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Scotland - Northern Ireland (Scot-NI) 3 and 4 Replacement Cables

Technical Appendix H - Underwater Noise Assessment

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Technical Appendix H - Underwater Noise Assessment

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CONTENTS

1. INTRODUCTION

1.1 Objective and Scope

This Underwater Noise Assessment is intended to establish whether the installation of the SCOT-NI Project will lead to sufficient levels of underwater sound to result in significant effects to fish and marine mammals.

The assessment focuses on continuous noise sources such as pre-lay grapnel run, route clearance, cable trenching and rock placement. The only source of impulsive sound anticipated during installation is from the use of ultra-short baseline acoustic positioning systems (USBL). The pressure levels and frequencies at which the USBL emit are not of a level where injury is expected but have the potential to cause brief disturbance to marine mammals and other protected species. The likelihood of a cetacean being close to operational equipment is extremely low when considering that the source is deployed from a moving vessel travelling and, in some cases, is being towed at depth within a few metres of the seabed. Whilst USBL may be deployed from a static vessel during specific activities (e.g. inspection works), these are anticipated to be limited to a period of up to a few hours. As such, although it is possible that a small number of animals may experience some level of brief disturbance for the very short period that they encounter installation activities injury is not expected from the use of USBL and brief disturbance will not be extensive, severe or biologically significant. Therefore, impulsive sound has not been considered further in this assessment.

To determine the zone of influence for each activity (the spatial extent over which the activities are predicted to have a potentially significant effect on the receiving environment) an assessment has been conducted which combines literature review with underwater sound calculations. This assessment has informed the Marine Environmental Assessment, Technical Appendix D: Protected Sites Screening Assessment.

1.2 Underwater Sound

1.2.1 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 Project Area; however, a report produced as part of Strategic Environmental Assessment (SEA) 6 (Harland *et al.* 2005) indicates that the dominant source of ambient noise in the North Channel and outer Firth of Clyde is expected to be shipping. Due to the lack of data, background noise has not been considered in this assessment. Therefore, the assessment is highly precautionary.

1.2.2 Continuous sound

The 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.

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. 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.

2. RECEPTOR SENSITIVITY

2.1 Introduction

Research has largely focused on effects of underwater sound on marine mammals and fish, but in the last few years evidence of effects in other species have been reported. Most research has described changes in behaviour or damage (or not) to hearing. In some extreme circumstances, significant underwater sound changes associated with impulsive noise sources can cause permanent injury, but this effect has not been reported for continuous noise associated with shipping activities.

2.2 Marine Mammals

Both cetaceans and pinnipeds 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.

Introduced sound may cause behavioural responses in animals, such as individuals moving away from the zone of disturbance 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.

Southall *et al.* (2019) provide sound exposure thresholds for injury to marine mammals which have been used in the assessment provided in Section 3.2.1. These reflect the current peer-reviewed published state of scientific knowledge.

2.3 Fish

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.

Popper et al. (2014) provide sound exposure guidelines for injury to fish, which have been used in the assessment presented in Table 3-1.

3. ASSESSMENT

3.1 Approach

3.1.1 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 zone of influence over which injurious or disturbance level effects may be experienced by a sensitive receiver.

As continuous sound is generally perceived as a lower risk to sensitive receptors a simple in-house geometric spreading calculation has been used to calculate attenuation distances. These distances were then compared to sound exposure thresholds published by Southall et al. (2019) for marine mammals and Popper et al. (2014) for fish to determine the range at which the received sound attenuates to levels below a defined threshold. The calculation uses the following equation (MMO 2015):

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

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

3.1.2 Effect thresholds

3.1.2.1 Marine mammals

Injury thresholds
Southall et al. (2019) provide different thresholds for PTS and TTS 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 3-1.

A review of the species present in the Project Area identified that they fall into four categories; low-frequency (LF) cetaceans (minke whale); high-frequency (HF) cetaceans (bottlenose dolphin); very high frequency (VHF) cetaceans (harbour porpoise) and phocid carnivores in water (PCW) (grey seal and harbour seal).

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. 140 dB re 1 μPa^2s rms has been used for continuous sound for all UK marine mammal species (Gomez et al. 2016, BOEM 2017, NMFS 2018).

3.1.2.2 Fish

The thresholds used in the assessment are taken from Popper et al. (2014) Table 7.7 which provides different thresholds for recoverable injury (which includes minor injury to tissues not involved in hearing) and TTS. For continuous noise the recoverable injury threshold is 170 dB re 1 µPa2s rms for exposure of 48 hours, and the TTS threshold is 158 dB re 1 µPa2s rms for exposure of 12 hours.

3.2 Results and discussion

3.2.1 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 3-1. It assumes a transmission signal which is constant with frequency but allows for increasing absorption loss at high frequencies. The model does not allow for filtering of long wave components in shallow water depths.

The model 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 effects the animal must remain within the area for at least 24-hours. It does not take into consideration the instinct of the animal to move away from the activity. 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 should 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.

Table 3-1 Distances at which injury and disturbance thresholds could be exceeded

Auditory group	PTS		TTS		Disturbance	
	Threshold of onset (dB re 1μPa^2s)	Distance to threshold (m)	Threshold of TTS onset (dB re 1μPa^2s)	Distance to TTS threshold (m)	Threshold of disturbance onset (dB re 1μPa^2s)	Distance to threshold (m)
LF	199	<1	179	9	140	2460
HF	198	<1	178	9		
VHF	173	22	153	397		
PCW	201	<1	181	6		
Fish	170 (recoverable injury, 48 hours exposure)	26	158 (TTS, 12 hours exposure)	160	N/A	N/A

Threshold Sources: Southall *et al.* 2019; and Popper *et al*. 2014.

3.2.2 Effects to marine mammals

Although the results presented in Table 3-1 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 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 extended 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.

Behavioural impacts to marine mammals from project-related vessel noise are expected but are not extensive, severe or biologically significant. Impacts could include 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.

Even at very low swim speeds (e.g. $0.5ms^{-1}$) it would take cetaceans <6hours 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 3-1. As a result, actual risk to marine mammals is not expected to be significant.

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 account for habituation of species to ambient sound. The Project 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 Project Area are habituated to noise of the type generated during cable installation activity.

3.2.3 Effects to fish

Data sources available (Popper *et al*. 2014 and OSPAR Commission 2012) consider that the potential for likely significant effects to fish 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. Potential effects are limited to fish with hearing specialties.

During cable installation, the worst-case zone of influence is estimated to be approximately 111m (Table 3-1). 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 24 hours, which is extremely unlikely based on the nature of these specialised species. 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.

It is therefore concluded that there will not be any significant effects to fish from underwater sound changes from the proposed activities.

4. CONCLUSION

In conclusion, there is an extremely low likelihood (negligible) that the project-related noise will cause injury to marine mammals or fish. Behavioural impacts to marine mammals and fish 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 any disturbance would negatively impact upon the Favourable Conservation Status (FCS) of any species which may be present in the Project Area. This is on the basis that the modelled level of disturbance will not affect the ability of any individual animal to survive or reproduce and will not have significant population impacts to any EPS. The activities are temporary and transitory and set within a region where shipping noise is common suggesting animals will exhibit a degree of habituation.

No potentially significant effects from underwater sound changes on marine mammals or fish have been identified.

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