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St Andrews Bay geophysical survey – European Protected Species Risk Assessment

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1 Introduction

This risk assessment supports a planned geophysical survey in St Andrews Bay to inform the design of a seawater supply system to the Scottish Oceans Institute (SOI) building (University of St Andrews).

The installation of a seawater supply system to the SOI is essential to the functioning of the Sea Mammal Research Unit pool facility to fulfil its duties as a marine research centre. Following the destruction of the previous system in storms over winter 2021-2022, a replacement system is required as a matter of urgency.

Use of the SBP will introduce noise into the marine environment, which may have the potential to result in injury and disturbance to noise-sensitive protected species, namely marine mammals. As European Protected Species (EPS), it is an offence to kill, injure or disturb cetaceans; if such an offence is likely to occur, an EPS licence is required.

Further details of offences and their legislative context are provided in **Section 2.1**.

This risk assessment considers the potential effects of the aforementioned activities on marine EPS and other relevant protected species and sites in the context of relevant legislation (see Section 2.1), therefore assessing the need for an EPS licence(s) and providing the information required by MS-LOT in support of any such applications[1]. The scope of the risk assessment is exclusively Scottish inshore (< 12 nm) waters.

1.1 Legislative context

Annex IV of the EC Habitats Directive (*European Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna*) lists species of European interest in need of strict protection – European Protected Species (EPS). All species of cetacean whose natural range includes waters around the UK are marine EPS.

The Habitats Directive is transposed into UK and Scots law by different regulations which define offences in relation to EPS. Those of relevance to this risk assessment are described in **Box 1**.

Box 1. Legislation and offences relating to EPS in Scottish inshore and offshore waters.

Cetaceans: European Protected Species
Legislation: *The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)* **Applicable to:** Scottish inshore waters (< 12 nm)

[1] For example, this document provides the 'Cetacean Risk Assessment' described in Marine Scotland (2020).

Offence(s): Regulation 39(1) makes it an offence to deliberately or recklessly to capture, injure, kill, harass or disturb a wild animal of a European protected species;

further, **Regulation 39(2)** provides that it is an offence to deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean). This offence is considered to relate to disturbance at the individual level.

For an EPS licence to be granted, the Habitats Regulations specify three tests which need to be met: (i) There must be a licensable purpose; (ii) there must be no satisfactory alternative; and, (iii) the activity must not be detrimental to the maintenance of the population of the species concerned at favourable conservation status in their natural range. This third test relates to impacts which might damage the status of the species in the long-term.

Specifically, the conservation status will be taken as 'favourable' when:

- *population dynamics data on the species concerned indicates that it is maintaining itself on a long-term basis as a viable component of its natural habitats; and*
- *the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and*
- *there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.*

This risk assessment provides the necessary information to determine the third test relating to favourable conservation status.

1.2 Relevant guidance

This risk assessment has been prepared with consideration of the following guidance:

- Marine Scotland (2020). The protection of Marine European Protected Species from injury and disturbance. Guidance for Scottish Inshore Waters (July 2020 Version).

2 Proposed Geophysical Survey

2.1 Survey location

The planned survey will take place within an area of St Andrews Bay extending from East Sands beach to a maximum of 1.5 km from shore (**Figure 1**). Survey activities will occur throughout this area, but with a greater proportion of time spent along a proposed seawater pipe route, extending approximately 600 m offshore of the Scottish Oceans Institute (**Figure 1**). Water depths in the survey area are < 10 m (Lowest Astronomical Tide).

The planned survey area covers a total of 1.5 km^2, all of which is within Scottish inshore waters (<12 nm).

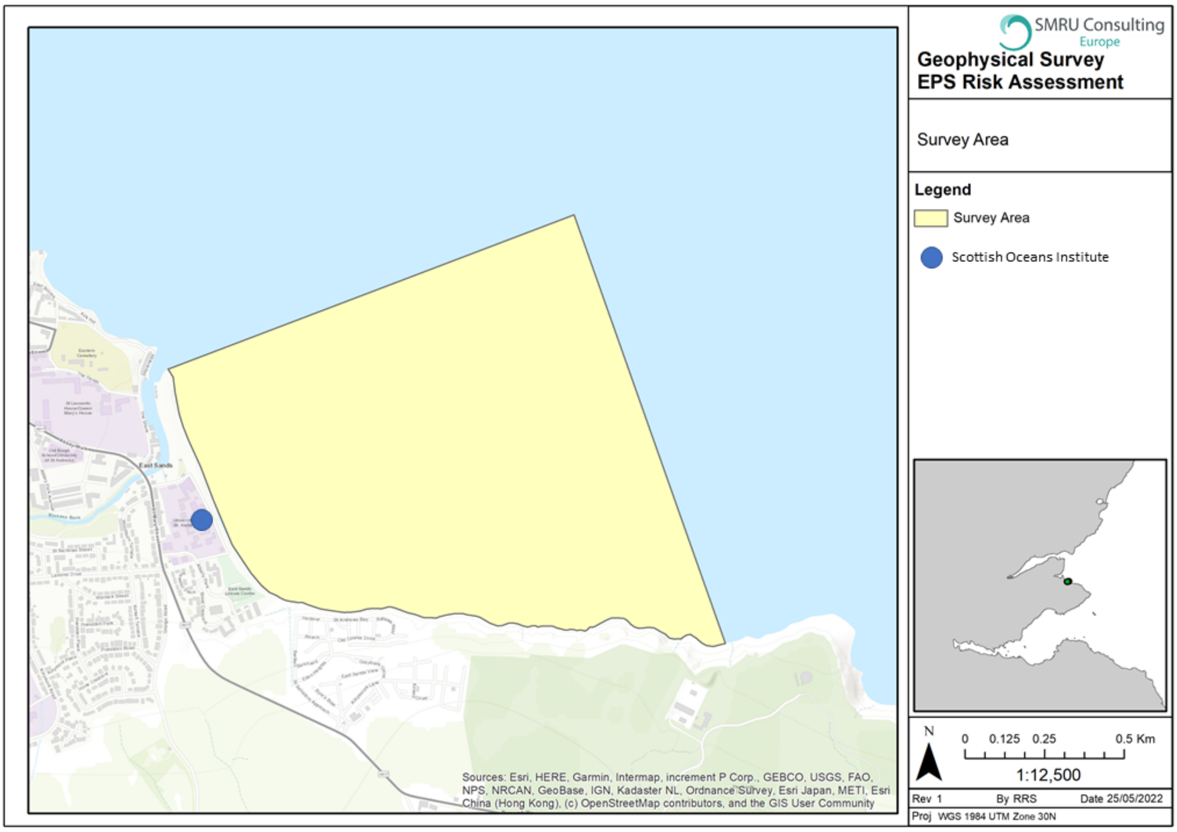

Figure 1. Planned survey area. The greatest amount of survey effort is anticipated to occur along the proposed seawater pipe route, extending approximately 600 m offshore from the Scottish Oceans Institute, approximately perpendicular to the coast.

2.2 Schedule

Surveys are planned to take place as soon as possible, within a 10-week window from 30th May 2022 to 31st August 2022. Within this period, data collection is expected to take a maximum of 3 days, with a maximum of 6 hours of data collection per day (constrained by tide).

2.3 Survey vessel

The survey will be conducted from the *Swordsman*, a 7.4 m MCA coded (Category 4) work boat owned by the Scottish Oceans Institute. The vessel is an aluminium hull cabin boat with single 175HP 4 stroke engine.

Figure 2. Survey vessel, the *Swordsman*.

2.4 Survey equipment

Shallow sub-surface soil conditions will be identified using a parametric sub-bottom profiler. Equipment specifications are summarised in **Table 1**.

A parametric SBP generates a primary signal at two slightly different higher frequencies which interact in the water column to produce a lower frequency secondary signal which can penetrate the seabed; while the primary signal is often of a high source level, the resulting secondary signal is of much lower amplitude. These types of SBPs are typically used to obtain information between a few metres to a few tens of metres below the seafloor. This is a highly-directional source which directs energy vertically down to the seabed in a narrow beam. Signals are emitted and received from the same transducer.

Table 1. Characteristics of parametric sub-bottom profiler

Equipment	Device	Planned operational frequency	Beam width	Estimated source sound pressure level (dB re 1 µPa @ 1m)
Parametric SBP	Innomar SES-2000 Quattro	Primary: 85-115 kHz Secondary: 2-22 kHz	3-5°	Primary: 235-245 Secondary: ~ 200

Notes: Values are derived from manufacturer specifications.

3 Environmental information

Based on the available literature (e.g. Hague et al. 2020), baseline surveys of the Seagreen and Neart na Gaoithe wind farm projects to the north (Seagreen 2012), passive acoustic monitoring data on the east coast of Scotland (Palmer et al. 2017, Palmer et al. 2019) and vessel (photo-identification) surveys of the Forth and Tay coast (Arso Civil et al. 2021), two cetacean and two seal species are those most likely to occur in the St Andrews Bay region:

- harbour porpoise (*Phocoena phocoena*);
- bottlenose dolphin (*Tursiops truncatus*);
- harbour seal (*Phoca vitulina*); and,
- grey seal (*Halichoerus grypus*).

And additional two cetacean species are likely to occur in the wider Forth and Tay region, although these are more likely to be encountered further from shore than the survey area within St Andrews Bay:

- minke whale (*Balaenoptera acutorostrata*);
- white-beaked dolphin (*Lagenorhynchus albirostris*);

These species include representatives of all functional hearing groups of marine mammals which may occur in Scottish waters: very high-, high- and low-frequency cetaceans, as well as phocid carnivores (grey and harbour seal).

Minke whale are summer visitors to the wider region, being primarily sighted between May and September (Reid et al. 2003); given their low densities in the region, there is a low likelihood they will be present in the survey area. All other species may occur in the region year-round, although sightings are often highest in the spring and summer months. Harbour porpoise are the most abundant cetacean in the region, and the most likely species to be present in the survey area. They are typically sighted in small groups between one and three individuals. While bottlenose dolphins are frequently recorded in waters around the mouth of the Tay, to the north of the survey area, they are occasionally sighted in St Andrews Bay (Arso Civil et al. 2021). Bottlenose dolphins in this area below to the Coastal East Scotland population, associated with the Moray Firth Special Area of Conservation (SAC). Whilst the inner Moray Firth is an important area for this population, these animals are highly mobile, and have a large range that extends east along the outer Moray Firth coastline and south to the Firth of Tay, Firth of Forth and coastal waters off north-east England (Cheney et al. 2013). Vessel surveys of coastal waters from St Andrews Bay to Montrose between 2017-2019 encountered bottlenose dolphin group sizes ranging from 1-50 individuals, with a mean group size of 11 individuals (Arso Civil et al. 2021).

Harbour and grey seals are common in the region, with colonies and haul-out sites around the Forth and Tay area and adjacent coast (e.g., Isle of May SAC and Berwickshire and North Northumberland Coast SAC - grey seal; Tay and Eden Estuary SAC - harbour seal). Both species have the potential to occur in the survey area.

Table 2 outlines the relevant species-specific density estimates and management unit abundance data for marine mammals. It is noted the density values presented for bottlenose dolphin reflect those used in recent EPS risk assessments in support of the nearby Seagreen offshore wind farm, as featured in the Seagreen Optimised Design 2018 EIAR (presented in Volume 3 Appendix 10A: Marine Mammal Baseline Technical Report (2018)), updated to reflect more recent information where available.

Table 2. Species-specific Management Units (MU), MU estimates and density estimates taken forward for impact assessment

Species	MU	MU estimate	MU Source	Density Estimate	Density Source
Harbour porpoise	North Sea (ICES Assessment Unit)	346,601	(IAMMWG 2021)	SCANS III Block R 0.599 porpoise/km^2	SCANS III (Hammond et al. 2017)
Bottlenose dolphin	Coastal East Scotland	224	(Arso Civil et al. 2021)	50% of the CES MU (112 individuals) spread evenly across the area inshore of 20 m depth contour (= 0.08 dolphins/km^2) beyond the Moray Firth SAC.	Agreed in consultation on Seagreen wind farm Optimised project assessment (2017 Scoping Opinion); updated to reflect latest recommended MU size
Minke whale	Celtic and Greater North Seas	20,118	(IAMMWG 2021)	SCANS III Block R 0.039 whales/km^2	SCANS III (Hammond et al. 2017)
White-beaked dolphin	Celtic and Greater North Seas	43,951	(IAMMWG 2021)	SCANS III Block R 0.243 dolphins/km^2	SCANS III (Hammond et al. 2017)
Harbour seal	East Scotland	476	Scaled August 2018 haul-out count† (SCOS 2021)	5x5 km grid cell-specific relative density‡	Carter et al. (2020)
Grey seal	East Scotland	15,410	Scaled August 2018 haul-out count† (SCOS 2021)	5x5 km grid cell-specific relative density‡	Carter et al. (2020)

Notes: † MU estimates for seals are derived from August counts scaled to the species-specific estimated proportion of animals hauled out at that time; for grey seals this is based on a count of 3,683 and proportion hauled out of 23.9% (Russell et al. 2016 but note currently under review); for harbour seals a count of 343 and proportion hauled out of 72% (Lonergan et al. 2013). ‡ Relative density estimates for seals presented in Carter et al. (2020) can be scaled according to the most recent at-sea population estimates for the British Isles to provide absolute density.

4 Assessment

4.1 Standard mitigation and guidelines

The proposed surveys will be undertaken with relevant best practice guidelines in place. These are currently as follows:

- JNCC (2017) Guidelines for minimising the risk to injury to marine mammals from geophysical surveys;
- SNH (Undated) Scottish Marine Wildlife Watching Code.

JNCC guidelines will be applied to reduce the risk of injury occurring. The relevant steps are detailed in Section 5. It is noted that adherence to the JNCC guidelines is considered to reduce the risk of injury to marine mammals from geophysical survey activities to negligible. The survey equipment and activities proposed here are well-within the envelope of those for which the guidelines were designed, with source levels and likely propagation of sound being considerably less than that generated by seismic survey using airgun arrays.

SNH guidelines for wildlife watching, although not directly relevant to the purpose of the surveys, will be applied in relation to vessel operations in the vicinity of marine mammals, especially during transit when not actively operating geophysical equipment.

4.2 Auditory sensitivity of marine mammals

An essential step in assessing the potential for effects on relevant species is a consideration of their auditory sensitivities. Marine mammal hearing groups and injury criteria from Southall et al. (2019), and corresponding species of relevance to this assessment, are summarised in **Table 3**. There are no data available for the audiometry of low-frequency cetaceans; therefore, audiometry predictions are based on the hearing anatomy for each species and considerations of the frequency range of vocalisations.

Further to the information provided in **Table 3** for functional hearing groups, anatomical modelling specifically for minke whale suggests 10 Hz to 34 kHz, with vocalisations spanning 50 Hz to 9 kHz (reviewed in Southall et al. 2019). Harbour porpoise hearing is most sensitive at high frequencies between approximately 100 kHz and 140 kHz (Kastelein et al. 2002, Southall et al. 2007), with maximum sensitivity occurring at 125 kHz across multiple tested individuals (Kastelein et al. 2017). Auditory evoked potential studies suggest grey seals have a hearing range of < 1.4 kHz to 100 kHz (Ridgway and Joyce 1975). Behavioural study data suggest harbour seals have a hearing range of < 0.1 kHz to 79 kHz (Terhune 1988, Kastelein et al. 2009, Reichmuth et al. 2013, Cunningham and Reichmuth 2016).

Table 3. Marine mammal hearing groups, estimated hearing range and sensitivity and injury criteria and corresponding species relevant to this assessment (Southall et al. 2019).

Estimated hearing range	Estimated region of greatest sensitivity † [peak sensitivity]	Injury criteria (Permanent threshold shift, PTS) for impulsive sounds	
		$SPL_{0\text{-peak}}$ dB re 1 µPa (unweighted)	SEL_{24} dB re 1 µPa^{2}s (weighted)
Low-frequency (LF) cetaceans (minke whale)			
7 Hz – 35 kHz	200 Hz – 19 kHz	219	183
High-frequency (HF) cetaceans (all dolphin species)			
150 Hz – 160 kHz	8.8 – 110 kHz [58 kHz)	230	185
Very high-frequency (VHF) cetaceans (harbour porpoise)			
275 Hz – 160 kHz	12 – 140 kHz [105 kHz]	202	155
Phocid carnivores in water (PCW) (grey seal, harbour seal)			
50 Hz – 86 kHz	1.9 – 30 kHz [13 kHz]	218	185

Notes: † Region of greatest sensitivity represents F_1 (low-frequency) and F_2 (high-frequency) inflection points, while peak sensitivity is the frequency at which the lowest threshold was measured (T_0) (Southall et al. 2019).

4.3 Screening for potential noise effects

The primary operating frequency of the parametric SBP is such that it will be audible all cetacean and seal species, albeit with the higher frequency primary signal (85-115 kHz) above the region of peak hearing sensitivity for seals, and only the lower frequency secondary signal (2-22 kHz) being audible to minke whale. Therefore, there is the potential for behavioural disturbance or hearing injury to all relevant species. The primary signal is anticipated to be of sufficient intensity at source to result in PTS for all hearing groups (although see Appendix 1), whereas the secondary signal is anticipated to be below the threshold to result in PTS to any species.

4.4 Assessment of potential effects

A recent review of evidence on reported and potential effects of acoustic survey sources on marine mammals is provided by Hartley Anderson Ltd (2020). The authors note that most evidence relates to seismic airguns and military sonar, with limited information for other sources. As such, inferences on the potential for effects must be made on the acoustic properties of the sources and limited field measurements.

<u>Acoustic properties</u>

For parametric SBPs (along with pinger and CHIRP SBPs), the periodic waveform does not exhibit the same steep rise time characteristic of the true impulsive signals from airguns or sparker or boomer

SBPs, and therefore the potential for auditory injury is less than those alternative SBP technologies. Parametric SBPs show strong directionality: the majority of acoustic energy emitted is focused down, in a narrow beam, towards the seabed (Crocker et al. 2019). As such, horizontal propagation of sound will be limited. While independent calibrated measurements are not yet available for parametric SBPs, manufacturer specifications indicate that primary signal source levels may be relatively high (>240 dB) but focused in a very narrow beam of <5° and relatively high primary frequencies of ~100 kHz. These characteristics are broadly comparable to a single beam echo-sounder, and therefore the emitted sound field is expected to be small.

Field measurements

Useful information on the potential effects of geophysical survey sources can be derived from empirical studies which have measured sound levels from these sources in open-water environments. For example, Hannay and Warner (2009) report open water noise measurements from geophysical survey equipment in the Beaufort Sea in water depths of 20-50 m. Measurements were taken as survey vessels approached, to provide measurements between approximately 200 m and up to 10 km distance of the source. Sources included a mini-airgun array (2 x 10 in^3 airguns), a pinger SBP (Kongsberg Geopulse) and a boomer-type SBP (Datasonics SPR-1200 Bubble Pulser). Within 500 m of the source, measured SPL_{peak} was 180 dB re 1uPa for the mini-airgun array, 175 dB for the pinger, and 140 dB for the boomer SBP. A level of SPL_{rms} 160 dB re 1uPa, used by the NMFS as a threshold for behavioural disturbance ('Level B harrassment'), was recorded at 830 m of the mini-airgun, an estimated 140 m of the pinger, and an estimated 6 m of the boomer SBP (extrapolated from a level of <160 dB re 1uPa at the minimum measurement distance of 190 m). Of these sources tested, the pinger SBP is probably the most closely comparable to a parametric SBP in terms of the beam width, with peak frequency and source level being comparable to the secondary signal of a parametric SBP.

Measurements in shallow (≤100 m depth) open-water environments to investigate sound propagation from a variety of geophysical sources (albeit not including parametric SBPs) are presented in Halvorsen and Heaney (2018). While it is acknowledged that these results require refinement (Labak 2019), it is worth noting some general patterns observed from the open-water tests, as were summarised in Hartley Anderson Ltd (2020). Broadband received levels from all MBES, SSS and CHIRP and boomer SBPs tested were rapidly attenuated with distance from source in all test environments, including particularly pronounced fall-off for directional sources when the receiver was outside of the source's main beam (Halvorsen and Heaney 2018). Acoustic signals from the sparker SBPs and mini-airgun showed slightly greater propagation, as would be expected from the lower-frequency and higher-amplitude impulsive signals produced by these sources. The greatest propagation was generally observed at the deepest test site (100 m water depth) from sources generating low frequencies (<10 kHz), whilst some of the highest frequency sources (>50 kHz) were only weakly detectable or undetected by recording equipment located a few hundred metres from the source. In all open-water test environments, broadband received levels did not exceed an SPL_{rms} of 160 dB re 1µPa beyond a few hundred metres from any SBP, echo-sounder or SSS device tested, or beyond several hundred metres and approximately 1 km for the mini-airgun tested (Halvorsen & Heaney 2018).

While acknowledging that the measurements reported in Halvorsen and Heaney (2018) require refinement (Labak 2019), for a variety of seafloor mapping and SBP sources of comparable source characteristics to those proposed here, broadband sound levels recorded a few hundred metres from the source were of a considerably lower magnitude than the criteria for permanent or temporary hearing loss for all functional hearing groups of marine mammals (Southall et al. 2019).

Summary

While recognising the lack of empirical studies of animal responses to geophysical sources and limited data from field measurements of such sources, the available evidence suggests that SBPs and seafloor mapping sources used in high-resolution geophysical surveys generate a very limited sound field in the marine environment, and have a very low potential for injury or significant disturbance of sensitive marine fauna (BEIS 2019). A similar conclusion has been drawn by the US Bureau of Ocean and Energy Management (BOEM), who note that "*HRG [high-resolution geophysical] surveys put out less energy than seismic airguns and operate in smaller areas. Therefore, the size of the area impacted by sound is much smaller, though they can impact marine animals at close ranges (mostly within 200 meters). No injury to marine mammals or sea turtles is expected from these sound sources, as sound has been shown to diminish rapidly with distance from the sound source*" (BOEM 2018).

Furthermore, JNCC et al. (2010) EPS Guidance concludes that the use of SBPs in geophysical surveys, "*Could, in a few cases, cause localised short-term impacts on behaviour such as avoidance. However, it is unlikely that this would be considered as disturbance in the terms of the Regulations. It is unlikely that injury would occur as an animal would need to locate in the very small zone of ensonification and stay in that zone associated with the vessel for a period of time, which is also unlikely.*"

The evidence and inferences made above are supported by the basic illustration of noise propagation presented in Appendix 1, which suggests that noise levels will be rapidly attenuated with distance from source. Even without accounting for the directionality of sources and many other factors which will reduce the horizontal propagation of sound, received sound pressure levels are estimated to be below the criteria for instantaneous auditory injury (PTS) for all EPS and seals within 500 m or less of the source (Appendix 1). This is well-within the range at which adherence to the JNCC Guidelines for minimising the risk to injury to marine mammals from geophysical surveys are considered to be effective to reduce the risk of injury to negligible.

Therefore, it is concluded that the risk of injury to EPS (or seals) from the planned surveys is negligible, and that an EPS licence for injury is not required.

The SBP to be used in the planned survey activities will be detectable to all species of EPS, and so may elicit behavioural responses such as avoidance. However, considering the evidence discussed above, along with the very limited spatial and temporal extent of the planned survey activities, any disturbance would be highly localised, short-term and temporary, therefore limiting the magnitude of effects in terms of numbers of individuals and severity of disturbance. For example, responses are unlikely to exceed or extend far beyond aversion distances commonly reported in response to the passage of a vessel among more sensitive species (i.e. harbour porpoise (Palka and Hammond 2001)). Such effects would not be likely to impair the ability of an animal to survive or reproduce or result in any significant impacts to the local populations or distribution, and would therefore not affect their Favourable Conservation Status. Disturbance of this magnitude is also considered to have no potential to impinge adversely upon the condition of species which are interest features of Special Areas of Conservation.

4.4.1 Extent of potential disturbance

Notwithstanding that disturbance effects are predicted to be limited in extent, **some disturbance of EPS is possible and therefore an EPS licence for disturbance is required for Scottish inshore waters**. This requires an estimate to be made of the number of individual cetaceans expected to be affected (seals lie outside EPS permitting). It has been conservatively assumed that over the course of each survey campaign, all cetaceans in the surveyed area could potentially be disturbed at some point. The total surveyed area over which disturbance is estimated to take place is 5.7 km^2, which comprises the entire survey area plus a 1 km buffer as a precautionary measure to account for propagation of noise which may result in disturbance beyond the site boundary.

This total survey area is combined with cetacean density estimates (see **Table 2**) to provide a precautionary estimate of the number of animals for the principal four European Protected Species that might potentially be disturbed over the duration of a survey campaign (**Table 4**).

Table 4. Estimated numbers of animals disturbed and proportion of the MU as a result of geophysical survey activities

Species	Density	Number of individuals disturbed	Proportion of MU (%)
Harbour porpoise	0.599	3	< 0.01
Bottlenose dolphin	0.08	< 1	0.20
Minke whale	0.039	< 1	< 0.01
White-beaked dolphin	0.243	1	< 0.01

For all species, the number of animals estimated to be disturbed based on density estimates in the wider region is very low, with these numbers all representing ≤ 0.2% of the corresponding management unit. This highlights the very low risk of animals experiencing disturbance from the planned survey activities. It is acknowledged that the average group sizes of bottlenose dolphin and white-beaked dolphin exceed the estimated ≤ 1 individual of each species based on this method, and that it is worth considering what proportion of the resulting management unit might be disturbed were all individuals within an average sized group experience disturbance. For bottlenose dolphins, considering a mean group size of 11 (Arso Civil et al. 2021), this represents 4.9% of the Coastal East Scotland MU. For white-beaked dolphins, considering a mean group size of 4 (Hammond et al. 2021), this represents 0.01% of the Celtic and Greater North Seas MU.

It is noted that the disturbance effects will be temporary and localised to a transient source, which will only be operational for a maximum of 6 hours a day, for a maximum of three days. Considering the nature and magnitude of likely effects described here, including the precautionary estimates of number of animals disturbed relative to their wider populations, the proposed survey activities will not result in detrimental effects on the long-term maintenance of populations of cetaceans, their range or habitats. Consequently, **it is concluded that there will be no impact on the favourable conservation status of any European Protected Species.**

5 Mitigation measures

5.1 Geophysical survey

Current guidelines (JNCC 2017) set out precautionary mitigation measures for the use of SBPs and these will be followed throughout relevant survey operations.

A trained marine mammal observer (MMO) will be on the survey vessel to implement appropriate mitigation as specified in the JNCC (2017) guidelines. These include the following specific procedures to minimise the risk of injury to marine mammals which are of relevance to the planned survey operations:

1. The MMO will conduct a pre-shooting search for a minimum of 30 minutes prior to commencement of soft start/equipment activation. If a marine mammal is observed within a 500 m mitigation zone around the acoustic source, survey commencement will be delayed until 20 minutes after the marine mammal has left the mitigation zone or was last observed.
2. Soft-start. Where possible, the operating power of the equipment will be ramped up gradually, in a uniform manner from a low-energy start-up, over a minimum period of 15 minutes. It is acknowledged that this is not possible for some SBP equipment (i.e. it is either on or off); in such cases these will not be subject to soft-start.
3. Line change. If line changes (or other planned pauses) are expected to be longer than 40 minutes, equipment operation will be stopped at the end of the survey line and procedures 1 and 2 will be completed prior to resuming survey at full power. Where practical, equipment operation will also be stopped or operated at a reduced power or pulse rate during line changes/pauses expected to be less than 40 minutes.
4. Unplanned breaks. Where there is a gap in data acquisition of greater than 10 minutes, procedures 1 and 2 will be completed prior to resuming survey at full power.

The pre-shooting search will comprise visual observations only (i.e. no passive acoustic monitoring), as surveys will only be undertaken in period of good visibility (daylight and sea state ≤ 3).

6 Conclusions

Considering the impact assessment for the planned survey activities and the mitigation measures that will be applied, the risk of auditory injury to EPS or seals is considered to be negligible and therefore it is proposed that an EPS licence is not required for injury under *The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)* (inshore waters, <12 nm).

There is a low potential of behavioural disturbance to a limited number of individuals of EPS within Scottish inshore waters (<12 nm). Therefore, an EPS licence is required for disturbance under *The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)*. It is noted that the disturbance effects will be temporary and localised to a transient source, which will only be operational for a maximum of 6 hours a day, for a maximum of three days. Considering the nature and magnitude of likely effects described here, including the estimated low numbers of animals disturbed which represent small proportions of their wider populations, the proposed survey activities will not result in detrimental effects on the long-term maintenance of populations of cetaceans, their range or habitats. Consequently, it is concluded that there will be no impact on the favourable conservation status of any European Protected Species.

7 Designated sites

7.1 Special Areas of Conservation

A number of SACs supporting certain marine mammal species that are potentially sensitive to underwater noise are present in the region; these sites are detailed in **Table 5**.

Table 5. Special Areas of Conservation for marine mammals in the region

SAC	Qualifying features of relevance to this risk assessment	Approximate minimum distance to survey area
Isle of May	Grey Seal	20 km
Berwickshire and North Northumberland Coast	Grey seal	55 km
Firth of Tay and Eden Estuary	Harbour seal	2 km
Moray Firth	Bottlenose Dolphin	> 200 km

While cetaceans and seals are wide-ranging and frequently occur beyond the boundaries of protected sites, these sites encompass areas of favourable habitat supporting higher densities of the species than other areas of UK waters and, in the case of seals, key breeding sites. Harbour seals exhibit strong site fidelity throughout the year, foraging within approximately 50 km of their breeding colony (Jones et al. 2015). Grey seals forage more widely, and may move between haul-out sites outside of the breeding season (Russell et al. 2013, Jones et al. 2015), but are considered to remain relatively close to colonies during the breeding season[2]. While the planned activities may result in some short-term disturbance to a very small number of grey seals associated with the Isle of May SAC or Berwickshire and North Northumberland Coast SAC outside of the breeding season, this is not considered to have the potential for long-term deterioration of the qualifying feature(s) and its habitats, and no adverse effect on the integrity of the site.

It is noted that the survey area is within 2 km of the southern boundary of the Firth of Tay and Eden Estuary SAC, which is designated for a breeding population of harbour seal. While surveys are planned to occur within the harbour seal breeding season (June-July), where seals may be more sensitive to disturbance, the lack of overlap with the SAC and limited spatial and temporal extent of activities results in a very low likelihood of temporary disturbance to a small proportion of the qualifying features when outside the site boundaries. Importantly, the nature of the planned survey activities is such that they do not present the potential for a long-term deterioration of the qualifying feature(s) and its habitats, and will not result in an adverse effect on the integrity of the site.

The Coastal East Scotland bottlenose dolphin population associated with the Moray Firth SAC have a large range that extends east along the outer Moray Firth coastline and south to the Firth of Tay, Firth of Forth and coastal waters off north-east England (Cheney et al. 2013, Quick et al. 2014, Arso Civil et al. 2019). Boat-based surveys have indicated relatively high encounter rates at the entrance of the Tay Estuary, although limited sightings within St Andrews Bay (Quick et al. 2014, Arso Civil et al. 2021). As described in Section 4.4.1, any disturbance to bottlenose dolphins which may be associated with the Moray Firth SAC arising from the planned survey activities will be short-term and to a limited number of individuals; therefore, there is not considered to be potential for long-term deterioration of the qualifying feature(s) and its habitats, and no adverse effect on the integrity of the site.

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Appendix 1 – Illustration of approximate reduction in noise levels within 1 km of source

In **Table 6**, overleaf, some simple calculations are provided, to illustrate how simple geometric spreading and absorption loss may influence sound levels (SPLs) from the parametric SBP to a distance of up to 1 km from the source. No information is provided on the more complex calculation of sound energy levels, either from single pulses of cumulative exposure levels weighted to specific marine mammal hearing groups.

Modelling the propagation of noise underwater is a complex task, with many influencing factors such as the directionality of the source, the frequency spectrum, bathymetry, seabed substrate, sea surface roughness, and sound speed profile of the water column. The calculations provided below do not consider any of these factors, and so should not be used to quantify of the range over which specific effects may occur to receptor species. Critically, no attempt is made for the directionality of the source, and so all values are only of relevance to the propagation of sound in the main beam, and so are highly conservative in terms of horizontal propagation for parametric SBP. For this source, energy is typically focussed in a narrow beam, and therefore sound levels propagated horizontally (outside of the main beam) would be of a significantly lower intensity than those illustrated below. For example, the first side lobes emitted by multi-beam echosounders and side-scan sonar (other directional geophysical sources) measured by Crocker and Fratantonio (2016) were between 14-25 dB lower in amplitude than the main beam. This contrasts to sound sources such as pile-driving or explosive detonation, which are more omnidirectional.

Nonetheless, by applying a commonly-used geometric spreading loss of 15log*R* (*R* = range from source) and an estimation of absorption loss (Ainslie and McColm 1998), a basic illustration can be made of the approximate rate at which noise levels reduce within a few hundred metres of the source, and the relative influence of source level and signal frequency. While it is acknowledged that the survey area is very shallow water (< 10 m water depth at lowest astronomical tide) and therefore a cylindrical spreading loss of 10log*R* may be expected, the use of 15log*R* is considered more appropriate given the highly directional nature of the source. This is also supported by measurements of a less directional mini airgun source in 15 m water depth which exhibited a spreading loss of 18log*R* (Hermannsen et al. 2015).

Table 6. Illustration of approximate reduction in broadband noise levels within 1 km of source.

		Parametric SBP primary signal	Parametric SBP secondary signal
Source sound pressure level (dB re 1 µPa @ 1m) (peak)		245	200
Assumed frequency of signal (kHz) for absorption loss [1]		85	2
Assumed absorption loss (dB/km) [2]		28.25	0.13
Assumed geometric spreading law		15logR	15logR
Estimated sound pressure levels at distance from source (dB re 1 µPa)	10 m	230	185
	50 m	218	175
	100 m	212	170
	250 m	202	164
	500 m	190	159
	1,000 m	172	155

*Notes: The 500 m distance from source is highlighted as this reflects the standard mitigation/monitoring zone under the JNCC guidelines (JNCC 2017). 1 The assumed frequency is taken as the lower limit of the dominant operational frequency range provided for each source (see **Table 1**); 2 Absorption loss calculated following Ainslie & McColm (1998) and assuming seawater at zero metres depth and a precautionary water temperature of 8 degrees.*