BRITISH TELECOMMUNICATIONS PLC

R100 Fibre Optic Cable Project - Inner Hebrides

European Protected Species Assessment - Cable Installation

P2308_R5285_Rev0 | November 2021

DOCUMENT RELEASE FORM

British Telecommunications Plc

P2308_R5285_Rev0

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European Protected Species Assessment - Cable Installation

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Rev No	Date	Reason	Author	Checker	Authoriser
Rev 0	30/03/2021	Original	NJM	PLD	ALF
Rev 0 Update 1	19/08/2021	Update with Basking shark and PD information as discussed with NS on 17/06/2021 and 13/07/2021.	PLD/JH	ALF	ALF
Rev 0 Update 2	27/08/2021	Update with client comments from Orkney EPS.	JH	PLD	EH
Rev 0 Update 3	21/10/2021	Update	PLD/JH	PLD	EH
Rev 0 FINAL	02/11/2021	Final	JH	PAD	EH

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1. INTRODUCTION

1.1 Project Overview

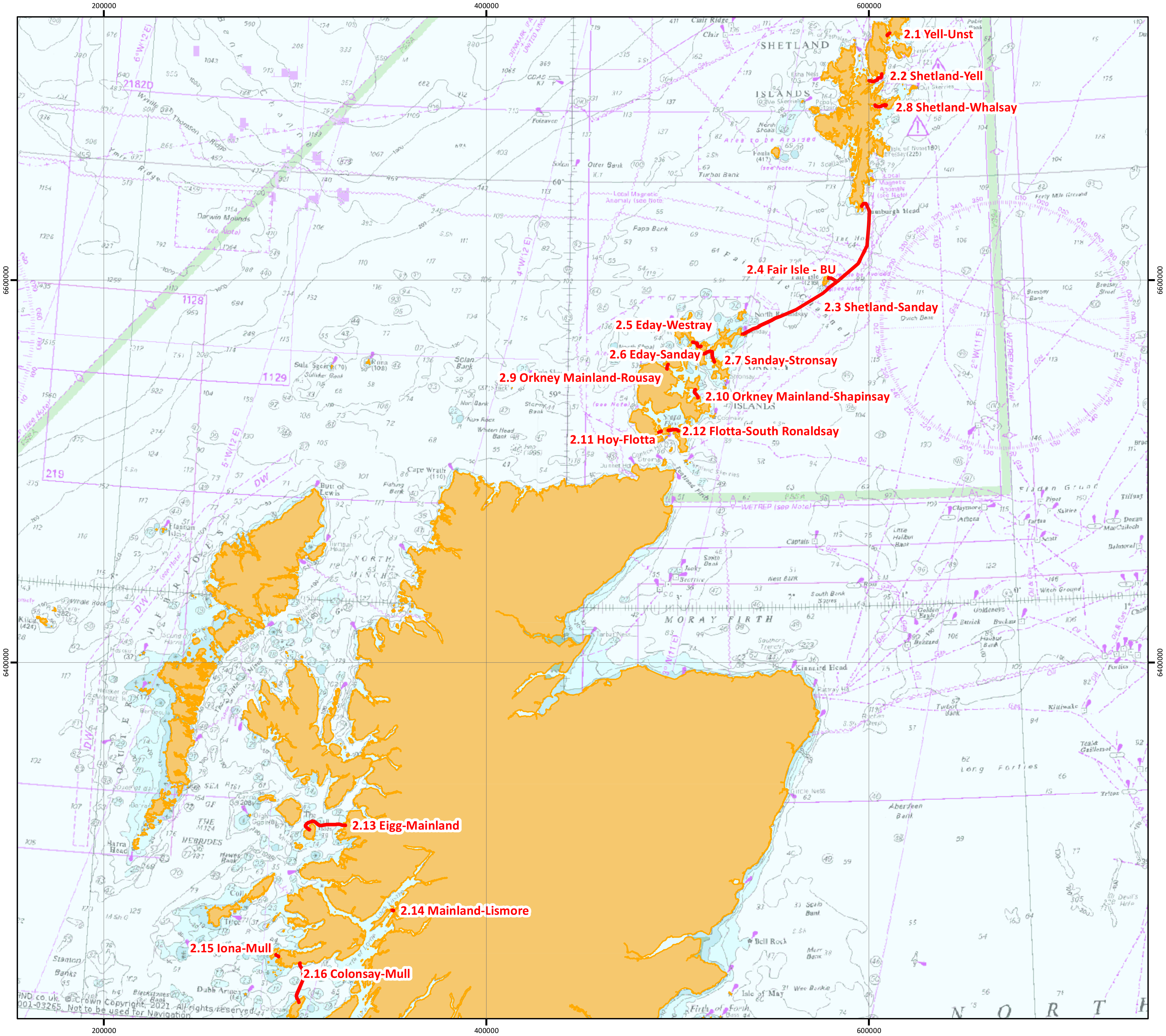
The R100 Project will enhance the existing telecommunication infrastructure and extend superfast broadband (30Mbps+) coverage across Shetland, Orkney and Inner Hebrides as part of the Scottish Government's 'Reaching 100%' (R100) programme. The contract for this was awarded to BT Plc.

BT have contracted Global Marine to supply and install 16 new cables in the following Geographical Areas outlined below and in Figure 1-1 (Drawing reference P2308-LOC-001-C).

- Orkney – 7 cables
- Shetland and Fair Isle – 5 cables
- Inner Hebrides - 4 cables

This European Protected Species (EPS) Assessment is intended to provide necessary information to establish the requirement for an EPS licence for the R100 Project within Inner Hebrides waters for the four cables shown in Figure 1-2 (Drawing reference P2308-LOC-001-B_IH) and outlined below:

- 2.13 Eigg-Mainland
- 2.14 Mainland-Lismore
- 2.15 Iona-Mull
- 2.16 Colonsay-Mull



SCOTTISH ISLES FIBRE OPTIC CABLE PROJECT

LOCATION OVERVIEW
Cable Application Corridors

Drawing No: P2308-LOC-001	D

Legend

Cable Route Application Corridor

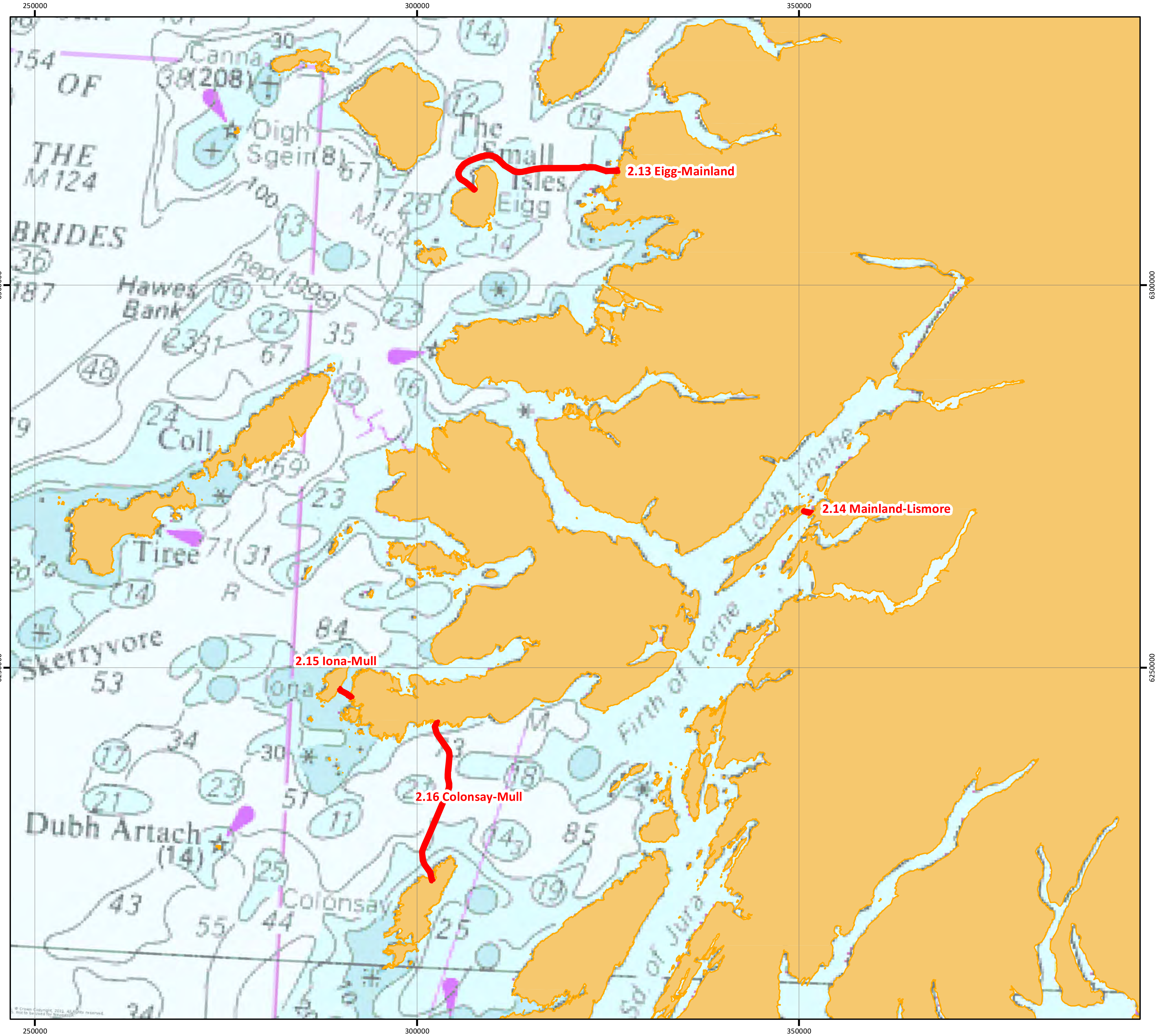
N W E S

NOTE: Not to be used for Navigation

Date	12 October 2021
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	ONS; MarineFind; ESRI;
File Reference	J:\P2308\Mxd\01_LOC\ P2308-LOC-001.mxd
Created By	Chris Dawe
Reviewed By	Abigale Nelson
Approved By	Paula Daglish

BT Global Marine intertek

0 25 50 75 100 km



SCOTTISH ISLES FIBRE OPTIC CABLE PROJECT

LOCATION OVERVIEW

Cable Route Application Corridors - Inner Hebrides

Drawing No: P2308-LOC-001_IH	D

Legend

Cable Route Application Corridor

N S W E

NOTE: Not to be used for Navigation

Date	18 October 2021
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	ONS; MarineFind; ESRI;
File Reference	J:\P2308\Mxd\01_LOC\ P2308-LOC-001_IH.mxd
Created By	Chris Dawe
Reviewed By	Abigale Nelson
Approved By	Paula Daglish

BT Global Marine intertek

0 5 10 15 20 km

1.2 Objective and scope

An EPS Licence is required under the Conservation (Natural Habitats, &c) Regulations 1994 (as amended) (the Habitats Regulations) where there is potential for the Project activities to cause an offence i.e. injury or disturbance to an EPS. An EPS Licence permits the developer to undertake such activities in a controlled manner.

The aspects of the proposed installation activities which have the potential to result in such an offence can be broadly separated into three categories:

- Presence and operation of the installation vessels and installation equipment resulting in underwater noise emissions and associated disturbance from vessel operation and cable installation works;
- Presence of the installation vessels resulting in visual disturbance; and
- Presence of the installation vessels resulting in injury through collision risk.

Marine species which are EPS are: all cetaceans, marine turtles (*Caretta caretta, Chelonia mydas, Lepidochelys kempii, Eretmochelys imbricate, Dermochelys coriacea*) and Atlantic sturgeon (*Acipenser sturio*). The assessment also considers basking shark (*Cetorhinus maximus*), which are not an EPS species, however they are afforded similar protections to cetacean and are sensitive to similar pressures as EPS species. Consultation with NatureScot (meeting held on 17/06/2021) confirmed that basking shark should be included in this assessment. The underwater noise assessment also includes pinniped as they are sensitive to similar pressures as cetacean. However, pinniped are not EPS and these have been discussed and assessed further in the MEA and are not considered further in this document.

This assessment has reviewed continuous and impulsive sound sources produced during cable installation activities. Continuous sound will be produced by vessels, and the equipment used during the pre-lay grapnel run, route clearance, cable trenching and cable protection activities. Impulsive sound will be produced during operation of subsea equipment which uses an acoustic positioning system called Ultra Short Baseline (USBL).

Visual disturbance will be from the presence of installation vessels and from cable landing activities at the landfall locations. Given the short term, and transitory nature of the installation, visual disturbance is not considered to be significant for fish, basking shark, cetacean and turtle species and has been scoped out.

The risk of collision of EPS and basking shark with installation vessels has been screened out of the assessment due to the slow speeds (maximum speed approximately 6 knots) of the installation vessel. The risk of collision is related to traffic and animal density. The most important influences on severity of any potential impact are vessel size and speed (Schoeman et al 2020). As there is only one installation vessel, with the potential for support at the landfalls from small inshore rigid inflatable boats (RIBs), traffic will not be significantly increased in Inner Hebrides. The installation vessels will be moving at 6 knots or less during installation, therefore it is unlikely that cable installation activities will increase the collision risk to EPS and basking shark, so this has been scoped out.

1.3 Project Description

The licensable marine activities considered as part of the supporting Marine Environmental Appraisal (MEA) (Document Reference: P2308_R5368_Rev0) include:

- Route preparation
- Cable installation
- Shore end installation; and

- Post lay inspection and burial (PLIB)

A full project description for all cable installation activities above is provided in Section 2 of the MEA.

This EPS Risk Assessment focuses on cable installation activities and equipment; plough installation and the use of USBL positioning equipment. The assessment has considered vessel movements and the use of the installation plough, which is the main method proposed for cable installation for the project. Sections of cable may also be installed using a trenching ROV or surface lay. The length of each cable to be installed for each of the cable routes within the Inner Hebrides Geographical Area is outlined in Table 1-1.

Table 1-1 Cable Corridor Lengths

Corridor	2.13 Eigg-Mainland	2.14 Mainland-Lismore	2.15 Iona-Mull	2.16 Colonsay-Mull
Length (km)	26.6	1.4	2.6	23.6

Details of the cable installation activities are summarised in the sections below.

1.3.2 Plough installation

Simultaneous cable installation with plough burial is the planned method of installation for the majority of the offshore route. Once the shore end has been landed, the main lay vessel will then lay away from the shore end position and tow the plough behind the vessel. The cable feeds into a bell-mouth at the front of the plough and is guided down through the shear to emerge in the trench.

Hydraulically adjustable skids are used to provide steering on the plough and the shear is used to vary the burial depth. On-board sensors ensure the cable passes through the plough in a safe manner before being buried. The sensors also record the burial depth achieved, for this Project the target burial depth is 1m subject to seabed conditions.

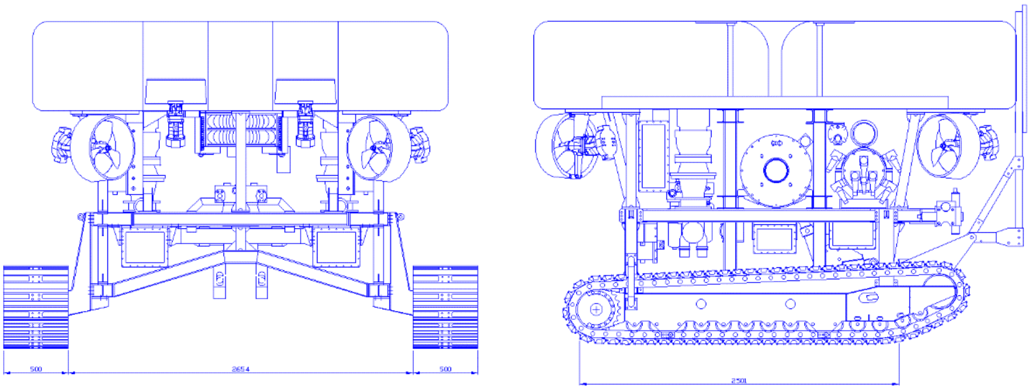
1.3.3 Post Lay Inspection and Burial (PLIB)

On completion of cable laying and plough burial operations there will be areas along the route where it has not been possible to plough, such as in-service cable crossings where the cable has been surface laid over the third-party cable, and where seabed conditions are unsuitable for plough burial. These areas will be buried by means of a trenching ROV, such as the Atlas ROV trencher (Figure 1-3) or similar. This operation is referred to as post lay inspection and burial (PLIB). The trenching ROV is tracked to allow it to sit on the seabed and follow the cable whilst burying the cable. The Atlas ROV is designed with two 500m0.5m wide tracks (Figure 1-4) each with a seabed contact length of 2,500mm2.5m; the target burial depth is 1m. It should be noted that the seabed will naturally reinstate to its original profile shortly after completion of the works.

The ROV will be deployed as required during the project activities.

Figure 1-3 Atlas ROV trencher

Figure 1-4 Atlas ROV Schematic



1.3.4 USBL equipment

During installation USBL is a commonly used technique for navigation and accurate positioning of mobile subsea equipment such as the plough and ROV. The system uses a vessel mounted transceiver, positioned using GPS, that transmits a sound pulse to a transponder array, mounted on the plough and/ or ROV. The transponder array responds to the received pulse by transmitting a pulse back to the vessel. The time between transmission and receiving the return pulse is used to calculate range (as with an echo sounder). Direction is established by variations in phase of the return signal.

The vessel mounted system to be used throughout cable installation activities is the HiPAP502. This transmits a directional beam, with a source level of SPL 190dB re 1µPa @1m (assumed to be 0-pk) in the frequency range 21-31 kHz, with an effective range of 2000m. This is within the audible range of all marine mammal groups. It should be noted, the transmitter characteristics are within the range of echo sounders used on a variety of vessels (including pleasure craft, yachts, fishing vessels and other marine craft). Such echo sounders used by other vessels common across the area operate in the frequency range 12-400kHz, with signal strengths up to 230dB re 1µPa @1m (Risch et al. 2017).

1.3.5 Alternatives

Alternative cable routing options have been considered in the early stages of the project. Corridors have been proposed where the best engineering option can be achieved and to minimise effects to the environment and other sea users. Landing points are constrained by the beach manhole (BMH) position, and other offshore route engineering has taken place considering all constraints, in line with International Cable Protection Committee (ICPC) Recommendations for desk top study..

During installation, it is vital to know the position of subsea equipment when deployed on the seabed or in the water column. USBL is the means by which the positions of the equipment are known, and in turn allows the subsea equipment to determine with precision the location of the cable on the seabed (for as-laid coordinates, charting, informing other sea users accurately etc). There are no effective alternative methods available for this.

2. INNER HEBRIDES SPECIES BASELINE

2.1.1 Cetacean

A total of 23 species of cetacean have been recorded in Hebridean waters) (HWDT 2018). Of these, seven species occur regularly: harbour porpoise, minke whale, short-beaked common dolphin, bottlenose dolphin, white-beaked dolphin, Risso's dolphin and killer whale.

The following summarises the species regularly sighted within Hebridean waters:

2.1.1.1 Harbour porpoise

This is the most frequently seen species in the Hebrides with almost half the sightings between 2003 to 2017 being harbour porpoise (HWDT 2018). Harbour porpoise can be found in inshore wats through the Northern Hemisphere, but the density of porpoises in Hebridean waters Is amongst the highest in Europe. This species is widespread amongst the Hebrides and can be seen in most coastal areas, however the highest encounter rates occur around the Small Isles. Harbour porpoise occur all year round in Hebridean waters and are considered a resident cetacean on the west coast of Scotland (IWDT 2018). The relative abundance of cetaceans between 1979 and 1997 provided by the NMPI (Marine Scotland 2020) show that harbour porpoise is present in high densities across all of the western coast of Scotland. The SCANS-III density estimate for harbour porpoise in waters off the north-western coast of Scotland is 0.397 animals per km^2 and in western waters is 0.336 animals per km^2, which is greater than the West Scotland average of 0.238 animals per km^2 (Hammond et al 2021).

2.1.1.2 Minke Whale

Minke whale sightings are widely distributed in Northern Scotland, both offshore in the northern North Sea. This species is the second most sighted cetacean, accounting for 7% of all sightings between 2003 and 2017 (HWDT 2018). The highest encounter rates for Minke whale are around the Small Isles and the east of the Outer Hebrides throughout the Minch and Sea of the Hebrides (IWDT 2018). Minke whales are migratory species and often seen on the west coast of Scotland in coastal waters between April and October. The majority of individuals seen are thought to migrate to breeding grounds to the south, however some individuals do remain in the region through winter (IWDT 2018). The SCANS-III density estimate for minke whale in waters off the north-western coast of Scotland is 0.020 animals per km^2 and in western waters is 0.027 animals per km^2 (Hammond et al 2021). These were also the highest densities observed across the SCANS-III survey area (Celtic, Irish, North, Kattegat and Belt Seas, West Scotland and the Iberian Peninsula) after Shetland, which collectively had an average density of 0.014 animals per km^2, demonstrating the importance of the Inner Hebrides waters and surrounding area for minke whale (Hammond et al., 2021).

2.1.1.3 Short-beaked common dolphin

Short-beaked common dolphin are widespread in coastal and offshore waters in subtropical and warm temperate seas. They are the most common seen dolphin during surveys by the IWDT, accounting for 4% of all cetacean sightings between 2003 and 2017 (IWDT 2018). Common dolphins can be seen throughout the west coast, with the majority of sightings east of the Outer Hebrides in the Minch, Little Minch and Sea of the Hebrides as well as inshore areas too (IWDT 2018). Common dolphin sightings peak between April and October and while they are considered a summer visitor, some individuals do remain throughout the winter months too (HWDT 2018). There is no SCANS-III density information available for short-beaked common dolphin. (Hammond et al.,2021).

2.1.1.4 Bottlenose Dolphin

The bottlenose dolphins encountered in the Hebrides are near the northernmost extent of the species global range. Generally, this species stays close to shore and follow the coastline as they travel through areas. This preference for inshore habitat means they have been sighted less during HWDT surveys which tend to be offshore. Therefore, bottlenose dolphin sightings only account for 0.5% of all cetaceans sighted between 2003 and 2017 (HWDT 2018). Bottlenose dolphin are often seen in and around the Sound of Baria and throughout the Inner Hebrides, with the majority of sightings around Mull, the Small Isles and Skye (HWDT 2018). Bottlenose dolphin are present in Hebridean waters all year round and are considered another resident species of the west coast of Scotland. The SCANS-III density estimate for bottlenose dolphin in waters off the western coast of Scotland is 0.121 animals per km^2, with no sightings in the area between Skye and Harris (Hammond et al.,2021). The densities observed off the western coast of Scotland are the highest observed across the SCANS-III survey area (Celtic, Irish, North, Kattegat and Belt Seas, West Scotland and the Iberian Peninsula) after Shetland, which included the, which collectively had an average density of 0.016 animals per km^2, suggesting that these waters are an important stronghold for bottlenose dolphin in the northernmost extent of their range (Hammond et al., 2021).

2.1.1.5 White-beaked dolphin

This species distribution is relatively restricted and are only found in temperate and subarctic waters of the North Atlantic (HWDT 2018). The Hebrides are located towards the southern extreme of the white-beaked dolphins' natural range and are typically seen in open waters further from the coast, favouring waters around the Outer Hebrides and the north Minch (HWDT 2018). White-beaked dolphin are present in Hebridean waters all year round and are considered another resident species of Hebridean waters. The SCANS-III surveys did not identify any white-beaked dolphin in the Inner Hebrides area (Hammond et al.,2021).

2.1.1.6 Risso's Dolphin

Risso's dolphin ae widely distributed in the region with the north of Scotland representing the northern limit of this species range. In the Hebrides, Risso's dolphins tend to prefer deeper waters which may be home to their preferred prey of squid, octopus and cuttlefish. Due to the bathymetry of the Hebrides, there is deep water close from land (such as Tiumpan Head) off the north east coast of Lewis in the Outer Hebrides which could support some individuals. Sightings of Risso's dolphins are distributed throughout Hebridean waters however, they are most commonly sighted around Coll, Tiree, Mull and Skye with some of the highest sightings off the Butt of Lewis (HWDT 2018). Risso's dolphins are present all year round in Hebridean waters. The SCANS-III survey did not have any Risso dolphin sightings in the Inner Hebrides area (Hammond et al.,2021).

2.1.1.7 Killer Whale

Killer whales can be seen throughout the west coast of Scotland and from the shore in coastal areas and offshore. During surveys between 2003 to 2017, HWDT have only had 16 sightings of killer whale, most of which are associated with the West Coast Community of killer whales, the UK's only resident group of killer whales (HWDT 2018). Killer whales are present in Hebridean waters all year round, however sightings are infrequent.

2.1.2 Fish

2.1.2.1 European sturgeon

European sturgeon (*Acipenser sturio)* are the only fish species protected as an EPS. Other species of fish that are not EPS but are afforded similar protection within Scottish waters are basking shark. European sturgeon migrate along the Atlantic coast of Europe from the Bay of Biscay to the Bristol Channel and North Sea (JNCC, Natural England and Countryside Council for Wales 2010). Based on the small population size, sturgeon is a rare visitor to Northern European waters and sightings within Scottish waters are extremely rare.

2.1.2.2 Basking shark

Basking shark are protected under OSPAR Annex V, in Scotland under the Nature Conservation (Scotland) Act 2004 and under the Wildlife and Countryside Act 1981, making it an offence to intentionally or recklessly disturb or capture individuals (Scottish Parliament, 2004). Basking shark are a UK Biodiversity Action Plan (BAP) species and as part of the Scottish Biodiversity Strategy are included as a Priority Marine Feature (PMF). Due to their low population numbers, the Northeast Atlantic population of basking shark are also listed as 'endangered' under the IUCN Red List of Threatened Species (Fowler, 2009).

Basking shark are summer visitors and are found throughout the UK, growing up to 12m in length, making them the second largest fish species in the world. Basking shark are thought to be on the continental shelf in winter months and migrate to Scottish coastal waters in the summer to feed on plankton and zooplankton. Higher densities occur in areas of high primary productivity, such as in thermal and shelf sea fronts (Speedie, Johnson and Witt, 2009; Sims and Quayle, 1998). Basking shark display both feeding and courtship behaviours at the water surface, which can make them vulnerable to vessel movements. Sightings typically occur between May and October, peaking between July and August (Speedie, Johnson and Witt, 2009; Dearing 2016).

There are two established hotspot sites in Scotland, which are the islands of Hyskeir and Canna situated in the Sea of the Hebrides, and the island of Coll (Gunna Sound, between Coll and Tiree) in the Inner Hebrides (Doherty et al., 2017; Speedie, Johnson and Witt, 2009). Large concentrations of up to 100 individuals have been observed in the Inner Hebrides, with densities of up to 5 individuals per km2 observed off the south-west coast of Tiree (Paxton et al., 2014; Rexstad, 2014). The estimated relative abundance of individuals within the Sea of Hebrides MPA is estimated to be approximately 602 individuals (Webb, Irwin and Humphries, 2018). However, basking shark densities within the application corridors for all cables in the Inner Hebrides are low, with only 0-0.1 animals per km^2 (Paxton et al., 2014).

2.1.3 Chelonians

There are five species of marine turtle listed under Schedule 2 of the Habitats Regulations and Schedule 1 of the Conservation of Habitats and Species Regulations 2017 (as amended). The species listed are Leatherback (*Dermochelys coriacea*); Loggerhead (*Caretta caretta*); Hawksbill (*Eretmochelys imbricate*); Kemp's Ridley (*Lepidochelys kempii*); and the Green Turtle (*Chelonia mydas*).

The leatherback turtle is the most frequently encountered within UK waters, accounting for 1,683 of the 1,997 turtle sightings from 1910 to 2018 (Botterell et al., 2020). Leatherback turtle migrate across the Atlantic Ocean to feed on rich swarms of jellyfish along the west and north coast (NatureScot, 2017). Loggerhead turtle and Kemp's Ridley turtle are extremely rare visitors linked to adverse weather conditions. Turtle sightings are often associated with jellyfish swarms which are the turtles' main prey item. Unlike hard shelled species, leatherbacks have a thick oily layer under their skin and a unique physiology (including a counter-current heat exchange system) to protect them and their internal body temperature from the colder sea temperatures such as those around the UK (Howe 2018). In Scotland, leatherback are the most common species of turtle, with loggerhead, green and hawkbill turtles only thought to arrive in Scottish waters by accident through currents from warmer waters (NatureScot, 2017). In the Inner Hebrides, less than 20 turtle sightings and strandings were recorded across all species between 2010 and 2020 by the Cetacean Strandings Investigation Programme (Penrose et al., 2020).

3. EFFECTS TO EPS

3.1 Underwater sound emissions

3.1.1 Background sound

How a receptor is affected by a change in underwater sound is linked to the current exposure levels and associated background noise. Sounds in the ocean originate from natural causes such as earthquakes, rainfall, and animal noises; and anthropogenic activities such as shipping, fishing activities, seismic survey, research activities, sonars, and recreation activities. Although some sound sources can be identified, the sources of others cannot, and they are considered part of the background noise.

Little is known about background (or ambient) sound levels in the Geographical Area; however, a report produced as part of Strategic Environmental Assessment (SEA) 6 (Harland *et al.* 2005) indicates that the dominant source of anthropogenic ambient noise in the Geographical Area is expected to be shipping. Due to the lack of data, background noise has not been considered in this assessment, though background noise does exist. Therefore, as the assessment is based on there being no background sound, the assessment is highly precautionary.

3.1.2 Continuous sound

Most activities being assessed produce non-pulse sound, which is generally broadband (white noise, with little or no variation with frequency), narrowband (consisting of a small range of frequencies) or tonal (a single frequency sine wave). Continuous sound can either be intermittent or constant within a 24hr period (NMFS 2018). Cable installation will be undertaken using a cable ship designed for 24-hour operation in medium to deep water depths. Other continuous noise sources are emitted from the cable plough and any external cable protection activities. Vessel noise emissions are the primary emission of continuous sound and will be used throughout the installation and therefore have been considered in this assessment.

Available data comparing vessel noise emissions (Genesis 2011) suggests that the greatest levels of sound are generated while vessels are in transit, with a maximum reported broadband (i.e. no peak frequency) transmission level of 192dB re 1 µPa @1m on a root mean square (rms) basis. This is for a moderately size (173m) cargo vessel travelling at 16 knots (approximately 8ms^{-1} or 29km/hr). This transmission level is assumed as worst case. The proposed installation vessel is likely to be smaller and travel at much slower speeds (6 knots), therefore the continuous noise generated by the equipment and activities (cable ploughing etc) will be far less than 192dB re 1 µPa @1m. Data given by Fischer (2000) suggests that individual thruster radiated underwater noise is likely to be in the range 145 to 155 dB re 1 µPa @1m, with a high dependence on design and operating conditions. Therefore, for assessment purposes, the source level 192dB re 1 µPa @1m has been used for continuous sound as the worst-case scenario.

3.1.3 Impulsive sound

The use of subsea equipment such as the plough and ROV requires use of a USBL positioning system. As described in Section 1.3.4, this transmits a directional beam, with a source level of Sound Pressure Level (SPL) 190dB re 1µPa @1m (assumed to be 0-pk) in the frequency range 21-31 kHz, with an effective range of 2000m. This source level has been used in the assessment below.

3.2 Receptor sensitivity

3.2.1 Cetacean

3.2.1.1 Underwater sound

Cetacean have evolved to use sound as an important aid in navigation, communication, and hunting (Richardson et al. 1995).

High intensity or prolonged noise can cause temporary or permanent changes to animals' hearing. Where the threshold of hearing is temporarily altered, it is considered a temporary threshold shift (TTS), and the animal is expected to recover. If there is permanent aural damage (permanent threshold shift (PTS)) where the animal does not recover, social isolation and a restricted ability to locate food may occur (Southall et al. 2007).

Behavioural disturbance from underwater sound sources is more difficult to assess than injury and is dependent upon many factors related to the circumstances of the exposure. An animal's ability to detect sound depends on its hearing sensitivity and the magnitude of the sound compared to the background. In simple terms for a sound to be detected it must be louder than background and above the animal's hearing sensitivity at the relevant sound frequency. The direction of the sound is also important. Cetacean are considered to have generalised hearing ranges. Minke whale hear in the range between 7Hz to 35kHz (low frequency (LF) cetacean). Dolphin and toothed whales hear in the range between 150Hz to 160kHz (high frequency (HF) cetacean). Harbour porpoise have hearing within the range 275Hz to 160kHz (very high frequency (VHF) cetacean) (Southall et al., 2019).

Introduced sound may cause behavioural responses in animals, such as individuals moving away from the sound source and remaining at a distance until the activities have passed. There may also be changes in foraging, migratory or breeding behaviours; all factors that can affect the local distribution or abundance of a species. Introduced sound may also cause masking or disruption of the animal's own signals, whether used for communication, foraging or other purposes. This may in turn affect foraging and reproductive opportunities. Behavioural disturbance to a marine mammal is hereafter considered as the disruption of natural behavioural patterns, for example: feeding, migration, breeding and nursing.

3.2.1.2 Visual disturbance

The sensitivity of cetaceans to visual disturbance is not fully known however, it is likely that the primary response is to acoustic stimuli. Therefore, if there is no injury or significant disturbance caused by acoustic stimuli, it is assumed that there will also be no significant visual disturbance which will cause harm to EPS species and basking shark

3.2.2 Fish

3.2.2.1 Underwater sound

Several features of a fish's anatomy, life cycle and habitats will determine the potential effects of sound on fish. Popper et al., (2014) classified sensitivity of fish species to underwater sound based on the presence or absence of a swim bladder, used by many teleost fish species for buoyancy control, hearing, respiration etc. Fish species that lack swim bladders, including shark species, are not as vulnerable to trauma from sound pressure changes and have low sensitivity to underwater noise (Popper et al., 2014).

Limited data is available to inform fish hearing capabilities however fish are able to detect sound pressure to hear from 1Hz to possibly 1000Hz (Popper and Hawkins, 2018). Popper et al., (2014) provide sound exposure guidelines for injury to fish, which have been used in the assessment for continuous noise presented in Table 4-1 and impulsive noise presented in Table 4-2. As shark species have low sensitivity to underwater noise, basking shark are likely to be well within the thresholds provided by Popper et al., (2014).

3.2.3 Chelonians

3.2.3.1 Underwater sound

Available evidence (e.g. Piniak et al., 2012) suggest that marine turtles have an acoustic range between 100Hz and 1000Hz in air and underwater and are therefore likely to be sensitive to anthropogenic noise. Popper et al., (2014) suggest that fish sensitivity data currently provides the best approximation to marine turtle sensitivity to underwater sound.

4. ASSESSMENT

4.1 Underwater noise

4.1.1 Calculation method

The propagation of sound from a source to a receiver can be modelled in a variety of ways, from simple calculations assuming spreading according to set principles e.g. spherical or cylindrical, to full acoustic models that account for bathymetry, salinity, sediment characteristics etc, all of which effect how noise attenuates. Generally, however the principle is to calculate the distance at which the sound pressure level attenuates to below set thresholds.

This is then used to define the distance from the source over which injurious or disturbance level effects may be experienced by a sensitive receiver. Intertek have used a simple in-house geometric spreading calculation to calculate attenuation distances at which the sound pressure level attenuates to below set thresholds of sensitivity for EPS. This provides conservative estimates for sound attenuation as it does not take into consideration the conditions within the area such as bathymetry, water depth or sediment type and thickness; all of which increase attenuation.

4.1.1.1 Method for calculation of sound attenuation

As sound from cable installation and USBL positioning is generally perceived as a lower risk to sensitive receptors a proportionate geometric spreading calculation rather than a full acoustic model has been used to calculate distances of an effect. The method uses the following equation from MMO (2015) to calculate sound attenuation from the source:

$$Sr = S - 15\log(r) - \alpha r/1000$$

Where:

- Sr = Sound at range r (m)
- S = Sound at 1m from the source
- r = distance from the source
- 15log(r) represents the spreading loss, in dB re 1m
- α = is the frequency related attenuation, $0.036*f^{1.5}$, where f is in kHz, in dB re 1m

Units of sound are dB re 1µPa or 1µPa^{2}s, which are equivalent for a 1 second transmission

4.1.1.2 Continuous sound thresholds

The distances over which sound attenuates that have been calculated are then compared to sound exposure thresholds published by NMFS (2018) and Southall et al., (2019) for marine mammals. NMFS (2018) provide different thresholds for PTS and TTS to marine mammals depending on the functional hearing category of the species and assuming exposure to sound (SEL) of 24 hours. Source levels are given as sound pressure level (SPL) which does not vary with time. NMFS (2018) state that a SEL threshold can be adjusted for different exposure times however this has not been done in this assessment. The thresholds used in the assessment are provided in Table 4-1.

Popper et al.,(2014) provides different thresholds for recoverable injury (which includes minor injury to tissues not involved in hearing) and TTS for fish. For continuous noise, the recoverable injury threshold is 170 dB re 1 µPa^{2}s rms for exposure of 48 hours, and the TTS threshold is 158 dB re 1 µPa^{2}s rms for exposure of 12 hours.

4.1.1.3 Impulsive sound thresholds

For the assessment of effects of the USBL, the sound exposure thresholds given in the NMFS (2018) for impulsive sound to marine mammals have been used as agreed with NatureScot (NatureScot *pers comms* 2021). For fish, the thresholds provided by Popper et al (2014) for mid-frequency sonar impulsive sound have been used.

4.1.1.4 Disturbance thresholds

There are no published guidelines on behaviour thresholds due to the complexity and variability of the responses of marine mammals to anthropogenic disturbance. The threshold of 140 dB re 1 µPa^{2}s rms is a conservative threshold which has been used for continuous and impulsive sound for all UK marine mammal species (Gomez et al., 2016; BOEM, 2017; NMFS, 2018; Xodus, 2015).

4.2 Results and discussion

4.2.1 Continuous noise results

The calculation undertaken for this assessment covered 16 octave bands, over a frequency range of 4hz to 131kHz (0.01 - 370m wavelengths) covering the entire hearing range of marine mammals. The worst-case results are presented in Table 4-1. The results are not weighted for the auditory range of the individual species groups, as this weighting is included in the thresholds (NMFS 2018, Southall *et al.* 2019). It assumes a transmission signal which is constant with frequency but allows for increasing absorption loss at high frequencies. The calculation does not allow for filtering of long wave components in shallow water depths. It should also be noted that the relative contribution of the higher frequencies decreases rapidly with distance from the source, with low frequency components, which form the oceanic background noise, becoming dominant.

The calculation determines the distance from the source (in metres) at which the sound could exceed the injury and disturbance thresholds. This distance assumes that to experience the sound levels sufficient to cause injury or disturbance the animal must remain within the area for at least 24-hours for marine mammals and 48-hours for fish and marine turtles. Animals disturbed by the installation activities could change their behaviour and temporarily leave the zone of disturbance before returning. Should disturbance be repeated or persistent over longer periods the animal may choose not to return or may take longer to return to the area.

Table 4-1 Distances at which injury and disturbance thresholds could be exceeded (assuming 24 hours exposure

Auditory group	PTS		TTS		Disturbance	
	Threshold of onset (dB re 1µPa^{2}s)	Distance to threshold (m)	Threshold of TTS onset (dB re 1µPa^{2}s)	Distance to TTS threshold (m)	Threshold of disturbance onset (dB re 1µPa^{2}s)	Distance to threshold (m)
LF	199	Threshold not exceeded	179	9	140	2460
HF	198	Threshold not exceeded	178	9		
VHF	173	22	153	397		
PCW	201	Threshold not exceeded	181	6		
Fish and turtles	170 (recoverable injury, 48 hours exposure)	26	158 (TTS, 12 hours exposure)	160	N/A	N/A

Threshold Sources: Southall *et al.*,(2019) Table 6; and Popper *et al.*,(2014) Table 7.7.

4.2.2 Impulsive noise results

Assuming 24 hours continuous exposure the injury criteria as given in NMFS (2018) for impulsive sound for a PTS in hearing and a TTS have been applied. A precautionary threshold for disturbance is given in Xodus (2015), for low level marine mammal disturbance by multiple pulses. This has been adopted for this assessment and the expected ranges for injury or disturbance (assumed to be the distance from either the vessel or the ROV) are set out in Table 4-2 below.

Table 4-2 USBL injury and disturbance range for cetacean and pinniped species

Species group	Response frequency band	Injury criteria	Threshold	Range (worst case)
			dB re: 1µPa2-s	m
Cetaceans	LF	PTS	219	Threshold not exceeded
		TTS	213	Threshold not exceeded
	HF	PTS	230	Threshold not exceeded
		TTS	224	Threshold not exceeded
	VHF	PTS	202	Threshold not exceeded
		TTS	196	Threshold not exceeded
Pinnipeds	-	PTS	218	Threshold not exceeded
	-	TTS	212	Threshold not exceeded
Fish and turtles*	-	Recoverable injury	210	Threshold not exceeded
	-	TTS	210	Threshold not exceeded
-	-	Disturbance	140	1.1km

Threshold sources: Southall et al.,(2019) Table 7 Peak SPL (unweighted); Popper et al.,(2014) Table 7.6

Note: The results within Table 4-2 are similar to that given by the NMFS 2018 User Spreadsheet (Version 2.2) using cable installation speeds of 6 knots (3 m/s) and an assumed ping repetition rate every 3.5 seconds. *The USBL is high frequency and unlikely to be audible to fish and turtles.

4.2.3 Effects to marine mammals

4.2.3.1 Continuous noise

Although the results presented in Table 4-1 indicate that there is the potential that continuous shipping noise could cause injury to marine mammals, animals will have to be present within the zone of influence for 24-hours for the onset of effects. Given the largest area is <400m radius from the installation vessel (for very high frequency cetacean such as harbour porpoise), this is highly unlikely to occur; the installation vessels will be continually moving along the linear cable corridor and therefore the zone of influence will be transient.

Should contingency measures of cable protection be required, the installation vessel may be stationary for short periods; however, this will only require low thruster power to maintain position, with consequent low levels of transmitted sound. Use of thrusters at high power, associated with manoeuvring, will be short term; hence, as discussed above, sensitive species are unlikely to remain within the zone of influence for 24 hours and no injury will occur.

Behavioural impacts to marine mammals from project-related vessel noise are expected but are not extensive, severe, or biologically significant. Impacts could include brief temporary disruption of communication or echolocation from auditory masking; behaviour disruptions of individual or localized groups of marine mammals; or limited, localized, and short-term displacement of individuals of any species from the immediate area around the vessels. These impacts will pass as the vessel moves through the area and normal behaviour will be re-established quickly.

A study examining odontocete cetacean speeds recorded the lowest speed at $1.ms^{-1}$ (Fish et al., 2003). At this speed, it would take cetaceans <4 hours to swim the total 5km diameter zone where disturbance could be experienced. At greater swim speeds (which would be expected in the event of disturbance) exposure times would be correspondingly less, suggesting that actual exposure times are well below the 24-hours exposure time used in determining the thresholds given in Table 4-1. As a result, actual risk to marine mammals is negligible.

It is important to note that the exceedance of the threshold for the onset of disturbance does not mean that disturbance will occur. It is also worth noting that the activities and noise sources modelled are temporary and transitory.

The assessment does not take into account background noise and therefore does not account for habituation of species to ambient sound. The Geographical Area is one in which shipping and fishing activity is common. Vessels are expected to transit the area routinely, generating relatively high levels of noise. As a result, it is likely that populations in the Geographical Area are habituated to noise of the type generated during cable installation activity and the addition of the installation vessels will have no effect.

4.2.3.2 Impulsive noise

The results represented in Table 4-2 indicate that there will be no injurious effects to EPS from operation of the USBL and mitigation measures are not required. The highly precautionary assessment identifies that there is potential for disturbance to marine mammals (if sensitive) up to 1.1km from the sound source.

It should be noted that the assessment results presented in Table 4-2 are highly precautionary. Both Xodus (2015) and NMFS (2018) acknowledge that criteria for disturbance (termed effective silence in the case of NMFS 2018), are not representative of the effects on animals within their natural environment but are based on a limited number of studies of captive individuals and do not consider habituation to ambient sound. Within Inner Hebrides waters, ambient sound is dominated by shipping noise (Richards *et al* 2007), which is of low frequency in addition to fishing and military operations. These ambient sound sources are likely to reduce the effects of disturbance from USBL to marine mammals from the distance provided in Table 4-2.

As the installation activities will move at a maximum speed of 6 knots, the highly precautionary area of disturbance will move with the vessel and the effects will be brief in any one place and localised to the installation activity. The localised zone of effect will not cause a barrier to marine mammal movement within Inner Hebrides waters and there will be no effect on the breeding or lifecycle activities from the proposed installation activities.

4.2.4 Effects to fish

Data sources available (Popper *et al.,*2014 and OSPAR Commission 2012) consider that the potential for likely significant effects to fish (including basking shark) from cable installation activities is low. Many species of fish lack the specializations for receiving sound, therefore no effects to these groups of fish are anticipated (Popper et al., 2014). Potential effects are limited to fish with hearing specialties.

During cable installation, the worst-case zone of influence is estimated to be approximately 160m (Table 4-1). Hearing fish may be present within a perceived temporary injury zone; however, to sustain an injury fish would need to be within this zone for 12 hours, which is extremely unlikely based on the nature of these specialised species and the progression of the cable installation at a maximum speed of 6 knots. Cable installation operations will be continuous and therefore fish, particularly those with swim bladders (which are both most vulnerable to injury and most mobile, Popper et al., 2014) will have the opportunity to move away from the sound source as it approaches, if it causes discomfort. The likelihood of Sturgeon being within 160m of the installation vessel for 12 hours is highly unlikely, therefore no effect to EPS species is expected from continuous noise from cable installation. Additionally, sensitivity of basking shark to underwater noise is likely much lower than hearing fish (Popper at al., 2014), therefore no effects to basking shark are anticipated.

It is also worth noting that the activities and noise sources modelled are temporary and transitory.

Fish are unlikely to be able to hear USBL in operation as it is above their audible range, therefore there will be no disturbance effects to fish.

5. CONCLUSION

In conclusion, there is an extremely low likelihood (negligible) that the project-related noise will cause injury to EPS and basking shark. The effects of disturbance from cable installation activities from continuous noise are limited to cetacean (and seal, which are not EPS), only if they are within the zone of influence for 24 hours. As this is highly unlikely due to the mobile nature of EPS, the effects are negligible. There is potential for temporary disturbance from underwater noise to cetacean (and pinniped (not EPS)) up to 1.1km from the operating USBL. There are no effects to fish or turtles from cable installation activities.

Temporary behavioural impacts (disturbance) to marine mammals are expected but will not be extensive, severe, or biologically significant, given the transient and short-term nature of installation activities. It is highly unlikely that disturbance would negatively impact upon the Favourable Conservation Status (FCS) of any species which may be present in the Geographical Area. The activities are temporary and transitory and set within a region where shipping noise is common suggesting animals will exhibit a degree of habituation.

As any disturbance to EPS within Scottish waters may constitute an offence, it is appropriate to obtain an EPS and Basking Shark licence under Scottish legislation (Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)), to avoid an offence. Therefore, an EPS and Basking Shark Licence application are attached with the R100 application for potential disturbance to cetacean and basking shark should they be present within the Inner Hebrides Geographical Area during installation.

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