ST. FERGUS NEARSHORE PIPELINE INSPECTION SURVEY

EIA Justification

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1.0 INTRODUCTION

Shell U.K. Limited (Shell) is planning to undertake a nearshore Acoustic Pipeline Inspection (API) survey of pipelines connecting to St. Fergus Gas Terminal, which is located on the North Sea coast in Aberdeenshire between Peterhead and Fraserburgh (see Figure 1-1). The gas terminal complex consists of four major onshore receiving, processing, and transporting facility complexes.

The Shell terminal receives gas and condensate from a number of pipelines including;

- the 289 km 20-inch pipeline (PL208) Fulmar Gas Line, which runs from the Central North Sea (CNS);
- the 101 km 20-inch Goldeneye gas pipeline (PL1978), which has the 4-inch monoethylene glycol (MEG) pipeline (PL1979) piggy-backed onto it;
- the 448 km 36-inch Far North Liquids and Associated Gas System (FLAGS) pipeline (PL002), which runs from the Northern North Sea (NNS); and
- the WAGES 16-inch Atlantic gas line from the Atlantic manifold to St Fergus (PL2029), which has the Atlantic 4-inch MEG pipeline (PL2032) piggy-backed onto it.

The objective is to carry out a pipeline inspection survey along these pipelines. This will involve the use of a sub-bottom profiler (SBP) and multi-beam echosounder (MBES). The survey will identify exposures, free spans, debris, obstacles, scarring (trawl, anchor), damage, scour or sedimentation along the pipelines and determine height and length of free-spans and any protective measures such as rock dumps and mattresses. The inspection can also include additional areas of interest, including but not limited to, pipeline or cable crossings as well as anomalous free spans / exposures. The survey performed on pipelines from a small nearshore survey vessel and within 5km of the landfall area in the vicinity of the St. Fergus Gas Terminal in the Central North Sea (CNS).

The proposed St. Fergus survey will cover an area of approximately 8 km^2 and will transect the United Kingdom Continental Shelf (UKCS) Blocks 19/11 and 19/12 in CNS. The location of the proposed survey area is illustrated in Figure 1-1 and the co-ordinates are provided in Table 1-1. The survey vessel will acquire SBP and MBES acoustic data along each pipeline route within the survey area from the shore outwards (seaward) to allow any potentially disturbed cetaceans to be directed away from the shore rather than onshore.

The proposed survey activities are planned to commence on the with an earliest start date of the ~~10th August 2023~~ 25th August. It is expected that the pipeline survey will be completed within a maximum of 14 working days, with the SBP component of the survey expected to take a maximum of four working days (subject to weather and tidal conditions). The latest completion date for the survey is the 30th November 2023.

This document presents an assessment carried out to determine the potential environmental impact of underwater sound from the proposed pipeline inspection and provides justification to support the application for consent to undertake the survey.

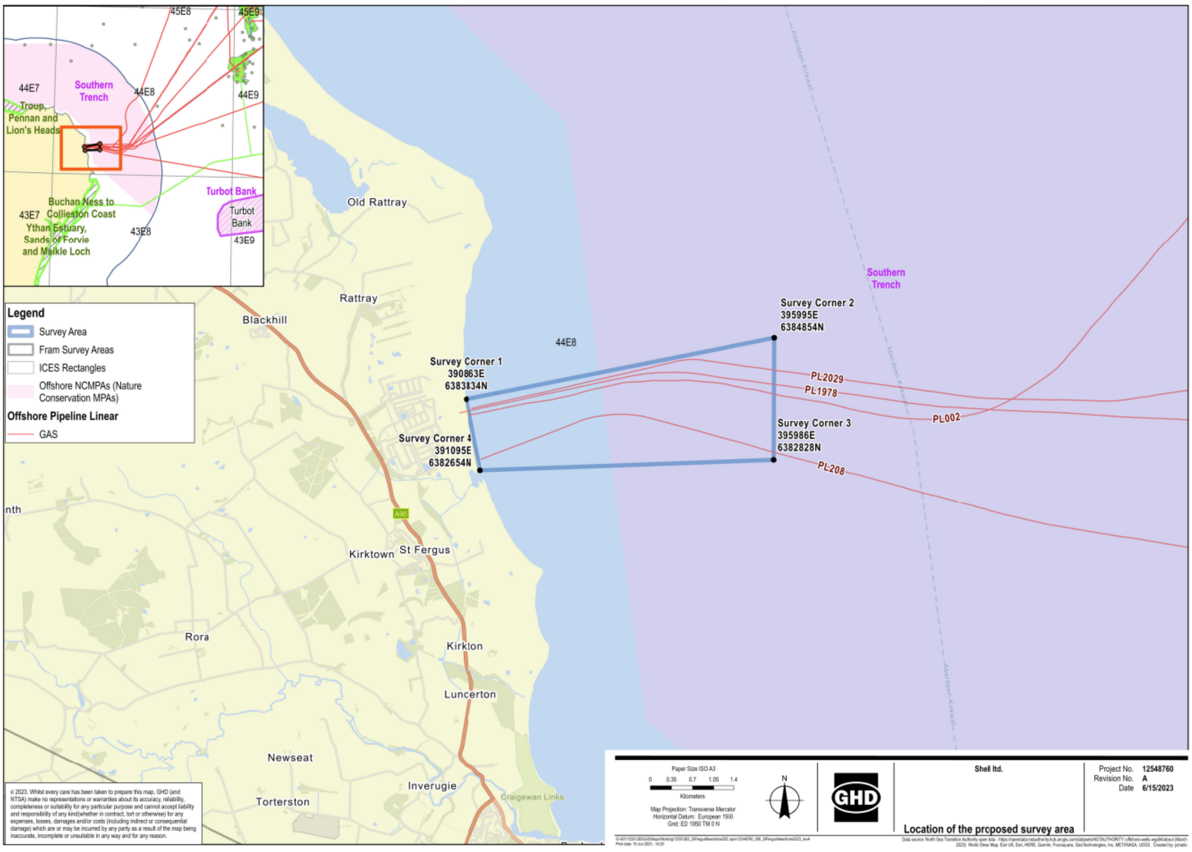

Figure 1-1: Location of the proposed survey area.

Table 1-1: Coordinates of the survey area.

Survey name	Location	Easting (m)	Northing (m)	Latitude (N)	Longitude (W)
St Fergus Survey area	Survey Corner 1	390862.99	6383834	57° 34' 54.291"	-01° 49' 36.708"
	Survey Corner 2	395995.04	6384853.9	57° 35' 31.619"	-01° 44' 29.461"
	Survey Corner 3	395985.58	6382828.1	57° 34' 26.132"	-01° 44' 26.902"
	Survey Corner 4	391094.98	6382653.9	57° 34' 16.352"	-01° 49' 20.842"
Coordinate System: Easting and northing coordinates are provided using European Datum (ED) 1950 Universal Transverse Mercator (UTM) Zone TM0 coordinate system, whilst latitude and longitude coordinates are provided using World Geodetic System (WGS) 1984 coordinate system.					

1.1 European Protected Species (EPS) license

JNCC (2010) provides guidance on the protection of marine European Protected Species (EPS) from injury and disturbance. They advise a risk assessment approach, which can be broadly split into two phases. Stage I requires assessing the likelihood of committing an offence, considerations of alternatives and mitigation measures must be considered. Should Stage I indicate impact to the EPS, then Stage II is considered as a last resort where a license to disturb the EPS is requested. The process will determine the likely consequences of any activity for which a license is sought.

1.2 Stage 1 – Assessing the likelihood of an offence

The following two main factors have the potential to cause an injury or kill marine mammals, resulting in an offence:

- physical contact, including collision; and
- anthropogenic sound (noise)

Section 5.0 of the JNCC guidance (2010) cover the anthropogenic impact in more detail. It states that impacts are unlikely to result from single, short-term operations, e.g., a seismic vessel operating in an area for 4-6 weeks. As discussed in this EAJ, specifically Section 6.0, the impact on mammals is negligible the case of this survey scope. However, since the work is being carried out within the 12 nautical mile from the shoreline and is located in the Southern Trench Marine Protection Area (MPA), an EPS licence will be requested.

2.0 SURVEY EQUIPMENT

The primary sources of underwater sound associated with the proposed survey will be due to the Sub-bottom profiler (SBP) and Multi-Beam Echosounder (MBES) equipment that will be used, as well as sound from the survey vessel.

2.1 Sub-bottom Profiler

Sub-bottom profiling is used to determine the stratification of soils beneath the sea floor. Various types of instruments may be used depending on the required resolution and seabed penetration. The majority of sound energy from SBPs is directed vertically downwards and the pulse duration is short (tens to hundreds of milliseconds). The actual source levels generated by a sub-bottom profiler depends on the type of equipment used and its operating specification.

The sub-bottom profiler that will be used during the proposed geophysical site survey will be a GeoAcoustics GeoPulse Pinger – 4 X surface mounted (Cat/Moonpool) transducers. Details of the SBP that will be used for the proposed pipeline inspection survey are summarised in Table 2-1.

Table 2-1: Sub-bottom profiler details.

Parameter		Value
Source		GeoAcoustics GeoPulse Pinger
Signal type		Linear frequency modulated chirp signal
Source Level	Zero-to-peak SPL	214 dB re 1 µPa-m
Frequency range (-3dB)		2 – 12 kHz
Pulse interval		0.1 s

2.2 Multi-beam Echosounder

The pipeline inspection survey will also employ a multi-beam echosounder (MBES). MBESs are used mainly to understand the seabed profile with respect to elevation and are capable of receiving several separate beams. The device use transducers to send out a swath of sound waves from the vessel covering a large, fan-shaped area. They have the capability to interpret directionality in the sound reflection they receive, which can be interpreted into depth. An illustration of the multi-beam echosounder operation is shown in Figure 2-1. The MBES equipment that will be used during the proposed pipeline inspection survey will be a dual-head Teledyne Reson 7125. The MBES will produce sound at a frequency of 400 kHz. The sound generated will therefore be outside the main hearing range of any marine mammals that are likely to be in the survey area (NMFS, 2018; Southall *et al.,* 2019) and will unlikely have any significant impact.

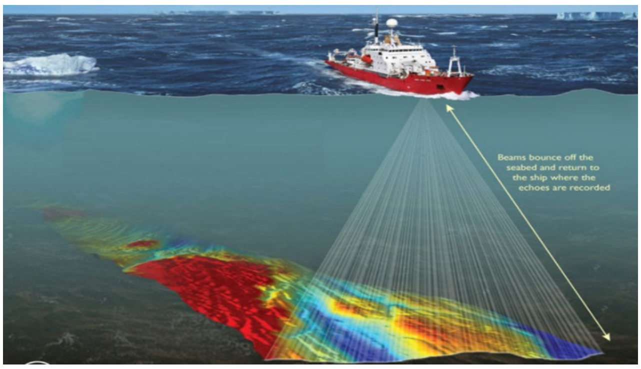

Figure 2-1 Multi-beam Echosounder illustration (British Antarctic Survey, 2015)

2.3 SURVEY VESSEL

Vessel sound is generally continuous and results from narrowband tonal sounds at specific frequencies and broadband sounds (Richardson *et al.*, 1995). Acoustic energy from vessels is generally strongest at frequencies below 1 kHz. Whilst the survey vessel will contribute sound to the marine environment, the level of sound will not be high enough to cause any significant adverse effect to marine mammals or fish. The pipeline inspection survey at St Fergus will be completed be the MV Titan Discovery, which can be seen in Figure 2-2. An overview of the vessel can be seen in Table 2-2.

Table 2-2 MV Titan Discovery vessel details

Vessel (Role)	Registration	Call Sign	Gross Tonnage (te)	Estimated Vessel Use
MV Titan Discovery (Dredger)	United Kingdom	2HCR3	12.1	14 days

Figure 2-2 MV Titan Discovery (Vessel Finder, 2023)

3.0 ENVIRONMENTAL BASELINE

This section outlines the main environmental sensitivities within the survey area that could be impacted by the proposed survey activities. This covers the main receptors sensitive to underwater sound such as marine mammals and fish. The environmental baseline is split into two areas, the physical environment (Section 3.1) and the biological environment (Section 3.2).

3.1 Physical Environment

3.1.1 Bathymetry

Bathymetry can strongly influence the propagation of sound. Sound propagating in shallow waters interacts with the seabed, which typically results in stronger attenuation. In deeper waters, there is less interaction of sound with the seabed and attenuation due to bottom loss is generally lower than in shallow waters, which can result in longer range sound propagation (Jensen *et al.*, 2011).

Bathymetry around the proposed survey area is shown in Figure 3-1. The water depth in the proposed survey area ranges from less than 10 m to approximately 50 m in depth.

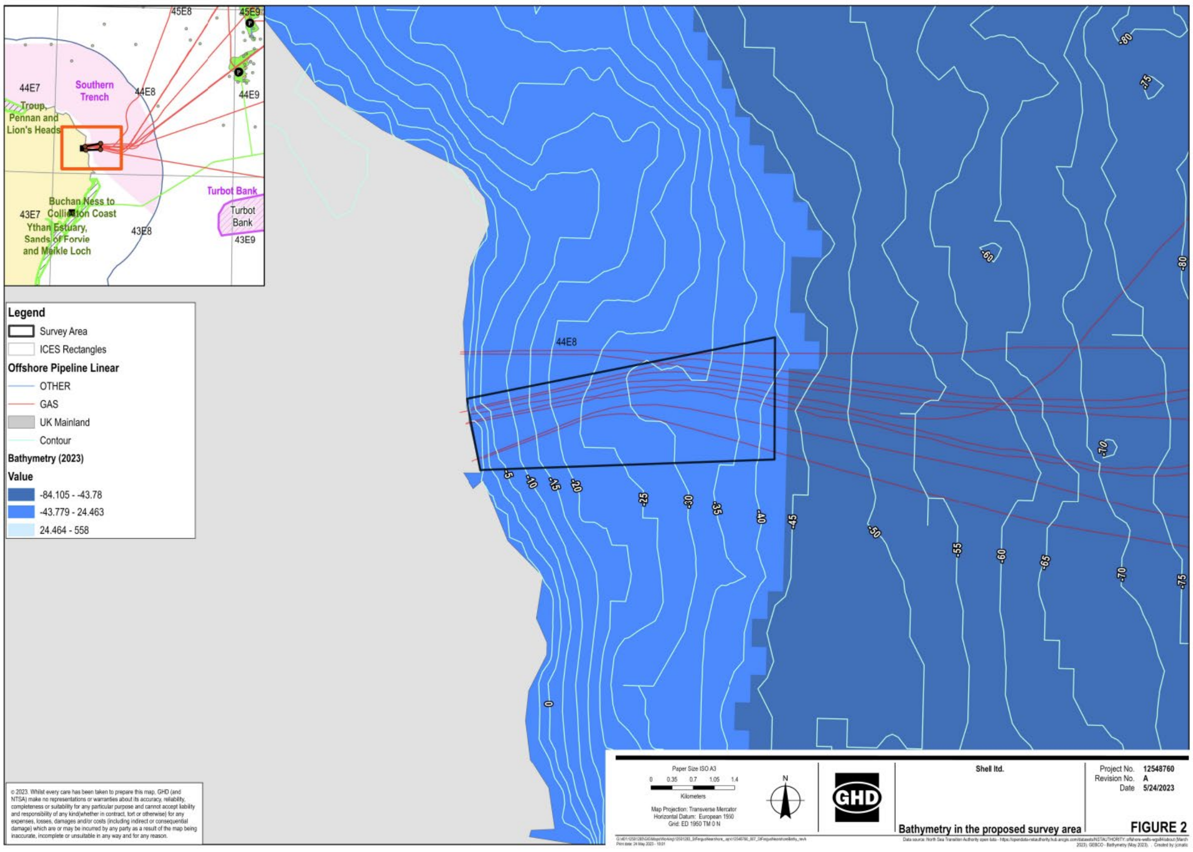

Figure 3-1: Bathymetry in the proposed survey area.

3.1.2 Seabed Sediments

The type of seabed sediments in an area can affect sound propagation through reflection, attenuation and scattering effects (Jensen *et al.*, 2011). An understanding of sediment distribution is therefore important for propagation modelling. Furthermore, the plant and animal species found in an area are often linked to the sediment type (particularly benthic species). The seabed sediments around the proposed survey area are shown in Figure 3-2. The sediments in the survey area is predominantly comprise circalittoral sand and some gravel.

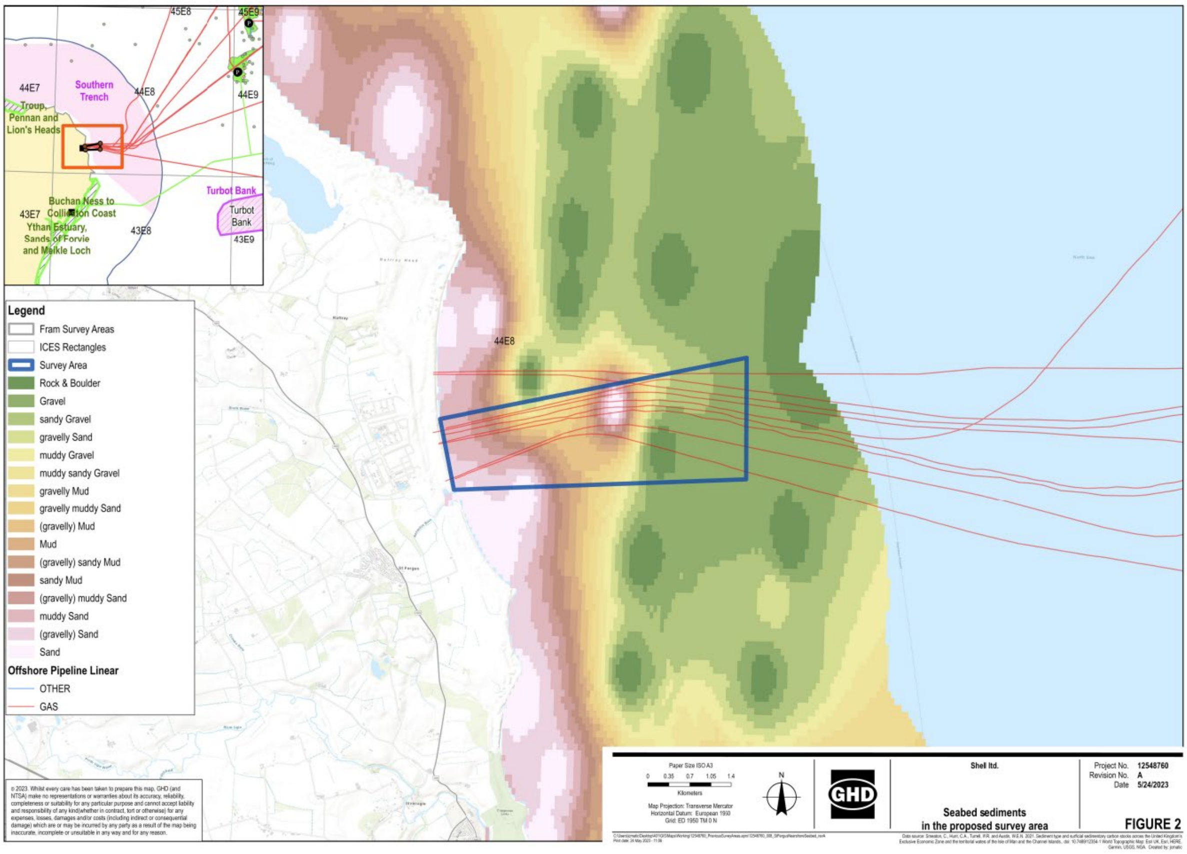

Figure 3-2: Seabed sediments in the proposed survey area.

3.2 Biological Environment

3.2.1 Cetaceans

A series of Small Cetacean Abundance in the North Sea (SCANS) surveys have been conducted to obtain an estimate of cetacean abundance in the North Sea and adjacent waters, the most recent of which is SCANS-III (Hammond *et al.*, 2021). Aerial and shipboard surveys were carried out during the summer of 2016 to collect abundance data for the most commonly occurring cetacean species in the North Sea. The proposed St Fergus survey lies within SCANS-III Block R (Figure 3-3). Aerial survey estimates of animal abundance and densities within this area are provided in Table 3-1. The data show that harbour porpoise, bottlenose dolphin, white-beaked dolphin, white-sided dolphin, and minke whale were observed in SCANS Block R during the SCANS-III survey. Based on the 8 km^2 survey area, the number of animals which may be present in the survey area is noted in Table 3-1.

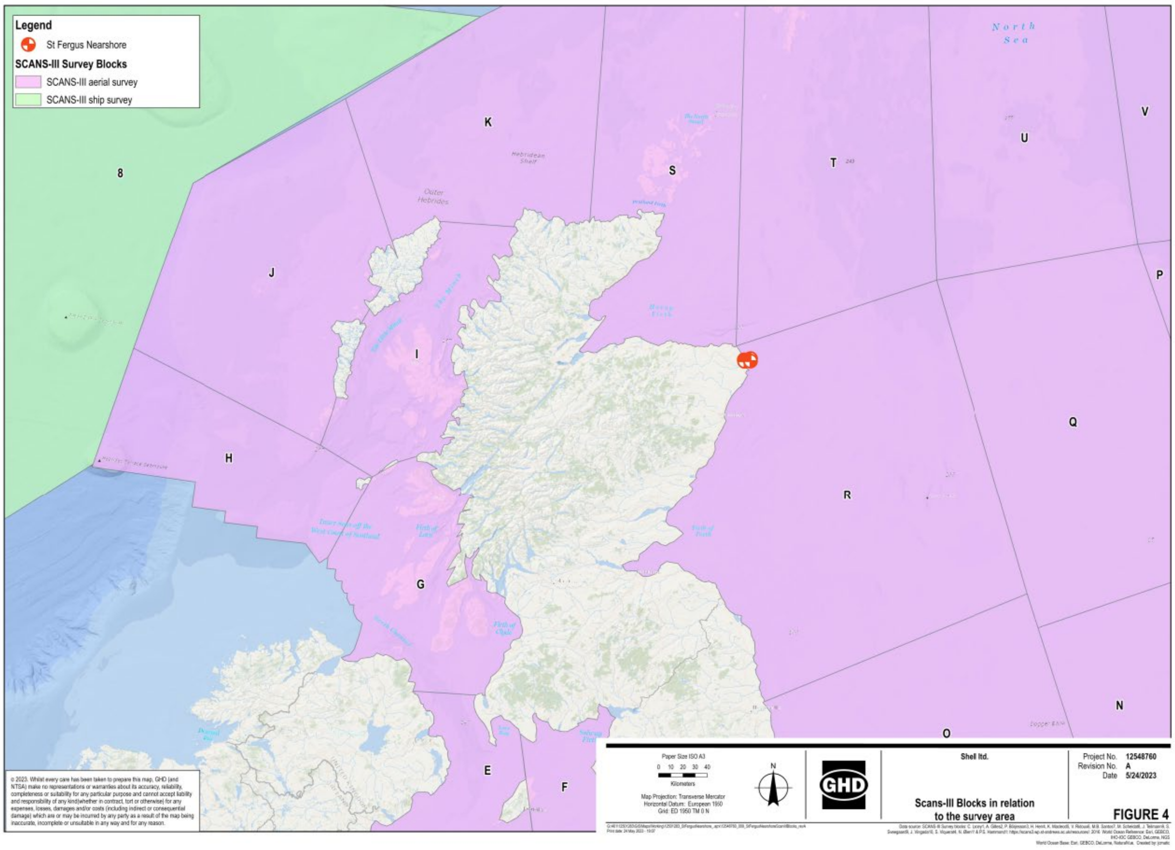

Figure 3-3: SCANS-III blocks in relation to survey area.

Table 3-1: Cetacean abundance in SCANS-III Survey Block R.

Species	Block R		Predicted number of animals present in the survey
	Animal abundance	Density (animals/km^2)	
Harbour porpoise	38646	0.599	5
Bottlenose dolphin	1924	0.03	1
White-beaked dolphin	15694	0.243	2
White-sided dolphin	644	0.01	1
Minke whale	2498	0.039	1

The Joint Nature Conservation Committee (JNCC) has compiled an Atlas of Cetacean Distribution in Northwest European Waters (Reid *et al.*, 2003) which gives an indication of the seasonal distribution and abundance of cetacean species in the North Sea. In agreeance with the SCANS-III survey data, the Reid *et al.* (2003) data show that harbour porpoise, bottlenose dolphin, white-beaked dolphin, white-sided dolphin, and minke whale have been observed in the area of the proposed survey location (Table 3-2). All cetaceans are European Protected Species (EPS) and are listed under Annex IV of the European Union (EU) Habitats Directive. Harbour porpoise are granted further protection under Annex II of the EU Habitats Directive.

Table 3-2: Seasonal cetacean sightings within the proposed survey area.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour porpoise	1	1	1	1	1	2	3	2	2	1	1	1
Bottlenose dolphin	1				1	1	1	1	1			
White-beaked dolphin		**1**	**1**			**2**	3	**3**	**3**	3		**2**
White-sided dolphin							1	1				
Minke whale						1	3	1	1			
Key - 1 = Low, 2 = medium, 3 = high The thicker box indicates the months the survey will take place in.												

3.2.2 Pinnipeds

Two species of pinnipeds (seals) are resident in British waters: the grey seal and the harbour seal. Although both species are Annex II species, they are not listed on Annex IV of the Habitats Directive, and as such are not classified as EPS. Seals are protected in the UK under the Conservation of Seals Act 1970. Both species are listed under Annex II of the EU Habitats Directive and are considered Scottish Priority Marine Features (PMFs).

Grey and harbour seals feed in inshore and offshore waters depending on the distribution of their prey, which changes seasonally and annually. Both species tend to be more concentrated close to shore, particularly during the pupping and moulting season. The movements of grey seals can involve larger distances compared to harbour seals, with ranges of up to several hundred kilometres from one haul-out to another having been recorded (SMRU, 2017).

Distribution maps (Figure 3-4) based on telemetry data and count data indicate that harbour seals are not likely to occur in the St Fergus survey area. However, grey seals are likely to occur in the area at an average abundance of roughly 5 - 10 seals at any time within each 5 km x 5 km square (Russell *et al.*, 2017).

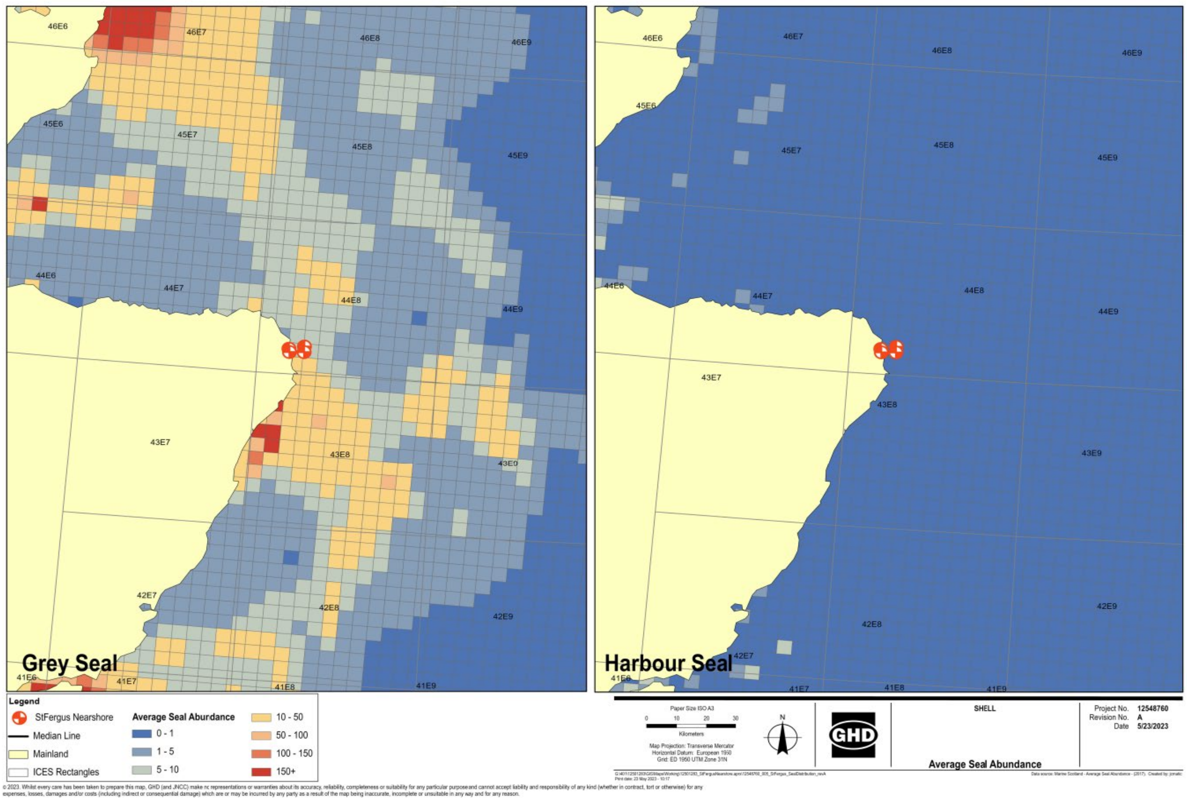

Figure 3-4: Average seal abundance near the survey area (Russell *et al.*, 2017).

3.2.3 Fish

More than 330 fish species are thought to inhabit the shelf seas of the UKCS (Pinnegar *et al.*, 2010). Finfish species can broadly be divided into pelagic and demersal species. Pelagic species (e.g. herring, mackerel, blue whiting and sprat) are found in mid-water and typically make extensive seasonal movements or migrations. Demersal species (e.g. cod, haddock, sand eels, sole and whiting) live on or near the seabed and, similar to pelagic species, are known to passively move (e.g. drifting eggs and larvae) and/or actively migrate (e.g. juveniles and adults) between areas during their lifecycle.

The proposed St Fergus survey area lies within International Council for the Exploration of the Seas (ICES) rectangle 44E8. High intensity nursery grounds for herring and whiting were identified in the area. No peak spawning periods were identified at the proposed time of the survey (see Table 3-3) (Coull *et al.*, 1998, Ellis *et al.*, 2012). There will be spawning for Herring, Lemon Sole, Sandeel, Sprat, and Nephrops in the area during the suggested survey months (Figure 3-5). Although there is fish spawning and nursery activity in the vicinity at certain times of the year, the spawning and nursery areas tend to be transient, and are part of larger offshore areas (Coull *et al.*, 1998, Ellis *et al.*, 2012). Aires *et al.* (2014) identified presence of juveniles in the area for whiting, haddock and cod (see Table 3-3).

Table 3-3: Spawning activity, nursery areas, and juvenile presence of commercial fish species within ICES rectangle 44E8.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Herring	N	N	N	N	N	N	N	SN	SN	N	N	N
Whiting	NJ	SNJ	SNJ	SNJ	SNJ	SNJ	NJ	NJ	NJ	NJ	NJ	NJ
Lemon sole	-	-	-	S	**S**	**S**	S	**S**	**S**	-	-	-
Norway pout	SN	S*N	S*N	SN	N	N	N	N	N	N	N	N
Sandeel	SN	SN	N	N	N	N	N	N	N	N	SN	SN
Sprat	N	N	N	N	S*N	S*N	SN	SN	N	N	N	N
Nephrops	SN	SN	SN	S*N	S*N	S*N	SN	SN	SN	SN	SN	SN
Haddock	NJ	**NJ**	**NJ**	NJ	**NJ**	**NJ**	NJ	**NJ**	**NJ**	NJ	**NJ**	**NJ**
Cod	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ

Key: S-Spawning; S*- Peak Spawning; N-Nursery; J-Juveniles (i.e. 0-group fish: < 1 year old)
Herring and whiting both have periods of high intensity nursery grounds (Ellis, et al., 2012, Coull, et al, 1998 and Aires, et al, 2014)
The thicker box indicates the months in which the survey will take place

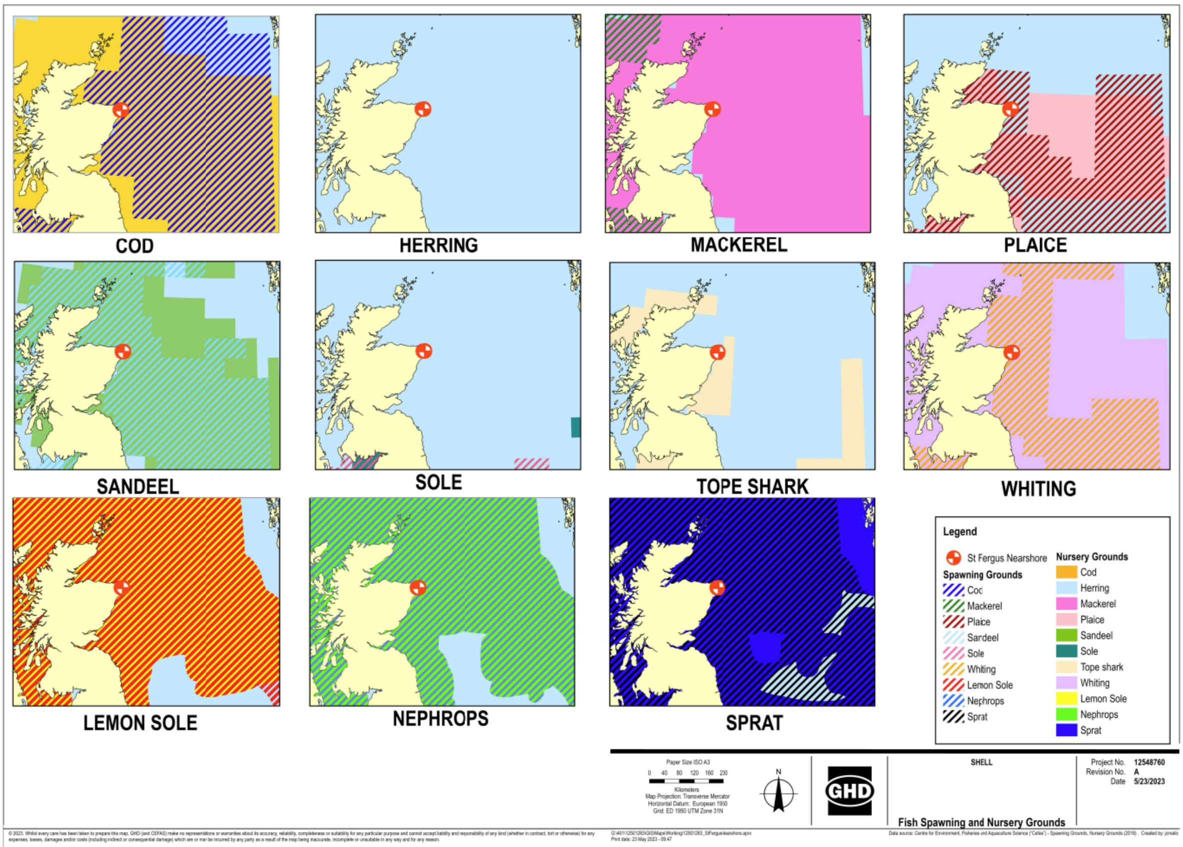

Figure 3-5: Spawning grounds of fish that spawn during the survey period.

3.2.4 Registered Concerns for Seismic Surveys

The North Sea Transition Authority (NSTA) (previously the Oil and Gas Authority – OGA) has published guidance (OGA, 2019), which includes advice from government departments and external agencies on seasonal concerns for fish spawning from offshore activities including seismic surveys. The St Fergus survey area lies within Blocks 19/11 and 19/12. There are identified periods of concern for seismic surveys during the survey period in these blocks, from January - February, August – September, and November – December. However, there are no concerns for the use of SBPs.

3.2.5 Protected Areas

A network of Marine Protected Areas (MPAs) is in place to aid the protection of vulnerable and endangered species and habitats through structured legislation and policies. These sites include Special Areas of Conservation (SAC) and Special Protection Areas (SPA), designated under the EC Habitats Directive (92/43/EEC) and EC Birds Directive (2009/147/EC), respectively, along with Nature Conservation Marine Protected Areas (NCMPAs) designated under the Marine (Scotland) Act 2010 or the Marine and Coastal Access Act 2009. Figure 3-6 illustrates the protected areas in the vicinity of the proposed survey area.

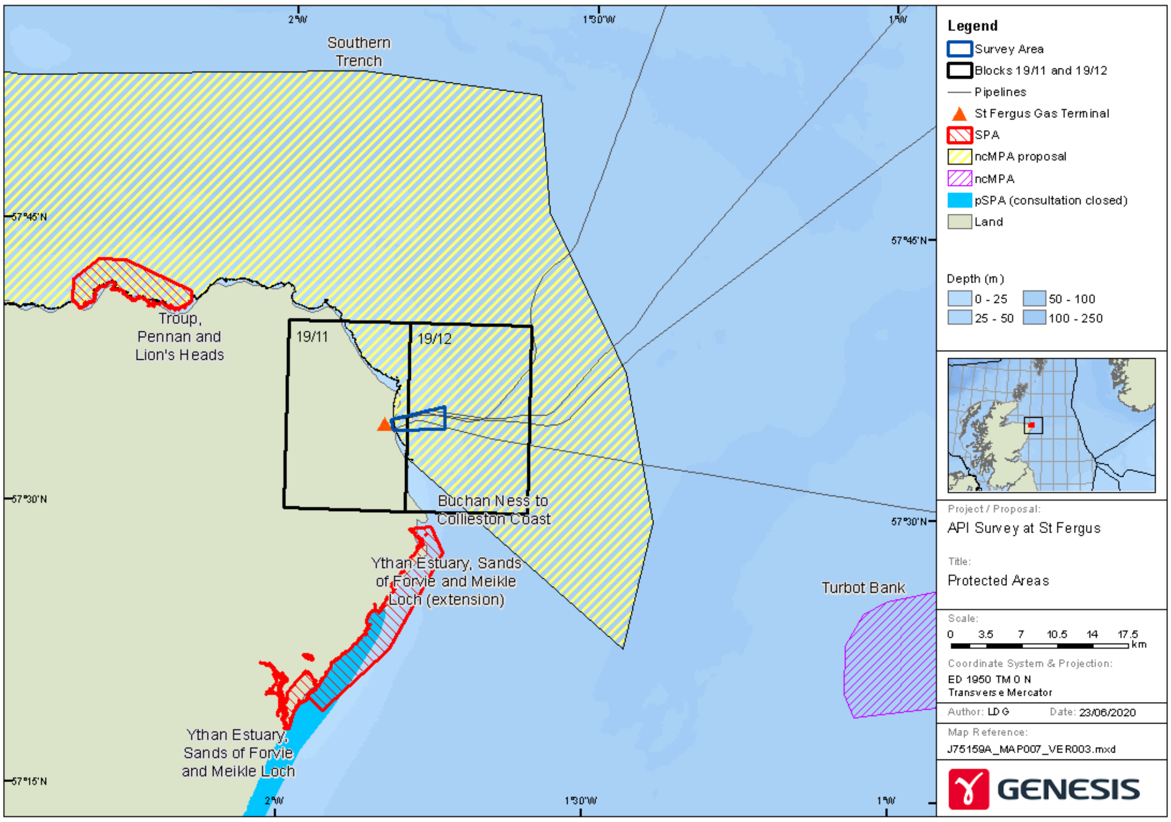

Figure 3-6: Sites of conservation interest in the vicinity of the proposed survey location.

3.2.5.1 Southern Trench MPA

The Southern Trench is one of four possible MPAs (pMPA) which were submitted to the Scottish Government for consideration in 2014 for inclusion in the existing MPA network. It was designated on the 17 December 2020. The proposed survey area is within the Southern Trench MPA. The Southern Trench MPA is shaped around a large undersea valley consisting of an area of deep water (~200 m) extending along the coast between Banff and Peterhead. The Southern Trench is considered to be an exceptional example of an enclosed glacial seabed basin and is regarded as scientifically important in developing an understanding of ice sheet drainage patterns in this region (Nature Scot, 2020a).

There are shelf deeps within the MPA, which are enclosed topographic depressions on the seabed. Large numbers of juvenile fish have been recorded within the shelf deep, suggesting the shelf deep represents an important nursery area. In addition, the waters off Fraserburgh produce frontal zones with strong horizontal gradients in surface and/or bottom temperatures. These fronts can concentrate nutrients and plankton, which are associated with pelagic biodiversity hotspots as they attract prey assemblages and higher trophic level foragers such as cetaceans.

The following are protected features/species within the MPA proposal:

- Burrowed mud;
- Minke whale;
- Shelf deeps; and
- Fronts.

Nature Scot published the conservation objectives for the MPA, which require the protected features listed above to maintain or attain favourable condition (Nature Scot, 2020b).

3.2.5.2 Buchan Ness to Collieston Coast SPA

The Buchan Ness to Collieston Coast SPA lies approximately 8.6 km to the south of the survey area. This site has been designated for the conservation of vegetated sea cliffs of the Atlantic and Baltic Coasts. It is a 15 km stretch of south-east facing cliffs formed of granite, quartzite and other rocks running to the south of Peterhead. The low, broken cliffs show many erosion features (such as stacks, arches and caves), and provide an important nesting area for a number of seabird species, which feed outside the SPA in the nearby waters, as well as more distantly (JNCC, 2005). During the breeding season, the area regularly supports 95,000 individual seabirds, including: fulmar (*Fulmarus glacialis*), guillemot (*Uria aalge*), herring gull (*Larus argentatus*), kittiwake (*Rissa tridactyla*), and shag (*Phalacrocorax aristotelis*). Given that the qualifying features for Buchan Ness to Collieston Coast SPA have no sensitivity to underwater noise, no further assessment of potential impacts on these have been undertaken.

3.2.5.3 Other Protected Areas

Other SPAs close to the survey site are Troup, Pennan and Lion's Heads SPA located approximately 23.5 km to the north west, which is designated for species Razorbill, Northern fulmar, Black-legged kittiwake, seabird assemblage, common guillemot, and herring gull, as well as marine area habitats. Ythan Estuary, Sands of Forvie and Meikle Loch is a SPA is located 18 km to the south and aims to protect species such as Little tern, Waterfowl assemblage, common tern, Pink-footed goose, and Sandwich tern, as well as habitats tidal rivers, estuaries, mud flats, sand flats, lagoons, salt marshes, sand pastures, salt steppes. These are considered to be out-with the area of any potential disturbance associated with the pipeline surveys and so have not been assessed further.

4.0 SOCIO-ECONOMIC BASELINE

4.1 COMMERCIAL FISHING

St-Fergus lies within ICES rectangle 44E8. The Scottish Government reports fish landings and effort data from vessels of greater than 10 m in length from UK waters. UK fisheries can be categorised into demersal, pelagic and shellfish fisheries with the shellfish sector being typically the most valuable. As shown by Figure 4-1 , which presents the kW days at sea by vessels over 10m, which considers both the time vessels spend fishing and the power (kW) of the vessel's engine, since 2003 fishing has decreased by roughly 43% (MMO, 2022).

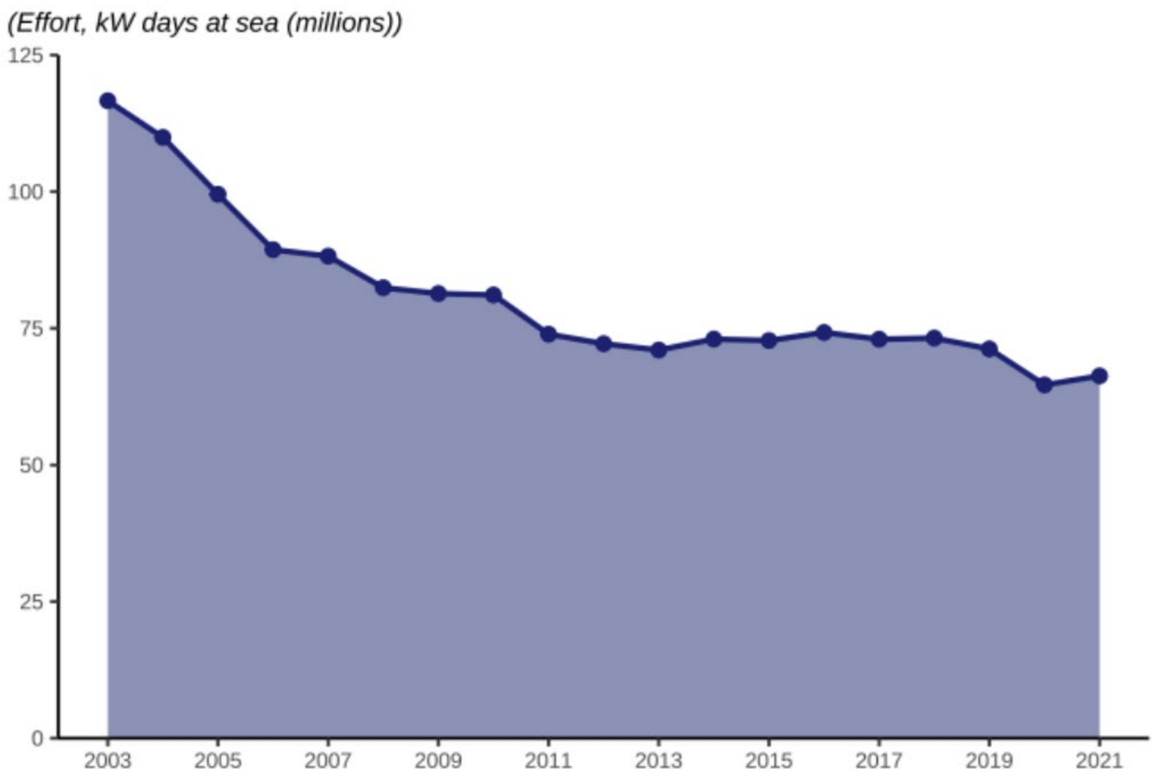

Figure 4-1 Fishing effort in kW days at sea (millions) from 2005 to 2020 (MMO, 2022)

Fishing effort and data for ICES rectangle 44E8 was obtained. Whilst the survey is not intrusive by nature, it is still important to understand the socio-economic impact. Table 4-1 shows the fishing effort, value, and landings in the rectangle in comparison to the UK. As shown, the value of caught goods in 44E8 was only 0.81% percent of the UK total. Table 4-2 shows the value of important species.

Table 4-1 Fishing effort, value, and landings in ICES 44E8

Year	Fishing Effort (days)		Value (£)		Landings (tonnes)	
	44E8	UK Total	44E8	UK Total	44E8	UK Total
2021	1430	100,720	5,293,780	651,104,554	2,650	502,998
2020	1680	152,921	4,771,743.88	830,832,127	2,104.24	588,759
2019	1377	181,814	5,050,243.10	563,000,000	2,554.70	386,000
2018	1596	125,704	5,488,100.59	676,432,222	2,185.05	501,217
2017	1533	126,863	4,616,085.83	717,531,114	2,370.34	531,361

Table 4-2 Landing values in 2021

Species	Landing values (£)	Species	Landing values (£)
Lobster	280,505.65	Cod	51,222.56
Scallops	761,290.63	Herring	406,058.00
Crab	1,424,865.47	Whiting	136,350.51
Nephrops	1,082,446.37		

4.2 Oil and Gas Infrastructure

ICES block 19/11 is well developed with oil and gas infrastructure. The PETS (Portal Environmental Tracking System) was consulted to determine what other activities were occurring in the area. Due to the localised nature of this project, only projects which occur in the same wider UKCS block (19) have been highlighted. The PETS documents (standalone applications) for 2022 and 2023 were analysed and the output can be seen in Table 4-2.

Table 4-3 Submitted PETS standalone applications in UKCS block 19

Operator	Year	Quadrant/ block	MAT reference	Application type	SAT Start date	SAT End Date
Approved applications						
PX Group Limited	2022	19/11	SA/1651	Notification of a Proposed Marine Survey	2022-07-29	Not available
Shell U.K. Limited	2022	19/11	SA/1598	Notification of a Proposed Marine Survey	2022-05-07	Not available
CNOOC Petroleum Europe Limited	2022	19/10	SA/1418	Notification of a Proposed Marine Survey	2021-11-20	Not available
CNOOC Petroleum Europe Limited	2022	19/10	SA/1418	Notification of a Proposed Marine Survey	2021-11-20	Not available
BP Exploration Operating Company Limited	2023	19/11	SA/1711	Notification of a Proposed Marine Survey	2023-04-20	Not available

It is most likely that the applications dated 2022 have been completed and only potential overlap may be the BP application in block 19/11.

5.0 NOISE IMPACT ASSESSMENT METHODOLOGY

The assessment method used here is largely based on the JNCC guidance on the protection of marine European Protected Species (EPS) from injury and disturbance (JNCC, 2010). The Conservation of Offshore Marine Habitats and Species Regulations 2017 have a revised definition of 'disturbance' to EPS. It is now an offence under UK Regulations to:

a) *deliberately capture, injure, or kill any wild animal of a European protected species;* (termed 'the injury offence'),
b) *deliberately disturb wild animals of any such species* (termed 'the disturbance offence').

Here, injury is defined as a permanent threshold shift (PTS; i.e. a permanent shift in the hearing of an EPS), and disturbance of animals includes any event that is likely:

a) *to impair their ability to survive, breed or reproduce, or to rear or nurture their young, or (in the case of animals hibernating or migratory species), to hibernate or migrate;*
b) *to affect significantly the local distribution or abundance of the species to which they belong.*

It has become increasingly evident that noise from human activities can have the potential to impact on marine species (OSPAR, 2009; Richardson, *et al*., 1995; Southall *et al*., 2007; NMFS, 2018; Popper *et al.,* 2014). Sound is important for marine mammals for navigation, communication and prey detection, and the introduction of anthropogenic sound therefore has the potential to impact marine mammals. Sound may also interfere with acoustic communication, predator avoidance, prey detection, reproduction and navigation in fish (Slabbekoorn *et al*., 2010).

The extent to which underwater sound might cause an adverse environmental impact is dependent on numerous factors. JNCC recommends considering the following factors when assessing the impact of sound exposure:

a) Duration and frequency of the activity;
b) Intensity and frequency of sound and extent of the area where disturbance and injury thresholds may be exceeded, taking into consideration species-specific sensitivities;
c) The interaction with other concurrent, preceding or subsequent activities in the area;
d) The most up to date thresholds for injury and behavioural responses; and
e) Whether the local abundance or distribution could significantly be affected.

The current assessment has followed these guidelines and considered the JNCC recommendations to assess the potential impacts of underwater sound.

5.1 Noise Modelling

A noise modelling exercise was carried out for this scope work in 2020 (submitted as part of application SA/1323). The SBP used for the 2020 survey and modelling exercise was the Innomar Medium Parametric. The parameters for this SBP can be seen in Table 5-1. As the Zero-to-peak SPL and the SEL used in the 2020 survey were higher than the Zero-to-peak SPL and the SEL of the GeoAcoustics GeoPulse Pinger (see Table 2-1), it has been assumed the noise modelling results will be applicable to this application.

Table 5-1 Parameters of sub bottom profiler used in 2020 survey and modelling exercise

Parameter		Value
Source		Innomar Medium Parametric SBP
Signal type		Linear frequency modulated chirp signal
Source Level	Zero-to-peak SPL	250 dB re 1 µPa-m
	SEL	243 dB re 1 µPa2s-m
Frequency range (-3dB)		5 – 15 kHz
Pulse interval		0.1 s

The modelling focuses on predicting received sound levels from the SBP since this is the loudest sound source associated with the proposed pipeline inspection survey that will be within the hearing range of most marine mammals. The sound propagation model used for this assessment is the Genesis in-house model FARAM (Faunal Acoustic Risk Assessment Model), which utilises range-dependent parabolic equation and ray tracing algorithms. Both these propagation algorithms incorporate varying environmental conditions with depth and range, including site-specific bathymetry, a range-dependent sound speed depth profile and geo-acoustic model. By explicitly modelling these factors affecting sound propagation, results obtained are more relevant to the area of interest than would be obtained with simpler models. Full details of the adopted modelling methodology are provided in Appendix A of this report.

5.2 Impact Thresholds for Marine Mammals

Potential impacts to marine mammals have been assessed using thresholds for injury and disturbance. The thresholds used in this assessment are based on a comprehensive review of evidence for impacts of underwater sound on marine mammals.

5.2.1 Thresholds for Permanent Threshold Shift

Numerous studies have been conducted to estimate the sound levels that can potentially cause injury to marine mammals, including permanent injury. Thresholds for estimating potential impacts to marine mammals have been suggested by the National Oceanic and Atmospheric Administration (NOAA) (NMFS, 2018) and Southall *et al.* (2019) based on the most recent studies and are now recognised as the appropriate criteria for assessing potential impacts to marine mammals as a result of underwater noise.

NOAA and Southall *et al.* (2019) proposed thresholds for marine mammals grouped into different functional hearing groups. It is noted that there is a slight difference in nomenclature between the NOAA guidance and that of Southall *et al.*: NOAA grouped marine mammals into low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, and phocid pinnipeds. Southall *et al.* (2019) proposed equivalent hearing groups but refers to them as LF cetaceans, HF cetaceans, very high-frequency (VHF) cetaceans and phocid pinnipeds, respectively. Table 5-2 shows the corresponding NOAA and Southall marine mammal hearing groups and lists marine mammal species that could potentially occur in the proposed survey areas categorised according to these hearing groups along with their permanent Threshold Shift (PTS) thresholds.

Table 5-2: Marine mammal species categorised according to the hearing groups proposed by NOAA (NMFS, 2018) and Southall *et al.* (2019) and PTS thresholds.

Hearing Group		Species [1]	PTS Threshold	
NMFS (2018)	Southall *et al.* (2019)		Zero-to-peak SPL (dB re 1 μPa)	Cumulative SEL (dB re 1 $\mu Pa^2 s$)
LF cetaceans	LF cetaceans	Minke whale	219	183
MF cetaceans	HF cetaceans	White-beaked dolphin, bottlenose dolphin, white-sided dolphin, pilot whale, killer whale, common dolphin, Risso's dolphin, striped dolphin	230	185
HF cetaceans	VHF cetaceans	Harbour porpoise	202	155
Phocid pinnipeds	Phocid pinnipeds	Grey seal, harbour seal	218	185

[1] Species listed in this table are the most commonly sighted marine mammal species in the North Sea (Reid *et al.*, 2003; Hammond *et al.*, 2021; Russel *et al.*, 2017).

Depending on the operating conditions, the SBP may be characterised as a non-impulsive source. However, the impulsive thresholds proposed by NOAA (NMFS, 2018) and Southall *et al.* (2019) have been adopted for this assessment since they are more conservative. The thresholds are expressed in terms of both zero-to-peak SPL and cumulative SEL. As dual-metric criteria, the onset of PTS is considered to potentially occur when either of the thresholds are exceeded (NMFS, 2018; Southall *et al.,* 2019). The zero-to-peak SPL thresholds are used to assess the potential for injury to occur in marine mammals due to instantaneous sound pressure and do not take into consideration the hearing range of any marine mammals. In contrast, the cumulative SEL metric considers the hearing capability of the species under consideration by weighting the received SEL using generalised auditory weighting filters that have been derived for different marine mammal hearing groups. NOAA and Southall *et al.* (2019) proposed the same auditory weighting filters, which are shown in Figure 5-1 (note that the Southall *et al.,* 2019 marine mammal naming convention has been used in this figure). In the rest of this impact assessment, the nomenclature used by Southall *et al.* (2019) for the marine mammal hearing groups is used.

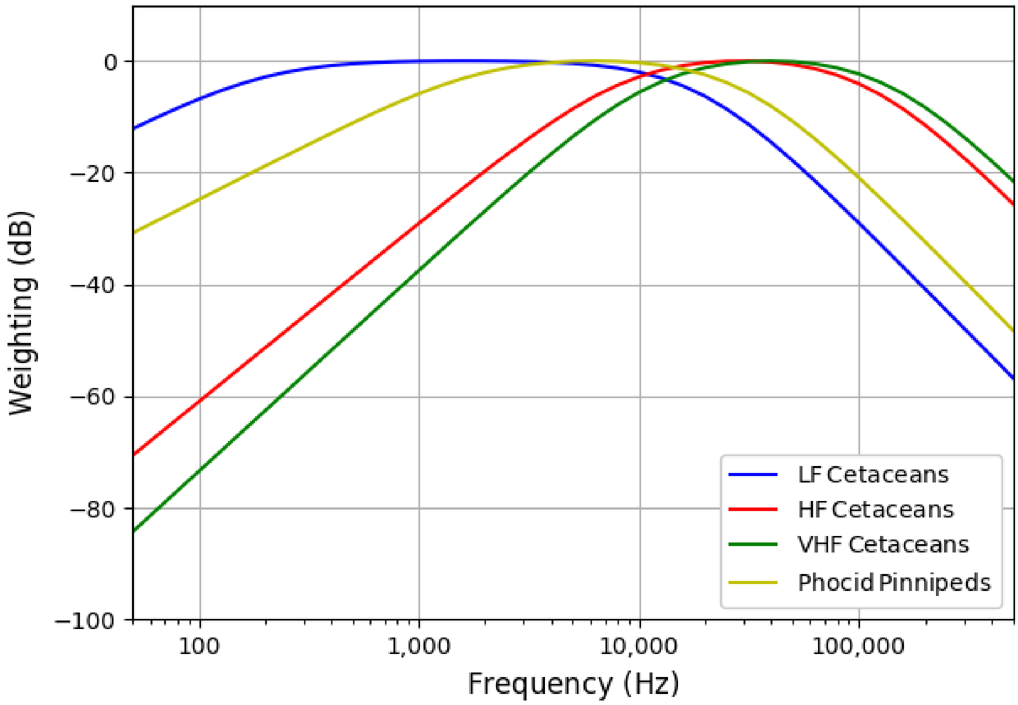

Figure 5-1: Auditory weighting functions for marine mammals.

5.2.2 Behavioural Disturbance Thresholds

Another important consideration in assessing the impacts of sound on marine mammals is the mammals' behavioural response. However, there are no well-established or accepted thresholds for behavioural disturbance to marine mammals (Southall et al., 2007; Southall et al., 2019; NMFS, 2018). This is because behavioural disturbance can range greatly from low level minor disturbance, such as changes in swimming behaviour and vocalisation, to higher levels of disturbance such as strong avoidance of an area. Southall et al. (2007) concluded that the available data on marine mammal behavioural responses were too variable and context-specific to justify proposing single disturbance criteria for all marine mammals. Instead, Southall et al. recommended assessing whether a noise from a specific source could cause disturbance to a particular species by comparing the circumstances of the situation with empirical studies reporting similar circumstances.

The studies reviewed by Southall et al. (2007) suggest that LF cetaceans will not exhibit behavioural changes at root mean square (rms) SPLs from non-impulsive sound sources below 120 dB re 1 µPa, but there will be an increasing probability of avoidance at rms SPLs between 120 – 160 dB re 1 µPa. All the studies reviewed by Southall et al. (2007) showed that harbour porpoise (VHF cetacean) exhibited strong avoidance from non-impulsive sound sources at received rms SPLs above 140 dB re 1 µPa. A rms SPL threshold of 140 dB re 1 µPa has been adopted in this assessment for assessing potential behavioural disturbance to marine mammals from the proposed survey.

5.3 Impact Thresholds for Fish

5.3.1 Fish Injury Thresholds

Popper *et al*. (2014) have defined criteria for injury to fish based on a review of publications related to impacts to fish, fish eggs and larvae from various sound sources. The review by Popper *et al.* (2014) is the most comprehensive available for potential impacts to fish species. The hearing capability of fish largely depends on the presence or absence of a swim bladder, which is taken into consideration in the thresholds derived by Popper *et al*. (2014). Different injury thresholds are derived in Popper *et al*. (2014) for the following categories:

- Fishes with no swim bladder or other gas chamber;
- Fishes with swim bladders in which hearing involves a swim bladder or other gas volume;
- Fishes with swim bladders in which hearing does not involve the swim bladder or other gas volume; and
- Fish eggs and larvae.

Popper et al. (2014) proposed thresholds for low-frequency and mid-frequency sonar, which are relevant for assessing potential impacts from the SBP. The low-frequency sonar thresholds proposed by Popper et al. (2014) are more conservative than the mid-frequency sonar thresholds and have been adopted in this assessment. The adopted thresholds are shown in Table 5-3.

Table 5-3 Thresholds for potential injury to fish

Fish Group	Sound Metric	Threshold for potential mortal injury
Fishes with no swim bladder	Unweighted zero-to-peak SPL	213 dB re 1 µPa
	Unweighted cumulative SEL	219 dB re 1 µPa^{2}s
Fishes with swim bladder involved in hearing	Unweighted zero-to-peak SPL	207 dB re 1 µPa
	Unweighted cumulative SEL	207 dB re 1 µPa^{2}s
Fishes with swim bladder not involved in hearing	Unweighted zero-to-peak SPL	207 dB re 1 µPa
	Unweighted cumulative SEL	210 dB re 1 µPa^{2}s
Eggs and larvae	Unweighted zero-to-peak SPL	207 dB re 1 µPa
	Unweighted cumulative SEL	210 dB re 1 µPa^{2}s

5.3.2 Fish Disturbance Thresholds

Documented behavioural effects of sound on fish behaviour are variable, ranging from no discernible effect (Wardle *et al*., 2001) to startle reactions followed by immediate resumption of normal behaviour (Wardle *et al*., 2001; Hassel *et al*., 2004). Despite some documented behavioural effects there are no well-established criteria or thresholds for assessing behavioural disturbance to fish. In fact, it was concluded in Popper *et al*. (2014) that there lacked sufficient evidence to recommend thresholds that correspond to behavioural disturbance for fish.

6.0 ASSESSMENT OF POTENTIAL IMPACTS

This section discusses any potential impacts to marine mammals and fish from the proposed pipeline inspection survey. The SSS and MBES equipment that will be used during the proposed survey will produce sound outside the main hearing range of marine mammals and fish species and will therefore not have any significant impact. The SBP that will be used during the pipeline inspection survey will produce the highest sound levels and is within the hearing group of most marine mammals and therefore the impact assessment has focussed on this sound source.

There are other smaller impacts which will also be considered in this section. The full list is the following:

- Impact of the presence of the survey vessel and equipment on other sea users;
- Impact of atmospheric emissions;
- Impact of underwater noise;
- Cumulative impacts;
- Transboundary impacts;
- Hydrocarbon spill risk; and
- Assessment against offshore marine plan policies and objectives.

Due to the short nature of the proposed activities, vessel discharge is not considered to be an issue. As per the MARPOL agreement, any vessel waste will be managed in accordance with the Waste Hierarchy, to ensure minimum disposal of waste to landfill and minimising the amount of waste generated.

6.1 PHYSICAL PRESENCE

The use of the MV Titan Discovery causes temporary constraints for other marine users, such as fisheries and commercial shipping. The vessel will be compliant with the International Convention for Prevention of Pollution from Ships (MARPOL). As demonstrated in Section 4.1, there is limited fishing and limited shipping the survey area. Shell, however, will still provide the relevant parties with sufficient notification of the timeframe of the proposed activities.

Given the short duration of the proposed survey activities (fourteen working days), the impact to other sea users is not considered to be significant. Other sea users will be able to access the area as soon as the survey activities are completed.

6.2 ATMOSPHERIC EMISSIONS

Emissions of direct greenhouse gases (notably CO_2, CH_4 and N_2O) can contribute to global climate change. Standard ratios are used to convert the various gases into equivalent amounts of CO_2. These ratios are based on the global warming potential (GWP) of each gas, which describes its total warming impact relative to CO_2 over a set period – usually a hundred years. The emissions associated with the proposed survey may result in short-term deterioration of local air quality. However, in the exposed conditions that prevail offshore, these emissions are expected to disperse rapidly such that the significance of any impacts on air quality are considered low. The emissions to air from the use of the Fugro Venturer can be seen in Table 5-1.

Table 5-1 Predicted emissions from Fugro venturer

Source	Fuel use/day (te)	Number of days	Total fuel use (te)	Emissions (Te)							
				CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC	CO_2e [2]
Emission factors – Diesel [1]				3.2	0.0594	0.0002	0.004	0.0157	0.0002	0.002	See Table below
MV Titan Discovery	0.3	14	4.20	13	0.25	0.001	0.02	0.07	0.001	0.01	13.73
Approximate annual upstream oil and gas production emissions 2020 (NAEI, 2022)				3,303,002	-	999	-	-	3,431	-	12,494,458
Emissions as a % of Upstream oil and gas production GHG Emissions according to NAEI 2022				0.0004	-	0.0001	-	-	0.00002	-	0.0001

Notes:

[1] Emissions calculated using EEMS emission factors (EEMS, 2008)
[2] Global worming potential used to calculate CO2e are from the Fifth Assessment Report of the GHG Protocol (CH4 = 25 and N2O = 265)

Due to the extremely short timeframe of the project (14 days), the total CO_2e of the project is only 0.0004% of the total 2020 National Atmospheric Emissions Inventory (NAEI) for upstream oil and gas production industry. The team will, however, work efficiently and proactively to try and reduce the number of days for the survey activities with a view to reducing emissions where possible. The MV Titan Discovery will use aim to not have any sudden variations in speed, which can lead to a potential increase in emissions to air. Based on the low level of emissions, the dynamic offshore environment and the shore duration of the works, the emissions to air are not considered to have a significant impact to the environment.

6.3 Underwater Noise

Potential impacts to have been predicted for marine mammals classified into the functional hearing groups proposed by Southall *et al.* (2019) (marine mammals classed as LF cetaceans, HF cetaceans, VHF cetaceans and phocid pinnipeds). There are several different types of impacts, the first is the permanent threshold onset (PTS Onset). The potential impacts have been quantified using information from the 2020 survey, which is seen as the worst-case scenario.

6.3.1 Vessel Noise

Richardson et al. (1995) reviewed the effects of sound from vessels, mainly from the propellers, propulsion and other machinery, on marine mammals. Marine mammals have been reported to display a range of reactions from ignoring to avoiding vessels. The latter can lead to temporary displacement from an area. However, JNCC considers that temporary exposure to sound from vessels is unlikely to cause more than trivial disturbance to marine mammals (JNCC, 2010). Given that marine mammals in the North Sea are generally habituated to the presence of vessels, and any impacts will be behavioural rather than physical (injury), it is considered that there will be no significant impacts to marine mammals due to sound from the survey vessel.

6.3.2 Survey Equipment

The proposed survey will utilise SBP and MBES survey equipment. The MBES operates at higher frequencies that are likely to be outside the main hearing range of marine receptors in the area and therefore are not expected to have a significant impact. Underwater noise from the SBP that will be used during the survey, however, will operate at frequencies in the hearing range of marine mammals and therefore was assessed further.

6.3.2.1 Marine Mammals PTS Onset

The potential for PTS onset to occur in marine mammals has been predicted by comparing estimated received sound levels to the Southall *et al.* (2019) zero-to-peak SPL and cumulative unweighted SEL thresholds. The potential onset of PTS is considered to have occurred when either the zero-to-peak SPL threshold or the corresponding cumulative SEL threshold is exceeded (Southall *et al.,* 2019; NMFS, 2018).

Zero-to-peak SPL

Received sound levels in terms of unweighted zero-to-peak SPL have been predicted for the SBP to identify potential areas where the instantaneous onset of PTS may occur to marine mammals. Figure 6-1 shows the predicted zero-to-peak SPL from the 2020 survey SBP equipment. This figure shows the maximum unweighted zero-to-peak SPL over all depths. The contours in Figure 6-1 highlight the zero-to-peak SPL thresholds for the potential onset of PTS to marine mammals (see Table 5-2).

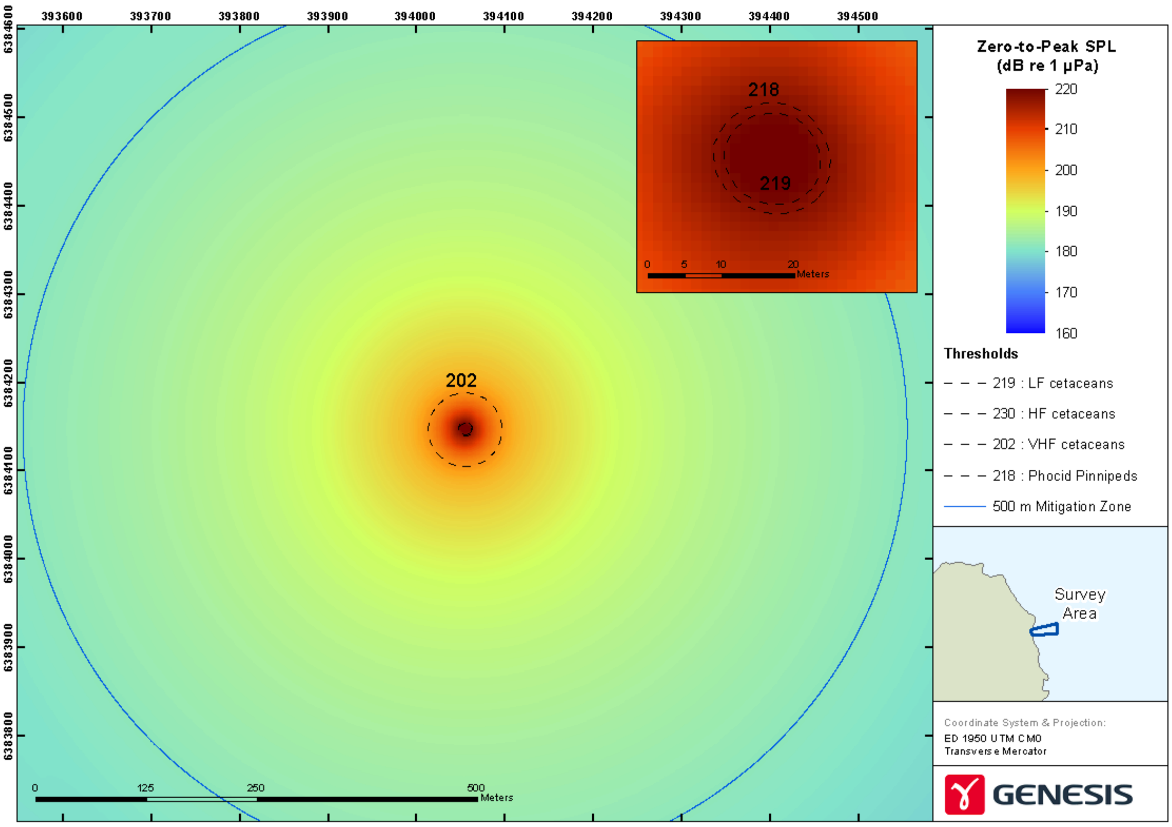

Figure 6-1: Predicted maximum zero-to-peak SPL for the SBP.

For the 2020 survey, the predicted maximum distances where the adopted zero-to-peak SPL thresholds for PTS onset are exceeded and summarised in Table 6-1. The modelling predicts that the threshold for PTS onset to HF cetaceans will not be exceeded. It is predicted that the threshold for PTS onset to LF cetaceans and phocid pinnipeds will not be exceeded outside 10 m from the SBP. The predicted distance to PTS threshold exceedance for VHF cetaceans is 40 m. The predicted distances are well within the nominal 500 m mitigation zone suggested by JNCC for the mitigation of impacts from geophysical surveys (JNCC, 2017). As the noise source for the 2023 SBP will be lower than the modelled equipment, it can be assumed that these distances will be even smaller for the proposed survey.

Table 6-2: Predicted maximum distances from the SBP where the zero-to-peak SPL thresholds for potential PTS onset to marine mammals are exceeded.

Marine Mammal Hearing Group	PTS Threshold	Predicted Maximum Distance to Threshold Exceedance in worst-case scenario*
LF cetaceans (minke whale)	219 dB re 1 µPa	10 m

Marine Mammal Hearing Group	PTS Threshold	Predicted Maximum Distance to Threshold Exceedance in worst-case scenario*
HF cetaceans (white-sided dolphin, white-beaked dolphin, bottlenose dolphin)	230 dB re 1 µPa	Threshold not exceeded
VHF cetaceans (harbour porpoise)	202 dB re 1 µPa	40 m
Phocid pinnipeds (grey seal)	218 dB re 1 µPa	10 m
*Predicted distances have been rounded up to the nearest 10 m.		

The SBP will be activated using a soft-start where the power (and therefore sound levels) of the SBP will be initiated at a low level and increased over the soft-start duration. This will be done by systematically increasing the array power by increments over a period of at least 20 minutes. This will ensure the mammals present in the impacted area will have ample time to disperse. The soft-start of the SBP should allow any marine mammals in the area to move away from the SBP to distances where they will not suffer PTS onset. Thus, there will be no significant impacts on marine mammals for PTS.

Cumulative SEL

The 20202 survey also determined the potential impacts to marine mammals due to cumulative SEL from the SBP. Following the guidance by Southall *et al.* (2019) and NOAA (NMFS, 2018), potential impacts from cumulative SEL have been assessed by weighting received SEL sound levels with the auditory weighting filters shown in Figure 5-1 and calculating the weighted cumulative SEL received by marine mammals as the survey vessel traverses the pipeline route. The cumulative SEL received by marine mammals has been estimated for mammals swimming away from the survey vessel.

Table 6-2 shows the maximum distances that marine mammals must be at the start of the SBP operation (i.e. safety distances) in order not to be exposed to cumulative SEL exceeding the thresholds for PTS when they swim away from the SBP at a swim speed of 2 m/s. The 2020 modelling predicted that the cumulative SEL thresholds will not be exceeded for HF cetaceans and phocid pinnipeds. The cumulative SEL thresholds for LF cetaceans and VHF cetaceans are predicted to be exceeded at distances of 50 m and 190 m, respectively.

Table 6-3: Predicted distances from the SBP where the cumulative SEL thresholds for potential PTS onset to marine mammals are exceeded.

Marine Mammal Hearing Group	PTS Threshold	Predicted Distance to Threshold Exceedance in worst-case scenario*
LF cetaceans (minke whale)	183 dB re 1 µPa2s	50 m
HF cetaceans (white-sided dolphin, white-beaked dolphin, bottlenose dolphin)	185 dB re 1 µPa2s	Threshold not exceeded
VHF cetaceans (harbour porpoise)	155 dB re 1 µPa2s	190 m
Phocid pinnipeds (grey seal)	185 dB re 1 µPa2s	Threshold not exceeded
*Predicted distances have been rounded up to the nearest 10 m. Marine mammals swimming away from the SBP at 2 m/s		

Based on the 2020 modelling results, when a nominal mitigation zone of 500 m is employed during the survey, it is considered unlikely that the pipeline inspection survey will cause PTS to any marine mammals. This holds true for this proposed survey, as the SBP noise source being used is lower than the modelled SBP equipment. Overall, PTS impact in the survey will be not be significant and easily avoided by the implementation of appropriate mitigation measures outlined later in this section.

6.3.2.2 Marine Mammals Behavioural Disturbance

To predict potential behavioural disturbance to marine mammals, received sound levels in terms of rms SPL from the SBP were estimated and compared to the adopted behavioural disturbance threshold of 140 dB re1 μPa. The estimated rms SPL from the SBP for the 2020 survey is shown in Figure 6-2, which shows the maximum rms SPL over all depths and does not signify sound levels at any specific depth. The contour highlighted in Figure 6-2 corresponds to the adopted behavioural disturbance threshold for marine mammals.

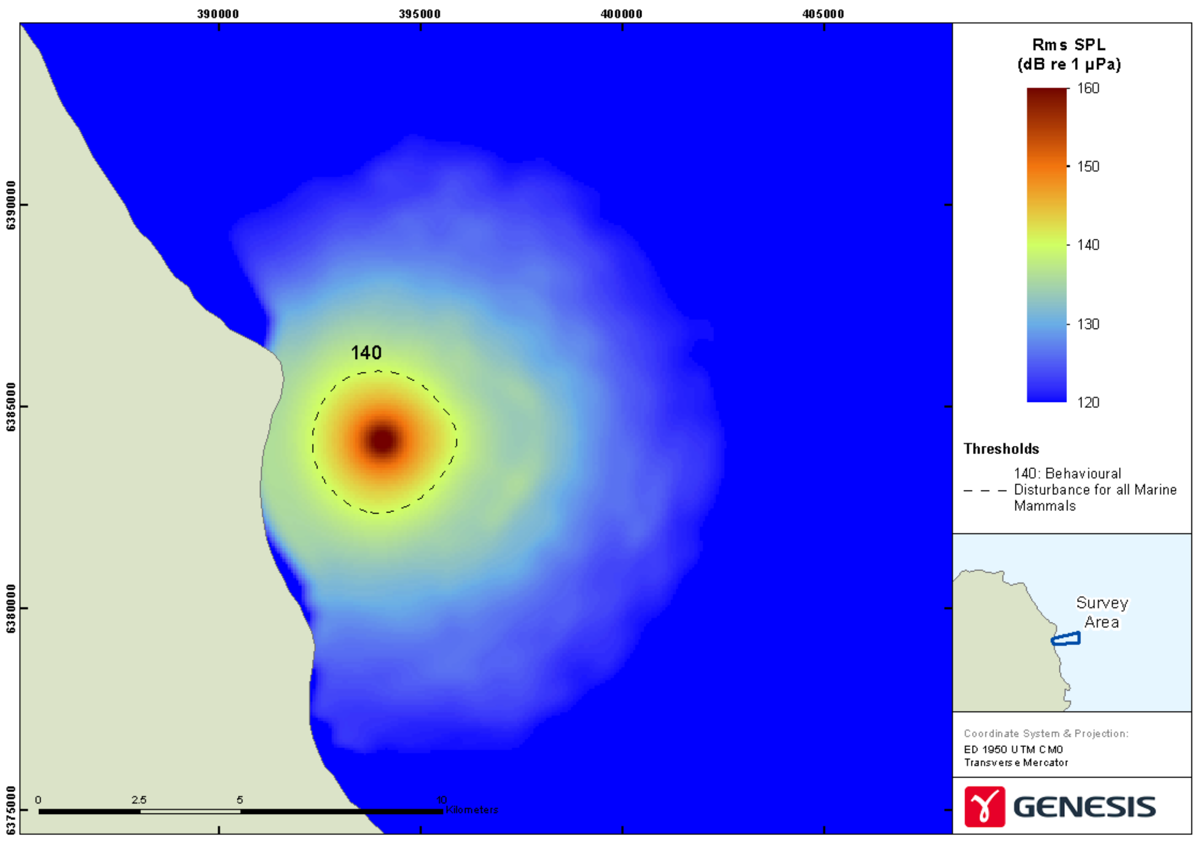

Figure 6-2: Predicted rms SPL for the SBP.

The predicted distances and areas where the adopted behavioural disturbance thresholds are exceeded are summarised in Table 6-3. The 2020 modelling predicted that marine mammals could experience behavioural disturbance within 1.8 km from the pipeline inspection survey. Measurements made during a seismic survey in the Moray Firth (Thompson et *al.*, 2013) showed displacement of harbour porpoise (VHF cetaceans) out to 5-10 km from a 470 in^3 airgun array. The proposed SBP survey is predicted to have a smaller impact to marine mammals compared to those measured by Thompson *et al.* (2013) for seismic surveys, as well as the 2020 modelled SBP equipment.

Table 6-4: Predicted distances from the SBP and areas where the adopted marine mammal behavioural disturbance thresholds are exceeded.

Marine Mammal Hearing Group	Behavioural Disturbance Threshold	Possible Behavioural Response	Predicted Maximum Distance to Threshold Exceedance in worst-case scenario [1]	Predicted Area of Threshold Exceedance in worst-case scenario [2]
LF cetaceans (minke whale)	140 dB re 1 μPa	Possible individual and/or group avoidance	1.8 km	11 km^2
HF cetaceans (white-sided dolphin, white-	140 dB re 1 μPa	Possible individual and/or group avoidance	1.8 km	11 km^2

Marine Mammal Hearing Group	Behavioural Disturbance Threshold	Possible Behavioural Response	Predicted Maximum Distance to Threshold Exceedance in worst-case scenario [1]	Predicted Area of Threshold Exceedance in worst-case scenario [2]
beaked dolphin, bottlenose dolphin)				
VHF cetaceans (harbour porpoise)	140 dB re 1 µPa	Possible individual and/or group avoidance	1.8 km	11 km^2
Phocid pinnipeds (grey seal)	140 dB re 1 µPa	Possible individual and/or group avoidance	1.8 km	11 km^2

[1] Predicted distances have been rounded up to the nearest 0.1 km.
[2] Predicted areas have been rounded up to the nearest 1km^2.

The number of animals that could potentially be disturbed or exhibit behavioural responses due to the proposed pipeline inspection survey have been calculated based on the predicted disturbance zones and estimated densities of animals in the area taken from SCANS III (Hammond *et al.*, 2021). The estimated number of animals that could potentially be disturbed (in the worst-case scenario) or exhibit behavioural responses is shown in Table 6-4. It should be noted that the proposed survey SBP has a lower noise source than the 2020 modelled SBP and, therefore, the values shown below are expected to be lower in the case of this survey.

Table 6-5: Estimated number of cetaceans within predicted behavioural disturbance zones and percentage of MU population disturbed in worst case scenario.

Species	Disturbance Area in worst case scenario	Animal Density [1] (animals/km^2)	Number of Animals in Disturbance Zone in worst case scenario	MU Population [2]	Percentage of MU Population Disturbed in worst case scenario
Harbour porpoise	11 km^2	0.6	7	159,632	0.0041
Bottlenose dolphin	11 km^2	0.03	0.3	224	0.1473
White-beaked dolphin	11 km^2	0.24	3	34,025	0.0078
White-sided dolphin	11 km^2	0.01	0.1	12,293	0.0009
Minke whale	11 km^2	0.04	0.4	10,288	0.0043

[1] Animal densities are from Hammond et al., (2021) SCANS-III Block R.
[2] MU populations are from IAMMWG, (2022).

The proposed pipeline inspection survey is expected to last a maximum of 14 working days, with the SBP component of the survey expected to take a maximum of four working days. Therefore, any disturbance to marine mammals will be short term. It is expected that any marine mammals disturbed from the area will return shortly after cessation of activities. This is supported by studies undertaken during a seismic survey in the Moray Firth where displaced harbour porpoises were observed to return to the area within one day after the survey finished (Thompson *et al.*, 2013). Similar studies based on impacts arising from piling noise have indicated that marine mammals displaced by noise return to the area within relatively short periods of time, usually within three days once the activity causing the displacement has ceased (Tougaard *et al.*, 2016; Brandt *et al.*, 2016). Overall, the impact to the behaviour of mammals in the survey will be not be significant, due to the short duration of the survey and the implementation of appropriate mitigation measures outlined later in this section.

6.3.2.3 Fish Impact

Injury

To assess any potential injury to fish from the proposed pipeline inspection survey, received sound levels in terms of unweighted zero-to-peak SPL and unweighted cumulative SEL from the 2020 survey have been predicted and compared to the Popper *et al*. (2014) thresholds for potential mortal injury (see Table 5-3).

Figure 6-3 shows the predicted zero-to-peak SPL from the SBP. This figure shows the maximum unweighted zero-to-peak SPL over all depths and does not signify the zero-to-peak SPL at any specific depth layer. The contours in this graphic highlight the Popper *et al*. (2014) zero-to-peak SPL thresholds for potential injury to fish species (see Table 5-3). The predicted distances where the Popper zero-to-peak SPL thresholds are exceeded are shown in Table 6-5.

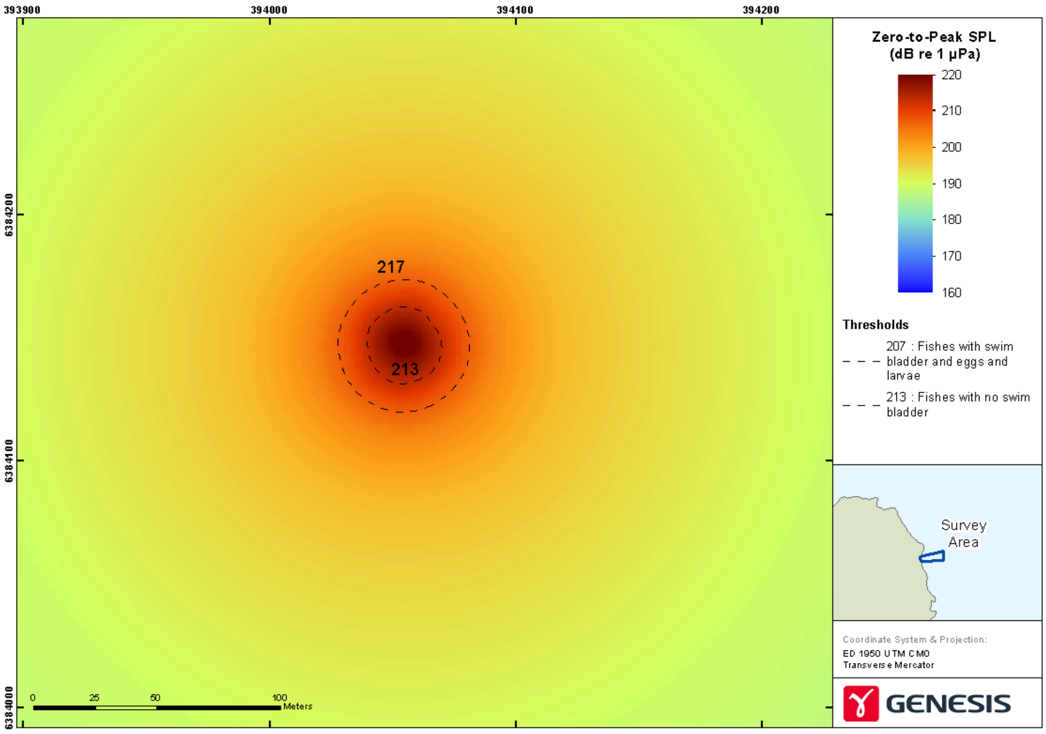

Figure 6-3: Predicted maximum zero-to-peak SPL for the SBP.

Table 6-6: Predicted maximum distances from the SBP where the Popper zero-to-peak SPL thresholds for fish injury/potential mortality are exceeded.

Fish Group	Threshold for Injury/Potential Mortality	Predicted Maximum Distance to Threshold Exceedance *
Fishes with no swim bladder (lemon sole)	213 dB re 1 µPa	30 m
Fishes with swim bladder involved in hearing (herring)	207 dB re 1 µPa	20 m
Fishes with swim bladder not involved in hearing (cod, sandeel, haddock, Nephrops, Norway pout, whiting, sprat)	207 dB re 1 µPa	20 m
Eggs and larvae	207 dB re 1 µPa	20 m
* Predicted distances have been rounded up to the nearest 10 m.		

The modelling predicts that injury to fish would be limited to a maximum distance of 40 m in the worst-case scenario. It is expected that a soft-start activation of the SBP would disperse any fish in the vicinity of the survey to safe distances where they would be unlikely to suffer injury. The Popper cumulative SEL thresholds were predicted not to be exceeded. The proposed survey could potentially be conducted during spawning of herring, lemon sole, Nephrops and sprat. However, given the small area of estimated potential impact to fish species, it is not expected that the proposed surveys will have a significant injurious impact on spawning fish, eggs or larvae.

Behavioural Disturbance

Behavioural disturbance to fish could not be predicted from the propagation modelling since there are no established disturbance thresholds for fish. However, fish are mobile animals that would be expected to move away from a sound source that had the potential to cause them harm. If fish are disturbed by sound, evidence suggests they will return to an area once the activity generating the sound has ceased (Slabbekoorn *et al*., 2010). Any disturbance to fish is expected to be of a short duration and therefore it is concluded that the proposed surveys will not have a significant impact on any fish species.

6.3.3 Mitigation Measures

To minimise the risk of potential impacts of sound from the survey further, the JNCC (2017) "Guidelines for minimising the risk of injury to marine mammals from geophysical surveys" should be followed. The following mitigation measures are suggested:

- There will be a qualified (JNCC accredited) Marine Mammal Observer (MMO) aboard the vessel during the entire survey, who will be following JNCC (2017) guidelines for minimising the risk of injury to marine mammals from geophysical surveys. When the MMO observation period is ongoing, the designated MMO will not be required to undertake any other duties on the vessel.
- The designated MMO will detect marine mammals within a 500 m mitigation zone. If any cetaceans are observed within 500 m from the source array, then the start of the seismic sources will be delayed for at least 20 minutes following last sighting.
- The designated MMO will carry out a 30-minute pre-data acquisition survey of the mitigation zone and, if an animal is detected, the soft-start of the seismic sources will be delayed until their passage, or the transit of the vessel, results in the marine mammals being more than 500 metres away from the source i.e. out with the 500 m mitigation zone.
- A soft-start activation of the SBP will be employed, whereby the source power will be incrementally increased over period of at least 20 minutes. This will allow any marine mammals to move away from the sound source and reduce the likelihood of exposing the animal to sounds that could potentially cause injury. A soft start will be employed whenever the SBP is used.
- If the SBP has been inactive for a period of 10 minutes or longer, the designated MMO will perform a visual inspection of the 500 m mitigation zone. If a mammal is detected within the 500 m mitigation zone, the restart of the survey will be delayed for at least 20 minutes following last sighting.

To minimise the risk of marine mammals being chased inshore, the survey vessel will acquire SBP and MBES acoustic data along each pipeline route within the survey area from the shore outwards (seaward) to allow any potentially disturbed cetaceans to be directed away from the shore rather than onshore.

6.4 Cumulative Impacts

The proposed survey will be conducted in a well-developed oil and gas production area (Section 4.2). There are no other known surveys or other significant noise generating activities planned in the same area or at the same time as the proposed survey. There may be ongoing activities associated with other developments in the region that generate underwater noise (e.g., the presence of vessels, production noise). However, due to the short duration of the proposed survey (14 days) it is not expected that there will be any significant cumulative impacts.

6.5 Transboundary impacts

The survey will take place on the eastern border of the UK. Thus, there is no opportunity for any transboundary impacts.

6.6 Hydrocarbon Spill Risk

In the highly unlikely event of a diesel spill from the survey vessel, diesel would evaporate quickly on release. The low asphaltene content of diesel prevents emulsification, reducing its persistence in the marine environment. Any marine mammals and fish in the area would be able to move away from the spill and it is not expected that there would be a significant impact on marine mammals or fish in the area.

6.7 Marine Planning

The UK Government has introduced several measures under the Marine and Coastal Access Act (MCAA) 2009 to deliver its vision of "clean, healthy, safe, productive and biologically diverse oceans and seas" for the whole of the UK. These measures include the marine planning system, comprising the UK Marine Policy Statement and the production of national marine plans (NMP). Marine plans seek to provide greater coherence of policy and a forward-looking, proactive, and spatial approach to the management of the marine area. The Department for Environment, Food and Rural Affairs has published regional marine plans for England while the national marine plans for Northern Ireland, Scotland and Wales have been published by the devolved administrations. An application for a proposed project to be undertaken within an area which is covered by an adopted plan must include relevant information to aid the Department for Energy Security and Net Zero (DESNZ) (formerly the Department for Business, Energy and Industrial Strategy (BEIS)) decision about the proposal (BEIS, 2018). The proposed survey is covered by Scotland's NMP.

Scotland's NMP covers the management of both Scottish inshore waters (out to 12 nautical miles (nm)) and offshore waters (12 to 200 nm). The aim of the NMP is to help ensure the sustainable development of the marine area through informing and guiding regulation, management, use and protection of the Marine Plan areas (Scottish Government, 2015). The NMP sets out general policies and objectives as part of the UK's shared framework for sustainable development. In accordance with BEIS Guidance (BEIS, 2018), the proposed survey as described in this EAJ, has been assessed against all NMP objectives and policies, but specifically GEN 1, 4, 5, 9, 13, 14 and 21 (Table 6-7).

Table 6-7: Assessment of proposed survey against Scotland's NMP policies.

Scotland's NMP Policies	Assessment Against Policy
GEN 1 – General Planning and Principle	
Development and use of the marine area should be consistent with the Marine Plan, ensuring activities are undertaken in a sustainable manner that protects and enhances Scotland's natural and historic marine environment.	Shell will ensure that any potential impacts are minimised as outlined throughout Section 6.0.
GEN 4 – Co-existence	
Where conflict over space or resource exists or arises, marine planning should encourage	Potential impacts to other users of the sea are considered to be minor, as discussed in Section 6.1. Shell

Scotland's NMP Policies	Assessment Against Policy
initiatives between sectors to resolve conflict and take account of agreements where this is applicable.	will give the relevant parties sufficient notification of the vessels involved in the operations to ensure potential impacts to other users of the sea during the operations are minimised.
GEN 5 – Climate Change	
Marine planners and decision makers should seek to facilitate a transition to a low carbon economy. They should consider ways to reduce emissions of carbon and other greenhouse gasses.	As discussed in Section 6.2, due to the short duration of the proposed survey (14 days), atmospheric emissions associated with the survey are not considered to present a significant environmental impact. The impact of vessel emissions from the survey vessel will be mitigated by optimising vessel efficiency and hence minimising fuel use and avoiding the unnecessary operation of power generation/combustion equipment.
GEN 9 – Natural Heritage	
Development and use of the marine environment must: • Comply with legal requirements for protected areas and protected species. • Not result in significant impact on the national status of PMFs. Protect and, where appropriate, enhance the health of the marine area.	Potential impacts to the marine environment are discussed throughout Section 6.0. The assessment concluded that the proposed operations are not considered to present a significant impact to the marine environment, including protected sites and species.
GEN 13 – Noise	
Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects.	Potential impacts associated with noise are discussed in Section 6.3. Underwater modelling results suggests that thresholds associated with PTS to marine mammals will not be exceeded during the survey and therefore the risk of injury is low. Whilst the survey may cause behavioural disturbance to marine mammals, the extent of disturbance will be localised (less than 2 km from the survey vessel). The short duration of the survey (14 days) means that any disturbance will be temporary, and any marine mammals disturbed will return to the area once the survey is completed. It is considered that impacts from underwater noise will not be significant.
GEN 14 – Air Quality	
Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits.	As discussed in Section 6.2, due to the short duration of the proposed survey (14 days), atmospheric emissions associated with the survey are not considered to present a significant environmental impact.

Scotland's NMP Policies	Assessment Against Policy
GEN 21 – Cumulative Impacts	
Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.	As discussed in Section 6.4, the proposed survey operations are not expected to significantly increase cumulative impacts from surrounding oil and gas assets.

7.0 CONCLUSIONS

The potential environmental sensitivities and impacts to the marine environment from the proposed survey scope at St. Fergus have been identified and assessed. The conclusions are summarised below:

- The physical presence of the vessel is not expected to have a significant impact on the marine environment including ecological receptors and other users of the sea.
- The atmospheric emissions generated from this survey will be minimal and, given the wider conditions of the Southern North Sea, the emissions will disperse rapidly. The atmospheric emissions generated from this project are therefore not significant.
- The introduction of a stop-start mitigation measure will prevent any permanent impact the mammals who are present. This will allow the mammals to travel to a safe distance where they cannot be impacted. Furthermore, the estimated number of marine mammals that will be temporarily disturbed is small compared to the total abundance of marine mammals in the wider Management Unit, and the North Sea. It is also anticipated that the impacted species will return to the survey site once the survey has been completed. Other mitigation measures, notably the presence of a qualified MMO will ensure cetaceans are ample distance from the survey site. This mitigation measure, in conjunction with the short timeframe of the project (14 days in total, with the SBP utilised for 4 days), indicates there is no significant impact to the marine mammals, permanent nor behavioural.
- In the worst-case scenario, the modelling predicted that injury to fish and their eggs and larvae would be limited to a maximum distance of 40 m from the SBP. It is expected that the soft start of the SBP would likely disperse any fish to safe distances where they would not experience sound levels that could cause injury. In addition, identified spawning areas are very extensive in comparison to the potential area of disturbance. It is concluded that the proposed survey will be unlikely to have any significant impact on spawning fish, their eggs or their larvae.
- No significant long term cumulative or transboundary effects are expected.
- The risk of a hydrocarbon spill is extremely small. In the highly unlikely event of a hydrocarbon spill, appropriate mitigation measures will be applied. Thus, the impact of this potential spill is would not be significant.
- The operations are not considered to contradict the objectives of Scotland's NMP.

All activities will be managed according to Shell's Health Safety and Environmental (HSE) Management System, which is certified to the ISO 14001 standard (last certified in November 2022), and fully embedded within its Business Management System (BMS) are requirements to eliminate or minimise potential impacts on the environment. Shell therefore concludes that the proposed operations do not present a significant impact to the surrounding environment.

8.0 CHANGE SUMMARY

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ACRONYMS AND ABBREVIATIONS

dB	Decibels
Defra	Department for Environment, Food and Rural Affairs
EC	European Commission
ED	European Datum
EEC	European Economic Community
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data network
EPS	European Protected Species
EU	European Union
FARAM	Faunal Acoustic Risk Assessment Model
GEBCO	General Bathymetric Chart of the Oceans
HF	High Frequency
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Seas
JNCC	Joint Nature Conservation Committee
kg/m^3	Kilograms per cubic metre
kHz	Kilo-Hertz
km	Kilometres
km^2	Square kilometres
LF	Low Frequency
m	Metres
m/s	Metres per second
MCZ	Marine Conservation Zone
MF	Mid Frequency
MMO	Marine Mammal Observer
MPA	Marine Protected Area

ms	Milli-seconds
MU	Management Unit
NCMPA	Nature Conservation Marine Protected Area
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OGA	Oil and Gas Authority
PE	Parabolic Equation
PMF	Priority Marine Feature
pMPA	Possible Marine Protected Area
pSPA	Possible Special Protection Area
PTS	Permanent Threshold Shift
RAM	Range-dependent Acoustic Model
rms	Root mean square
SAC	Special Area of Conservation
SCANS	Small Cetacean Abundance in the North Sea
SCOS	Special Committee on Seals
SEL	Sound exposure Level
SMRU	Sea Mammal Research Unit
SPA	Special Protection Area
SPA	Special Protection Area
SPL	Sound Pressure Level
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
VHF	Very High Frequency
WGS	World Geodetic System
WOA	World Ocean Atlas

APPENDIX A: MODELLING METHODOLOGY

This appendix discusses the modelling methodology that has been adopted for this assessment. The noise modelling focuses on sound generated by the sub-bottom profiler since it is the loudest sound source associated with the proposed survey that is within the hearing range of marine mammals that are likely to be in the area.

A.1. Source Modelling

The sub-bottom profiler that will be used during the proposed geophysical site survey will be a Innomar Medium Parametric SBP. The profiler is predicted to have a zero-to-peak SPL of 250 dB re 1 µPa-m, and an SEL of 243 dB re 1 µPa^{2}s-m. The SBP will emit a linear frequency modulated chirp signal over a frequency range of 5-15 kHz. The estimated third octave band SEL spectra of the SBP is shown in Figure A-0-1. The pulse interval of the SBP is 0.1 s. Details of the sub-bottom profiler are summarised in Table A-0-1.

Table A-0-1: Sub-bottom profiler details.

Parameter		Value
Source		Innomar Medium Parametric SBP
Signal type		Linear frequency modulated chirp signal
Source Level	Zero-to-peak SPL	250 dB re 1 µPa-m
	SEL	243 dB re 1 µPa^{2}s-m
Frequency range (-3dB)		5 – 15 kHz
Pulse interval		0.1 s

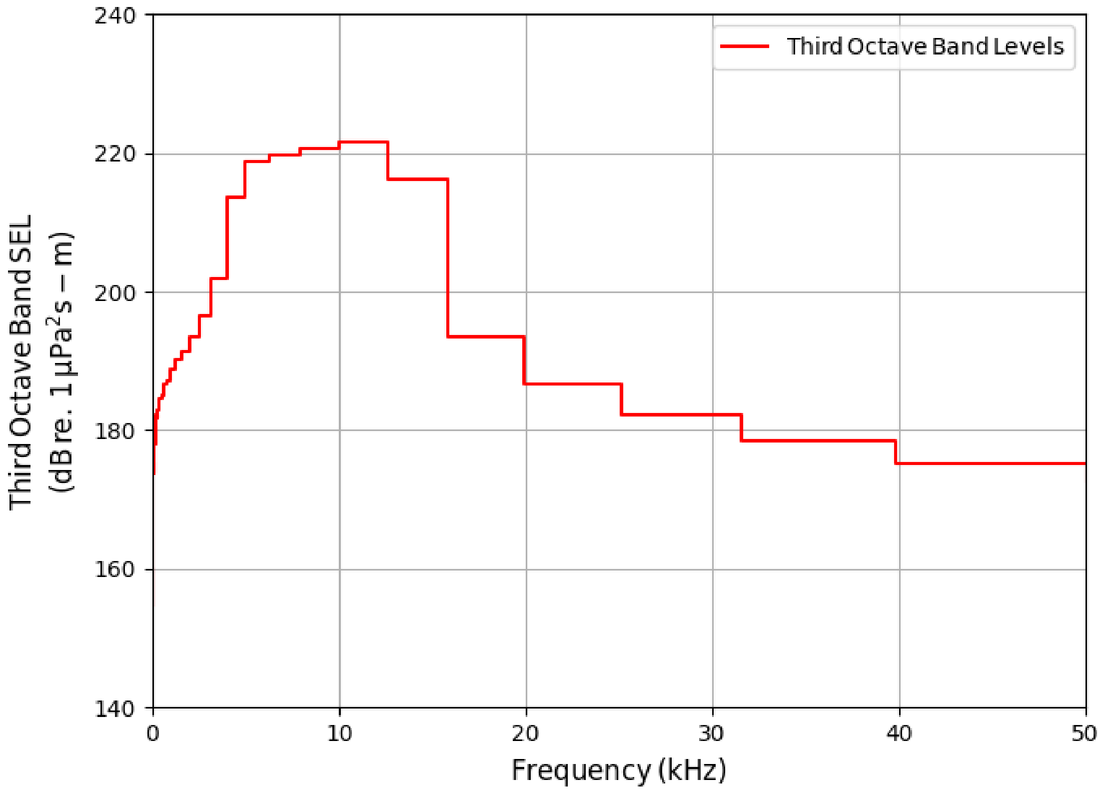

Figure A-0-1: Third octave band SEL for the SBP used in the modelling.

SBPs are highly directional sound sources, with the largest portion of energy being directed vertically downwards to the seabed. The directivity of these devices results on horizontal propagation being substantially reduced, and it is therefore important to account for the effects of such directionality. Neglecting directionality effects can lead to received sound levels (and consequently estimated impacts to marine life) being significantly overestimated. The Innomar Medium Parametric SBP is conservatively estimated to have a -3 dB beam-width of 40°. The beam pattern for the sub-bottom profiler that has been used in the modelling is shown in Figure A-0-2.

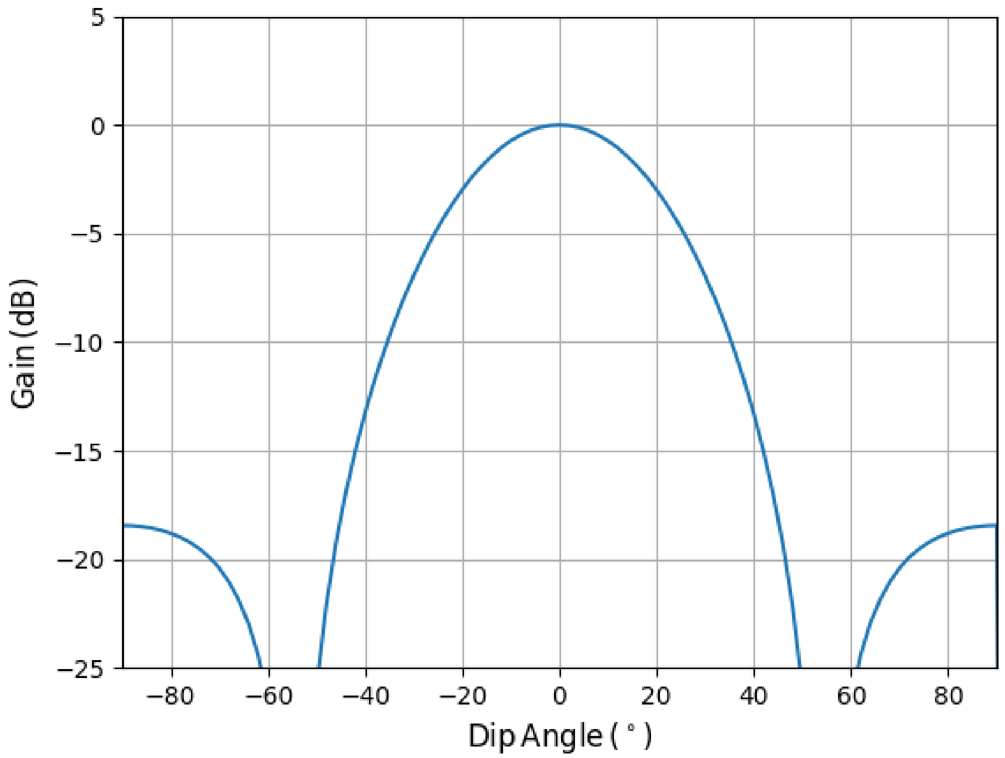

Figure A-0-2: Beam pattern for the sub-bottom profiler used in the modelling.

A.2 PROPAGATION MODEL

The Genesis in-house software FARAM has been utilised for modelling sound propagation. FARAM is an underwater sound propagation model that incorporates site-specific environmental data such as a full bathymetric grid, varying water column temperature and salinity profiles, and geo-acoustic properties of the seabed. By explicitly modelling the factors affecting sound propagation, results can be obtained that are more accurate and relevant to the area of interest than would be obtained with more simplistic models (e.g. simple spreading models). FARAM contains implementations of a parabolic equation (PE) and ray tracing algorithms, which have been used to estimate received sound levels.

A.2.1 Parabolic Equation Algorithm

PE algorithms approximate the wave equation, allowing a solution to be found computationally (Jensen *et al.*, 2011). This is one of the most popular wave-theory techniques for modelling sound propagation in spatially-varying environments (Jensen *et al.*, 2011). The computational scheme used in this assessment is based on the Range-dependent Acoustic Model (RAM) implementation of the PE (Collins, 1993).

PE techniques are complex and require careful selection of environmental parameters (e.g. variation in bathymetry and sound speed profiles) and computational parameters (e.g. depth and range resolution) to ensure that the solution is accurate. The PE algorithm is best suited to calculation of low frequency sound propagation since the computational complexity (and hence implementation time) of the PE method significantly increases with frequency. The PE algorithm has been used to estimate the propagation of frequencies up to 500 Hz for the modelling conducted in this assessment. A ray tracing algorithm has been utilised for sound propagation of frequencies above 500 Hz.

A.2.2 Ray Tracing Algorithm

The ray tracing method that has been utilised for modelling higher frequencies is the Bellhop Gaussian beam ray tracing model (Porter and Liu, 1994). Bellhop is an efficient algorithm that is well suited for the modelling of higher frequency sound sources.

Similar to the RAM PE algorithm discussed previously, Bellhop also incorporates acoustic propagation effects resulting from range dependent sound speed depth profiles and geo-acoustic properties. However, in contrast to the RAM PE algorithms, Bellhop also accounts for increased sound attenuation due to volume absorption. This type of sound attenuation becomes more prominent at higher frequencies and cannot be neglected without significantly over estimating received levels at large distances from the sound source.

A.2.3 Environmental Input Data

The implemented propagation algorithms account for various site-specific environmental properties including a bathymetric grid, geographically and depth varying sound speed profiles and geo-acoustic properties of the sediment. To model the effects of these environmental properties, input data are required that describes the surrounding environment. The environmental input datasets that are utilised in the propagation model are discussed in the following sections.

Sound Speed Profile

A major factor that influences the propagation of sound in water is the speed of sound through the water column, which influences how an acoustic wave refracts. Sound speed data can be derived from measurements/modelling of temperature and salinity, which are more readily available. Sound speed profiles for the model location were derived from temperature and salinity profiles taken from the World Ocean Atlas (WOA; 2013). WOA is an objectively analysed 1° resolution database where temperature and salinity data are given based on historical data. Since the sound speed profile is a function of temperature, pressure (which is a function of depth) and salinity, this database can be used to calculate the sound speed profile. The empirical formula in (Jensen *et al*., 2011) has been used to calculate sound speed profiles based on temperature, salinity and depth.

Bathymetry and Seabed Properties

Seabed bathymetry strongly influences the propagation characteristics of sound; in shallow water regions, there is significant interaction of the sound with the seabed through reflections and scattering effects, which can result in strong attenuation. In deep water regions, there is typically less interaction of sound with the seabed and attenuation due to bottom loss is small, which can result in longer propagation distances.

The bathymetry data that have been used in the noise modelling is provided by the General Bathymetric Chart of the Oceans (GEBCO) 30 arc-second grid (GEBCO, 2014), which is a continuous terrain model for ocean and land with a spatial resolution of 30 arc seconds.

The implemented propagation model accounts for attenuation effects of sound due to interactions with the seabed. The modelling has assumed a sandy seabed in line with the expected sediments in the area) and the main geo-acoustic properties associated with the seabed that have been used in the modelling are shown in Table A-0-2 (Jensen *et al.*, 2011).

Table A-0-2: Geo-acoustic parameters that have been used in the model.

Geo-acoustic Parameter	Value
Predominant sediment	Sand
Sound speed in sediment	1650.0 m/s
Sound attenuation in sediment	0.8 dB/wavelength
Sediment density	1,900 kg/m^3