arising from the potential for a sudden and unexpected autopilot course adjustment for a vessel crossing the cable.

2 QUANTITATIVE RISK ASSESSMENT

2.1 CHARACTERISATION OF MAGNETIC ANOMALIES

Moyle Interconnector Ltd commissioned experts from DNV KEMA[2] to computationally model the potential magnetic anomaly effects caused by currents flowing in the new cable configuration (i.e. east to west through the IRC cables and west to east through the MRC cables). The calculations were based on the following well-understood theories:

- All DC conductors generate a magnetic field, proportional to the current and aligned according to the ‘right hand screw rule’.
- The magnetic fields generated by two DC conductors bundled together with opposing currents cancel out and have very little magnetic signature.
- Separation of DC conductors can lead to increased magnetic effects, however the strength of the magnetic effect reduces significantly with distance from the conductor (e.g. depth of water / burial in the case of submarine cables).

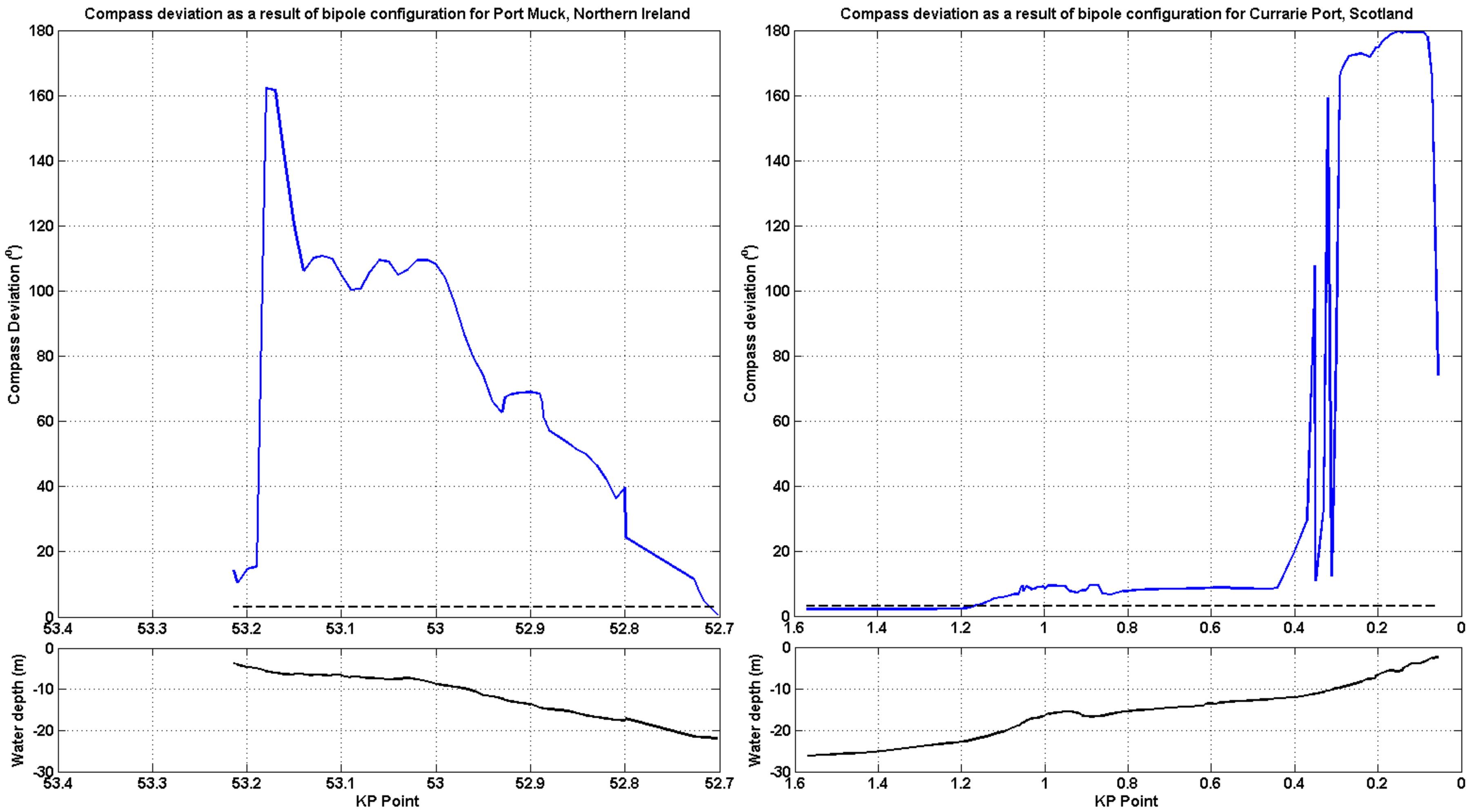
The model incorporated the depth of water and depth of burial in the seabed of the existing HVDC cable. In areas where the cables are protected by rock-placement (rock berm), it was assumed that the cable was laid on the seabed surface as it had not been possible to bury due to soil conditions, this being a conservative approach to the potential surface effects.

2.1.1 Worst case: Outward & Return Current Directed Through Existing IRC Cable Corridors

Worst case deviation would be if current carried by the cables were directed such that "outbound" circuit was through the conductor in one existing IRC cable and the "return" was via the other existing IRC cable. This is deemed worst case because these two existing cable corridors were purposely laid as far apart as possible to reduce the potential of incident such as anchor drag affecting both. But being so disparate, the fields in each have a negligible cancelling effect upon one another. This configuration showed compass deviations of up to 180° in very shallow water with effects felt (at lower levels) up to water depths of approximately 22m or approximately 1 km from the landfall (see **Figure 2-1**). Results were calculated for water depths at lowest astronomical tide (LAT).

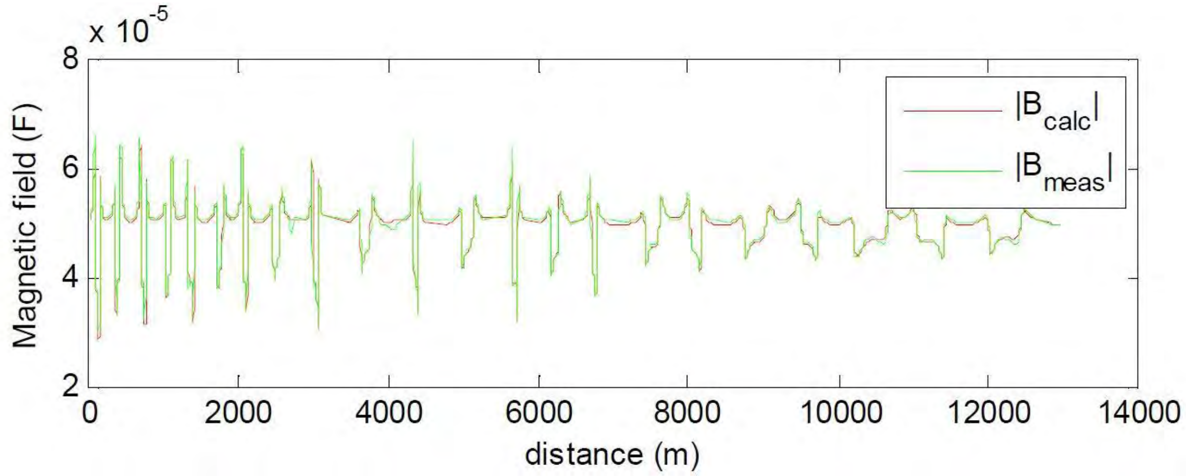
Figure 2-1 demonstrates the effects of this configuration for the Northern Ireland and Scottish nearshore sections. Compass deviation is seen to drop below 3° at a water depth of approximately 22 m. For water depths of up to 10 m, compass deviation effects could range between 60° and 180°.

Figure 2-1: Compass deviation as a result of the bipole configuration for Port Muck and Currarie Port.



It was possible to physically reconfigure the interconnector to create this configuration of current flow in practice and to carry out ground-truth to validate the computational model. Details of the ground-truthing are available in the report by Geomara[3] (see **Figure 2-2**).

Figure 2-2: Comparison of measured and calculated magnetic flux variation for Port Muck, Northern Ireland[2]



Nb. The horizontal axis on **Figure 2-2** refers to the distance travelled by the vessel transecting both cables and heading gradually offshore into deeper water.

2.2 Navigation Risk

The magnitude of compass deviation reduces rapidly with depth, and modelling predicts no significant (above 3°) compass deviation in water depths greater than approximately 22m of water. Noting that any anomaly will be local to the cable, this means that for the central 50 km of cable between Northern Ireland and Scotland, there is insignificant risk to navigation of vessels using a compass.

Most vessels use GPS and navigation software, which will not be affected by magnetic anomalies; however, some may occasionally use a more traditional 3-point fix on stationary landmarks using a handheld magnetic compass. For a vessel transiting the cable the anomaly will last for a very short period (a few seconds), which is shorter than the time needed to take a fix. This means that the error would be apparent when measuring such that there will also be no risk in the nearshore sections of the route.

It can therefore be concluded that navigational risks to vessels are not significant.

2.3 Safety Risk

Unlike navigational risk, a magnetic anomaly affecting the course holding of an autopilot for a short period could have a potentially material impact: if, for example, it led to an unexpected broach. A boat can broach if its heading suddenly changes resulting in a steering imbalance for which the rudder cannot then compensate. The imbalance can result from a combination of angular momentum, wind forces on the sail and wave / drag forces on the hull.

Only vessels in relatively shallow water using a fluxgate controlled autopilot will be at risk and the following are considered:

- Motor vessels taking an inshore passage;
- Yachts taking an inshore passage;
- Yachts in the process of anchoring (NI only);
- Inshore fishing vessels.

At the Northern Ireland end, inshore motor vessels in the vicinity of the cable will be (or about to be) piloting around Isle of Muck. Such vessels will probably not be on autopilot or, if so, will be alert to their situation. Similarly, inshore vessels at the Scottish end will be piloting around the drying obstruction at Currarie Port and should also be alert to their situation.

Like motor vessels, yachts taking inshore passage, will be in ‘pilotage’ mode and alert to their general situation. However, if short-handed, they may be reliant on autopilot for keeping a stable course and a sudden, unexpected course change could have more severe implications for a yacht under sail.

Occasionally, yachts may take up (marked) anchorage in the bay to the South of Port Muck. These vessels can be assumed to have consulted the chart to assess ground conditions, and should be aware of the presence of a cable (and magnetic anomaly). It is also very unlikely that a yacht will be using autopilot with sails up, in the vicinity.

Inshore fishing vessels are assumed not to deploy autopilots. These will be local boats and well aware of the cables.

Of the above, only yachts under sail taking an inshore passage face plausible risk.

2.4 YACHT RISK ASSESSMENT

The risk assessment considers two, water depth dependent areas at each landfall:

- “Nearshore”, representing the section of the cable route where there is elevated compass deviation and where increased vessel risk needs to be considered (this is approximately the 22 m contour);
- “Inshore”, within the Nearshore area, where the deviation is defined to be sufficient to lead to credible vessel risk. The depth at which this occurs will be an output of the risk assessment.

The level of risk will depend on:

- Magnitude of the compass deviation experienced
- Numbers of vessels under sail in the vicinity of the nearshore sections of the cables
- Likelihood of vessel taking an inshore crossing of the cable (for example to counter an adverse tide)

- Likelihood of autopilot being deployed
- Weather conditions (wind strength and wave height) and point of sailing: a course deviation leading to an involuntary gybe could result in a severe incident, one leading to a course change for a few seconds will not.
- Mitigation factors, for example:
  - Vessel safety equipment
  - Pilotage: awareness of magnetic anomaly information on charts

2.4.1 Vessels within the vicinity of nearshore cable sections

Nearshore vessel traffic will be dominated by local fishing vessels and leisure craft.

Figure 2-3 and **Figure 2-4** show the existing HVDC Moyle Interconnector cable landfall locations with Royal Yachting Association (RYA) cruising passages marked on the charts. Each chart shows a 10nm square area, representing approximately 20% of the Moyle Interconnector cable corridor.

In the vicinity of the Port Muck landfall (**Figure 2-3**), one 'medium' RYA cruising passage intersects the 1 km radius, and another medium cruising passage is within 3 km. Local anecdotal evidence would suggest that 'very few' vessels can be seen in this area as there are a number of rocky outcrops to avoid and the identified anchorage is not used as it dries out.

The definitions of 'light', 'medium' and 'heavy' are defined by the RYA:

- Light – 'routes known to be in common use but which do not qualify for medium or heavy classification.'
- Medium – 'Popular routes on which some recreational craft will be seen at most times during summer daylight hours.'
- Heavy – 'Very popular routes on which a minimum of 6 or more recreational vessels will probably be seen at all times during summer daylight hours. These also include the entrances to harbours, anchorages and places of refuge.'

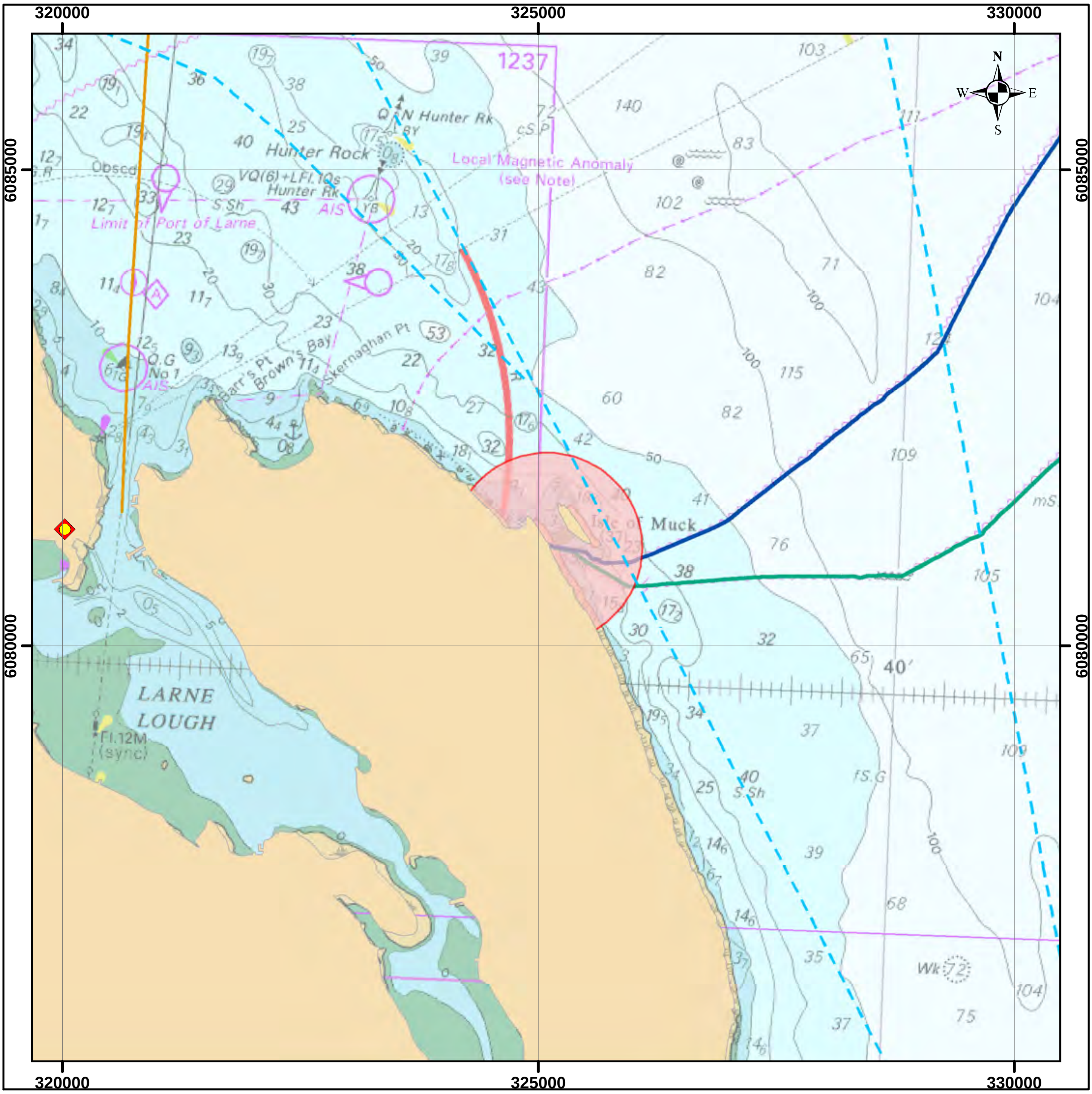
It is reasonable to assume that vessels using these routes, and not restricted by depth, could choose to operate close to the shore to shelter from predominate south-westerly winds and to keep out of tidal currents. This may include access to the marked anchorage close to Port Muck.

Figure 2-4 shows the Scottish landfall site and the calculated boundary of impact of compass deviations. It can be observed that, while close, no passage intersects the 1 km compass deviation impact zone directly. Unlike Northern Ireland, it is anticipated there would be very few vessels navigating in this area owing to a lack of marinas and harbours. It is possible however that there would be a number of occasional transects across the cable.

The risk assessment assumes the following:

- Yachts are extremely unlikely to make a passage inshore of Isle of Muck.
- Vessel density for the nearshore area of the Isle of Muck will be a maximum of 5 vessels visible.

- Those yachts taking an inshore passage to avoid the tide will need to pilot around the Isle of Muck and in doing so will cross the cables at a depth of 10m or greater.

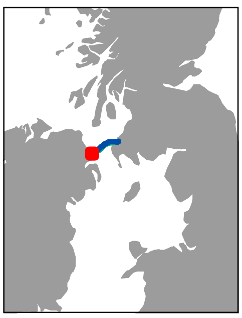


Legend

- Moyle North Cable
- Moyle South Cable
- Sector Light (navigational aid related to lighthouse)
- 1km Boundary
- Sailing Clubs
- RYA Training Centres

RYA Cruising Route

- Medium recreational use
- Light recreational use



NOTE: Not to be used for Navigation

Moyle Interconnector Compass Deviation Risk Assessment

Figure 2-1: Port Muck Landfall Site - Overview

Date	Thursday, October 16, 2014 12:22:20
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	Intertek, SeaZone, RYA
File Reference	J:\P1796\Mxd\RYA\ RYA_Portmuck_Landfall_v2.mxd
Created By	Ian Charlton
Reviewed By	Emma White
Approved By	Emma Pidduck

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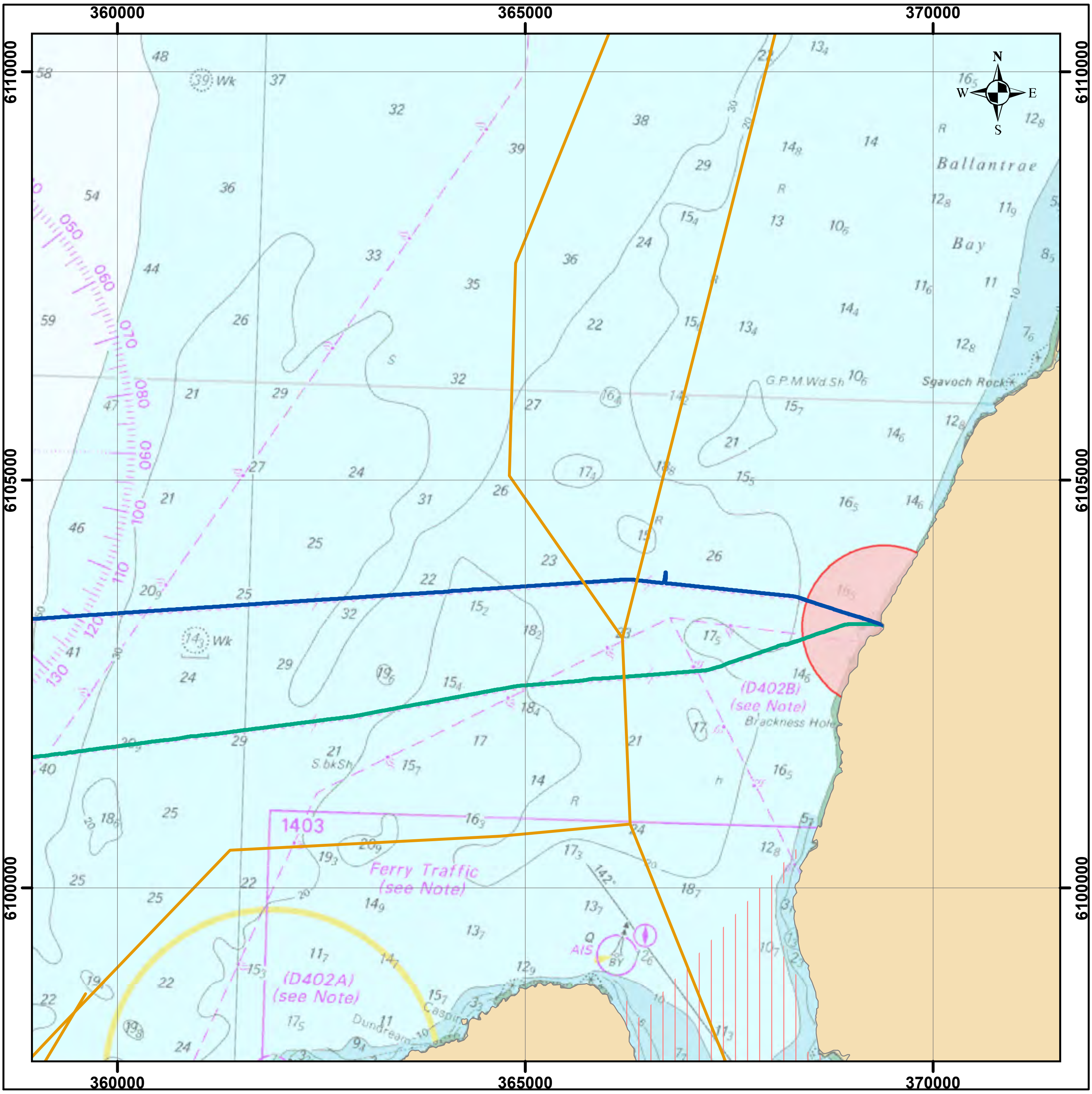
km 0 0.5 1 1.5 2 2.5

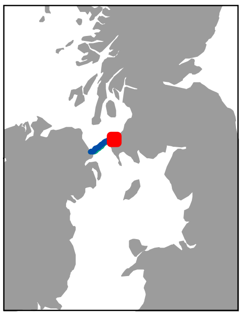


Legend

- Moyle North Cable
- Moyle South Cable

RYA Cruising Route

- Light recreational use
- Sailing Areas
- 1km Boundary



NOTE: Not to be used for Navigation

Moyle Interconnector Compass Deviation Risk Assessment

Figure 2-2: Currarie Landfall Site – Overview

Date	Thursday, October 16, 2014 12:33:44
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	Intertek, SeaZone, RYA
File Reference	J:\P1796\Mxd\RYA\ RYA_Currarie_Landfall_v1.mxd
Created By	Ian Charlton
Reviewed By	Emma White
Approved By	Emma Pidduck

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0 1 2 3 4 km

The method used to assess risks to yachts sailing within the nearshore vicinity is outlined in **Appendix A**. It addresses the assessment of the risk to vessels using an autopilot of a sudden change in direction for 3 points of sailing (close hauled, reach and downwind). The assessment then evaluates potential numbers of vessels (based on the RYA data described previously) and uses wind-rose data to apportion the fraction of vessel transits likely to be carried out under each of the three points of sailing.

2.4.2 Weather & sailing conditions

Level of risk depends on the likelihood of vessels being subject to suitable combinations of wind direction and strength (and also wave conditions).

The Met Office wind rose data (see **Table 2-1**) demonstrated that over the course of a year, the dominant wind direction is from the south to south west, with the majority of recorded occurrences below a Force 7 (> 28 kts) on the Beaufort scale. Wind speeds were most commonly below a Force 3 (< 10 kts) for all directions.

Table 2-1: Wind rose percentage data Northern Ireland (primary area of concern).

ALL YEAR	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
<F3	4.6	3.3	3.2	3.3	4.3	7.1	9.2	10.3	10	6.5	5.5	8.1
F4-F6	1.2	0.7	0.5	0.8	1.9	2.5	3.7	3.6	3.1	1.2	1.8	2.6
>F7	0	0	0	0	0	0	0	0	0	0	0	0
MAR-MAY	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
<F3	5.4	4.6	4.3	3.9	5.1	8.2	9.1	8.8	8.1	5.8	5.5	4.8
F4-F6	1.3	0.9	0.9	0.9	1.9	2	3.3	2	2.2	1.9	1.7	3
>F7	0	0	0	0.1	0	0	0	0	0	0	0	0
JUN - AUGUST	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
<F3	6.2	4	2.9	3.4	5.1	10.5	10.1	9.4	9.1	6.8	7.7	14.3
F4-F6	0.3	0.2	0.1	0.2	0.5	1.1	1.3	0.7	0.6	0.7	1.3	3.1
>F7	0	0	0	0	0	0	0	0	0	0	0	0

The assessment assumes that vessels would only operate in the nearshore vicinity to avoid an opposing tide and when not on a lee-shore (a shore lying on the leeward side of a ship and onto which a ship could be blown in foul weather).

The risk assessment was carried out for four levels of compass deviation: 20°, 30°, 45° and 90°.

The results of the assessment are summarised on the risk matrix in **Figure 2-5**, which shows the annual risk to individuals on vessels using the nearshore “Medium recreational use” route from the RYA data shown in figure 2-3.

The risk matrix shows the potential severity of a risk against the likelihood of it happening. Risks with very severe outcomes that are likely to happen (the upper right hand corner) are unacceptable and shown in red. Conversely low severity risks that are unlikely to happen are deemed broadly acceptable and shown in green. The grey section between the red and green areas then represents risks that are acceptable provided that they are reduced to As Low As Reasonably Practicable. This is termed the ALARP range.

The values circled show the risk for the four compass deviations assessed. In all cases the most significant outcome for sudden unexpected course change is assessed to be level 4 - potential for single fatalities. Yachts using autopilot under the circumstances assessed are likely to be sailing shorthanded and, in comparison, multiple fatalities would be extremely rare.

Figure 2-5: Risk assessed for deviation angles of 20, 30, 45 and 90°

A level of uncertainty must be acknowledged in this type of assessment and therefore all assumptions used have been conservative (tending to overestimate risk). So, whilst it is theoretically possible that risk could have been slightly underestimated, it is probable that the likelihoods plotted in the above figure are considerably over-estimated. The most significant reasons for the findings being conservative are:

- The assessment has been carried out for the interconnector operating at full rated capacity (500MW). During the summer months, when vessel intensity is at its highest, the interconnector is rarely used at full capacity (less than 50% is typical) so current and thereby compass deviation is reduced by proportion.
- The assessment has been carried out for the Northern Ireland landing only. Vessel intensity on the Scottish side is considerably lower.
- The assessment has been carried out for water depths at LAT. For most of the tidal cycle the actual water depths will be greater such that the deviation experienced will be lower.

- Many vessels will elect to stay further offshore to avoid tidal effects around the Isle of Muck;
- Of those vessels taking an inshore route, almost all will cross the cables in greater than 10m of water in order to pass around the Isle of Muck. This is found to be a significant factor by the ALARP assessment is Section 3;
- Vessels piloting around the Isle of Muck will be in the process of changing course and are far less likely to be vulnerable to an unexpected course change from the autopilot.

These issues are considered further in the ALARP assessment in Section 3.

3 ALARP ASSESSMENT

As previously noted the magnetic anomaly risk reduces if the MRC cable is laid closer to the existing HVDC cable; to the extent that this particular risk could be eliminated if the new MRC cables were laid adjacent and touching the existing HVDC cable.

However proximity of installation to the existing HVDC cables substantially increases the risk of damage to the existing asset which would result in a prolonged power outage. Additionally there would also be greater potential for need for diver intervention to carry out the installation process and any future repairs would become considerably more difficult.

In the nearshore approach areas, the HVDC cable is buried / protected with a rock berm that extends towards the shore from the 10m depth contour (approximately). Little information exists about the exact position of the existing IRC cable within the rock berm. However, conservative assumptions for the extent of ‘off centre’ alignment of the cable with the approximately 6m wide berm suggests that the cable will generally be within 4m of the edge of the berm. This is used to define the minimum separation distance that can be achieved with confidence.

It is likely that the installation of the MRC cables will be completed using a combination of techniques in the nearshore area. One of the installation methodologies will include the use of divers. Keeping to the edge of the existing rock berm will reduce diver hours and associated risk exposure.

If the existing HVDC cable gets damaged during the installation process, a separation distance is required to allow a repair to be completed whilst adequate protection is provided to the new MRC cable. A 4m separation distance is the recommended minimum required to allow intervention whilst providing full protection.

There is therefore a need to balance the separation distance to achieve a design solution which ensures that magnetic anomaly risks are reduced to ALARP, but without compromising safety and asset performance.

Having established, through the assessment in Section 2, the relationship between magnitude of deviation and vessel risk, the ALARP assessment first:

- Modelled the magnetic anomalies in the vicinity of the nearshore sections for a series of separation distances;
- Used results to cross plot the cable separations required along the nearshore sections to limit the magnetic compass deviation to threshold values of 20, 30 and 45°;

The results of this exercise are shown in the Cable Installation constraint schematic shown in **Figure 3-1** and **Figure 3-2**. Each schematic shows a 0.5nm square area of the cable corridors in the near shore region.

In both figures, the upper graph shows how the cable separation needed to limit magnetic anomalies to 20, 30 and 45° varies along the nearshore route. For example, the 20° line (shown in black) shows the installation route for the new MRC cable which would result in a 20° compass deviation. For a cable route closer to the existing cable (represented by the X-axis) the resulting magnetic deviation will be less than 20°.

Also shown on the figure is the notional 4m minimum separation aligned to the route of the existing HVDC cable. This represents the location of the outer edge of rock berm (where used) to protect the existing HVDC cable on the seabed. As noted earlier, installation closer than this would result in additional technical and safety risk.

Thus, to limit compass deviation to 20° at the Northern Ireland end, the separation distance close to KP 52.85 would need to be less than 15m, reducing to less than 4m just inshore of KP52.95. For the Scotland side, close to 0.4 KP, the separation distance would need to be less than 15m, reducing to less than 4m just offshore of 0.2KP.

The lower graph in **Figures 3-1** and **3-2** shows the variation of water depth with KP. Important observations from **Figures 3-1** and **3-2** are:

- For water depths of greater than 10m (KP53 and KP0.4) it will be possible both to limit magnetic anomaly to 20° and install outside of the edge of the existing rock berm;
- Shallower than 10m water depth (KP53 and KP0.4) it becomes considerably more difficult to engineer a solution which limits magnetic anomaly. Furthermore, the contours for 20, 30 and 45° begin to converge such that small increments in separation distance can have a significant impact on reducing the magnitude of deviation.

The Risk Assessment in Section 2 established that:

- Substantial risk mitigation will be achieved by decreasing cable separation to reduce deviation from 90/45° to 20°; and,
- Vessels taking a nearshore passage are extremely unlikely to transit the cable at less than 10m water depth – and any which do will be piloting through a course change to avoid the Isle of Muck and are far less likely to be vulnerable to an unexpected autopilot course deviation.

On the basis of the above, it is concluded that an ALARP solution is established for the nearshore section (less than 22m water depth) whereby:

- **At water depths between 10m and 22m LAT the MRC cables are laid close enough to the existing HVDC cables to limit compass deviation to less than 20°.**
- **At water depths shallower than 10m LAT, the MRC cables are laid as close as reasonably practicable to the existing HVDC cables but without disturbance to the existing cable protection; i.e. along-side the edge of any existing rock berm protection or approximately 4m separation.**

Figure 3-1: Installation corridors to limit compass deviation to 20, 30 and 45 degrees and the engineering solution (4m) - Port Muck

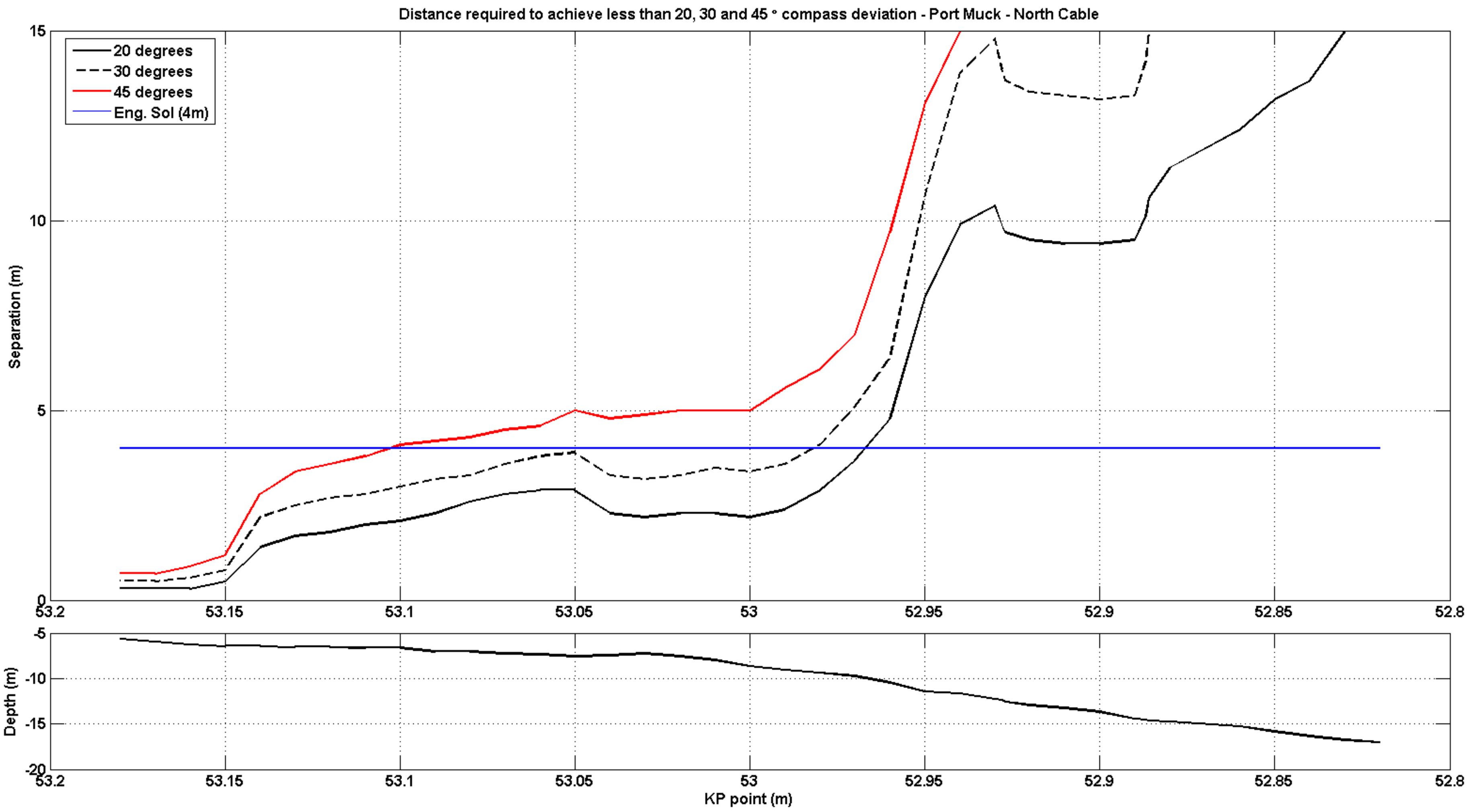
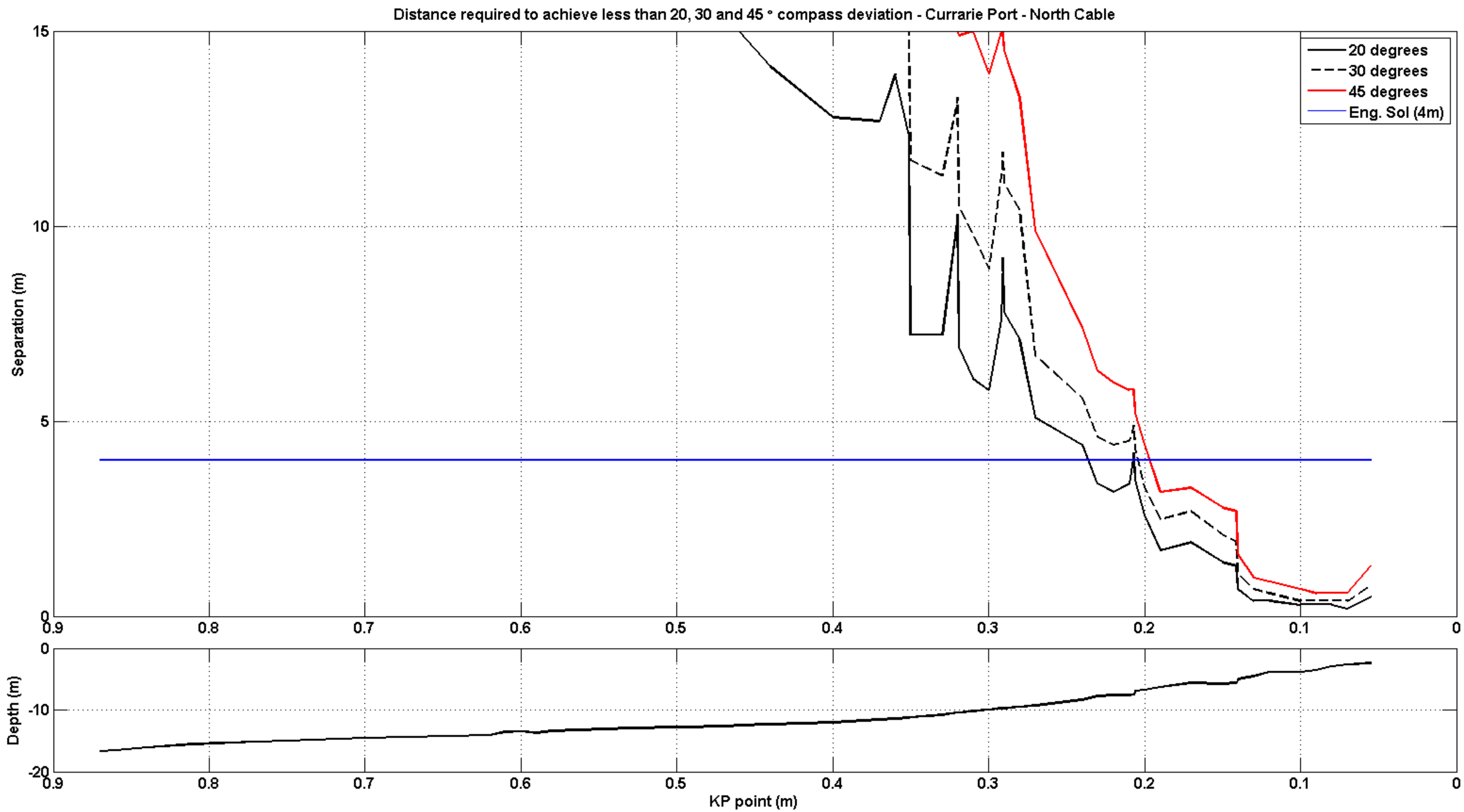
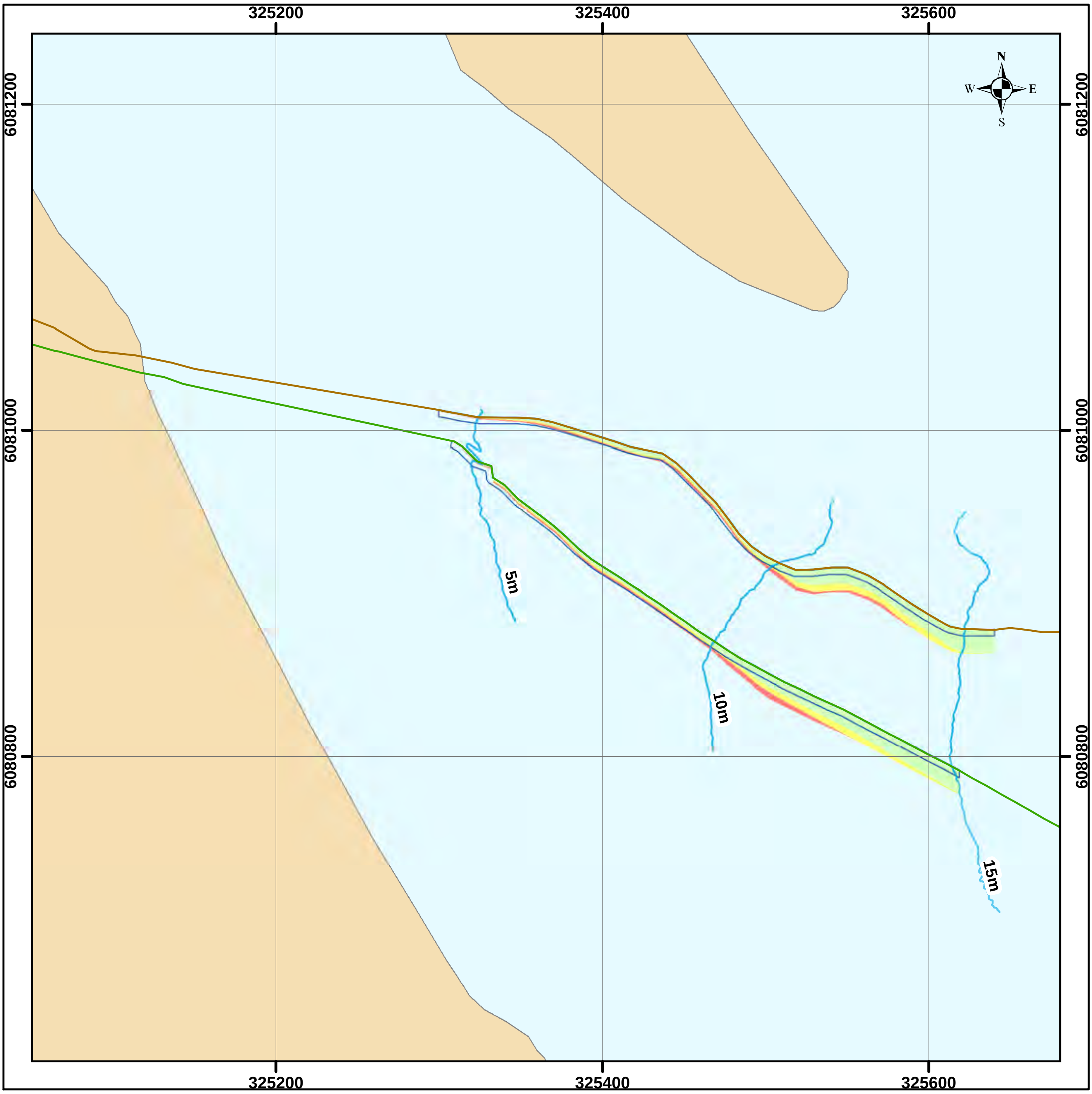


Figure 3-2: Installation corridors to limit compass deviation to 20, 30 and 45 degrees and the engineering solution (4m) - Currarie Port





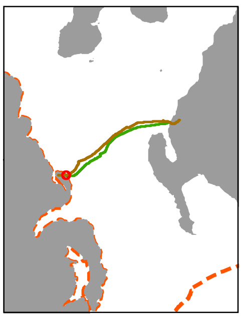
Legend

- North Cable Route
- South Cable Route

Required Separation To Obtain:

- Installation corridor to limit compass deviation to 20 degrees
- Installation corridor to limit compass deviation to 30 degrees
- Installation corridor to limit compass deviation to 45 degrees

- Engineering Solution
- 5m Depth Contours
- Median Line



NOTE: Not to be used for Navigation

Installation Corridors to limit compass deviation to 20, 30 and 45 degrees and the engineering solution (4m)

Figure 3-3: Port Muck

Date	Thursday, August 14, 2014 17:03:21
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	OSOD, GEBCO
File Reference	J:\P1796\Mxd\Compass Deviation\ Portmuck_Compass Deviation_Requirements_v2
Created By	Ian Charlton
Reviewed By	Emma White
Approved By	Emma Pidduck

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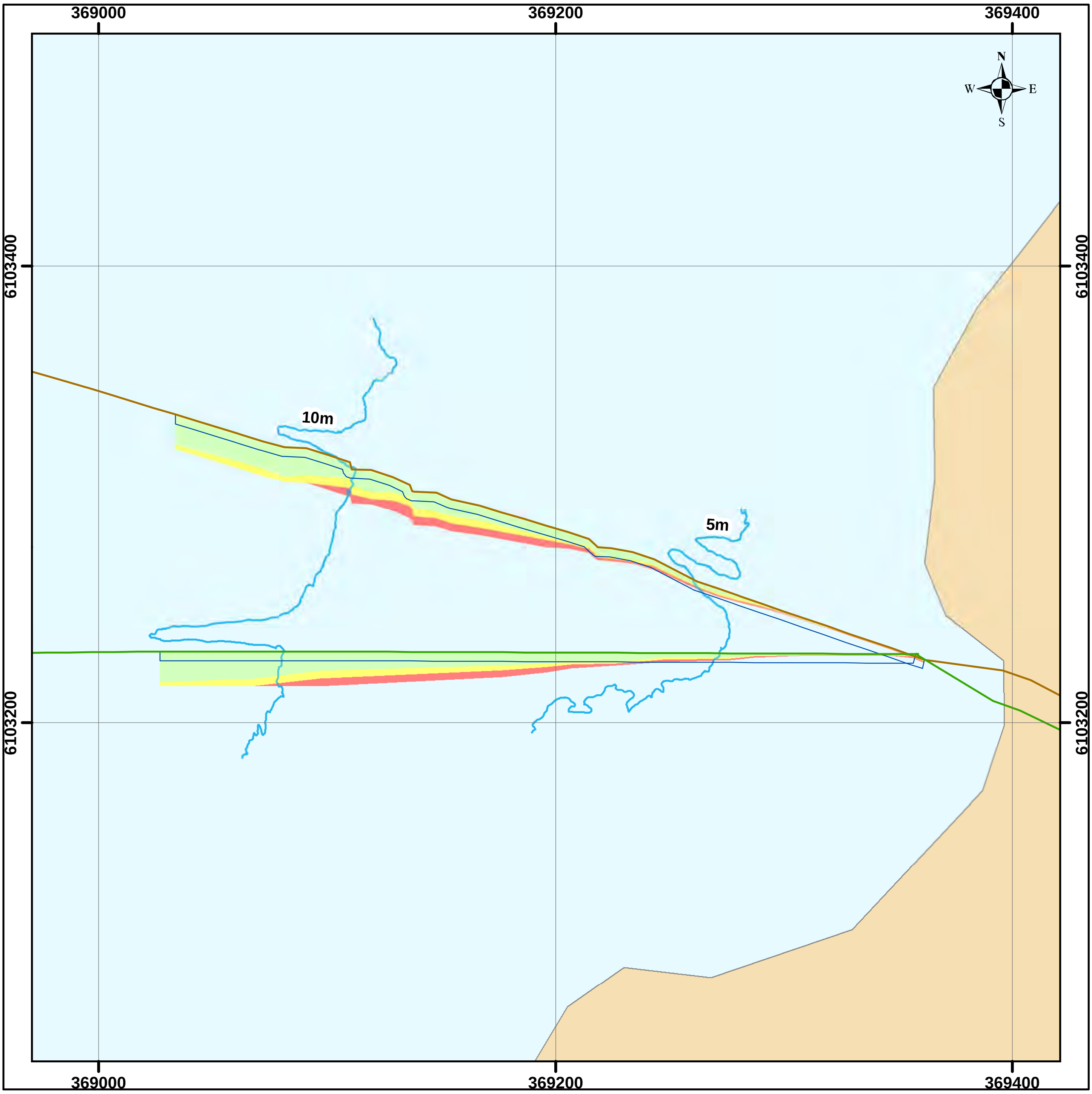
0 50 100 150 200 m



Legend

North Cable Route

South Cable Route

Required Separation to Obtain:

Installation corridor to limit compass deviation to 20 degrees

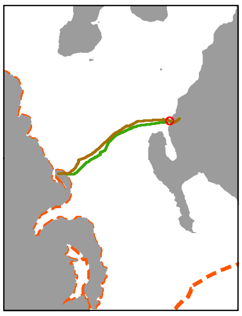
Installation corridor to limit compass deviation to 30 degrees

Installation corridor to limit compass deviation to 45 degrees

Engineering Solution

5m Depth Contours

Median Line



NOTE: Not to be used for Navigation

Installation Corridors to limit compass deviation to 20, 30 and 45 degrees and the engineering solution (4m)

Figure 3-4: Currarie Port

Date	Thursday, August 14, 2014 17:14:18
Projection	WGS_1984_UTM_Zone_30N
Spheroid	WGS_1984
Datum	D_WGS_1984
Data Source	OSOD, GEBCO
File Reference	J:\P1796\Mxd\Compass Deviation\.mxd Currarie_Compass Deviation_Requirements_v2
Created By	Ian Charlton
Reviewed By	Emma White
Approved By	Emma Pidduck

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m
0 20 40 60 80 100

4 CONCLUSIONS

Magnetic anomalies generated by the Moyle Interconnectors operating with the new MRC cables installed have potential to pose a risk only to vessels using a fluxgate controlled autopilot under sail in shallow water. The potential risk stems from a sudden and unexpected course change by the autopilot in response to magnetic anomalies induced by currents in the cable.

Risk to safe navigation associated with position fixing is negligible; the time taken to use the compass would exceed that of the time the compass was subject to magnetic anomalies. Furthermore, most vessels will use GPS as a means of verifying position and course.

Vessels taking a nearshore passage are extremely unlikely to transit the cable at less than 10m water depth. At the Northern Ireland end, any which do will be piloting through a course change to avoid the Isle of Muck and are far less likely to be vulnerable to an unexpected autopilot course deviation.

The Quantitative Risk Assessment conducted for vessels under sail in waters of depth less than 22m (termed nearshore and deemed to be the only the area along the entire cable length where the magnetic effect is considered to have any potential material effect), demonstrates that substantial risk mitigation will be achieved by taking measures in the design and installation of the new MRC cables to reduce any compass deviation effect to 20° or less.

The ALARP assessment weighed compass deviation risk against risks to safety and the cable integrity associated with installing the new MRC cables in close proximity to the existing HVDC cables laid on the seabed.

The ALARP assessment concluded that an ALARP solution is provided for the nearshore section (less than 22m water depth), whereby:

- At water depths between 10m and 22m LAT the MRC cables are laid close enough to the existing HVDC cables to limit compass deviation to less than 20°.
- At water depths shallower than 10m LAT, the MRC cables are laid as close as reasonably practicable to the existing HVDC cables but without disturbance to the existing cable protection; i.e. alongside the edge of any existing rock berm protection or approximately 4m separation.

Cable route positions for the above have been derived using validated prediction from DNV KEMA.

5 REFERENCES

[1] Worzyk, T. *Submarine Power Cables: Design, Installation, Repair, Environmental Aspects.* Springer, 2009.

[2] DNV Report (2014) Moyle Interconnector LV Conductors Replacement – Compass Deviation. Report no to follow.

[3] Keiran, E. (2014) Field Report, Magnetic Survey, Moyle Interconnector, Isle of Muck and Currarie Point, *Geomara Job Number G13016.*

Appendix A Outline of QRA method

A.1 Risk to vessels on different points of sail

The potential impact of a given magnitude of compass deviation will depend on the point of sailing. For yachts sailing up wind, a change in direction would result in a tack or 'head-to-wind' situation. The most dangerous point of sail in relation to a change of direction is for a vessel sailing downwind, whereby an involuntary gybe could result – with the boom crossing the boat at high speed. Table 5-1 illustrates the relative likelihoods of an incident for different course changes on the three main points of sailing under different wind strength ranges.

Table 5-1: Risk assessment of wind speed and direction in relation to compass deviation effects on a yacht for each point of sail.

	Wind Speed (Knots)								
	Close-hauled			Reach			Downwind		
Compass Deviation	0-10	11-21	22+	0-10	11-21	22+	0-10	11-21	22+
0									
20									
30									
45									
90									

Data used to develop Table 4-1 were combined with information on annual wind direction and strength, as well as the likelihood of auto helm usage, to develop a combined table for the risk of incident for a vessel crossing the cable (see Table 4-2):

Table 5-2: Probability (%) of all incidents (vessel course unidirectional)

Deviation	<F3	F4 – F6	>F7
10	0%	0%	0%
20	1.1%	1.3%	1.0%
30	2.9%	5.9%	4.1%
45	2.8%	11.9%	7.8%
90	2.6%	12.5%	10.9%

Note that the probability of an incident occurring is greater for wind strengths of between F4 and F6, than F7 because the likelihood of using an autopilot in winds above F7 is lower.

A.2 Risk of fatality (severity level 4) given an incident

Most incidents will not lead to any injury and only a small proportion will result in a severe outcome. The Heinrich accident triangle states that the ratio of no-injury to fatal incident is 1:300 for industrial incidents. The present analysis is similar to industrial incidents in that trained individuals are at risk in an environment where incidents may involve high energy or moving equipment. The ratio was adjusted to reflect the increased risk potential, (multiple crew members and drowning risk) by changing the ratio to 1:75. The risk of drowning to injury fatalities was taken to be 2. This gave a final fatality per incident value of 0.013.

A.3 Number of vessels crossing the cable

The analysis used as a starting point a maximum of 5 vessels visible. This was converted to the potential number of vessels taking an inshore crossing of the cable (NI landing) by assuming all vessels subject to an adverse tide and with suitable wind conditions would go inshore. Estimates were made to convert peak numbers to an average number per day with the result that the potential number of nearshore crossings is estimated at 400 per annum.

A.4 Risk to individuals

Risk tolerability is based on deriving the potential risk to exposed individuals –in this case, those who elect to sail vessels along the coast of Northern Ireland. Using the RYA vessel density, the population at risk was estimated to be 2200 people in a year.

The risk levels are then calculated by dividing the annual number of potential fatalities by the numbers of individuals at risk.

A.5 Met Office wind rose data for Northern Ireland

Wind rose data provided by the Met Office highlighted a predominately south-westerly wind direction, with the majority of occurrences below a force 3 on the Beaufort scale. The data used allowed the likelihood estimates in table 4.2 to be combined into the single annual figure for each deviation single shown in figure 2-6.