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Seagreen Alpha and Bravo Site and Seagreen 1A Export Cable Corridor Geotechnical Surveys – Marine EPS Risk Assessment

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1. Introduction

Seagreen Wind Energy Limited (hereafter referred to as 'Seagreen') was awarded consents by Scottish Ministers in October 2014 for the Seagreen Alpha and Seagreen Bravo Offshore Wind Farms (OWF) and the Offshore Transmission Asset (OTA), collectively referred to as the 'Seagreen Project'. The OWF includes the wind turbine generators (WTGs), their foundations, associated inter-array array cabling and the WTGs to offshore substation platform (OSP) cables. The OTA includes two OSPs, their foundations, OSP interconnection cables and the offshore export cables up to mean high water.

The OWF, which comprises up to 150 WTGs in total, is located in the North Sea, in the outer Firth of Forth and Firth of Tay (**Figure 1.1**). The OWF array area is entirely within offshore Scottish waters (>12 nm from shore), with a minimum distance of approximately 27 km to shore near Johnshaven on the Aberdeenshire coast. The primary export cable landfall is at Carnoustie on the Angus coast, which will export energy from 114 of the WTGs. It is planned that the remaining 36 WTGs will export energy to shore via an additional export cable, known as the Seagreen 1A project, which will make landfall at Cockenzie in the Firth of Forth.

To help facilitate engineering decisions regarding the construction of the WTGs and OTA Seagreen plans to undertake geotechnical surveys of the OWF array area and a proportion of the Seagreen 1A export cable corridor (ECC) between 15th January and 30th April 2024.

The planned surveys include the following data acquisition:

- Seabed cone penetration tests (CPT)
- Vibrocore sampling

These activities will use an ultra-short baseline (USBL) acoustic positioning system to obtain accurate equipment positioning. The USBL emits impulsive underwater noise which, if of sufficient magnitude, may present a risk of injury (i.e. hearing damage) or disturbance to noise-sensitive protected species, namely marine mammals. As European Protected Species (EPS), listed on Annex IV of the EU Habitats Directive, 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 1.1**.

While seals are not EPS, they may be interest features of protected sites, including Special Areas of Conservation (SACs) under the Habitats Directive, and as such potential effects on harbour and grey seals are also assessed.

This risk assessment considers the potential effects of the aforementioned USBL use on marine EPS in the context of relevant legislation and guidance (see **Sections 1.1** and **1.2**), therefore assessing the need for an EPS licence(s) and providing the information required by MS-LOT in support of any such applications[1]. Consideration is also given to the potential for the planned survey activities to impact seals and relevant protected sites (i.e. marine protected areas for cetaceans and seals; see **Section 6**).

[1] For example, this document provides the 'Cetacean Risk Assessment' described in: *Marine Scotland. 2020. The protection of Marine European Protected Species from injury and disturbance. Guidance for Scottish Inshore Waters (July 2020 Version).*

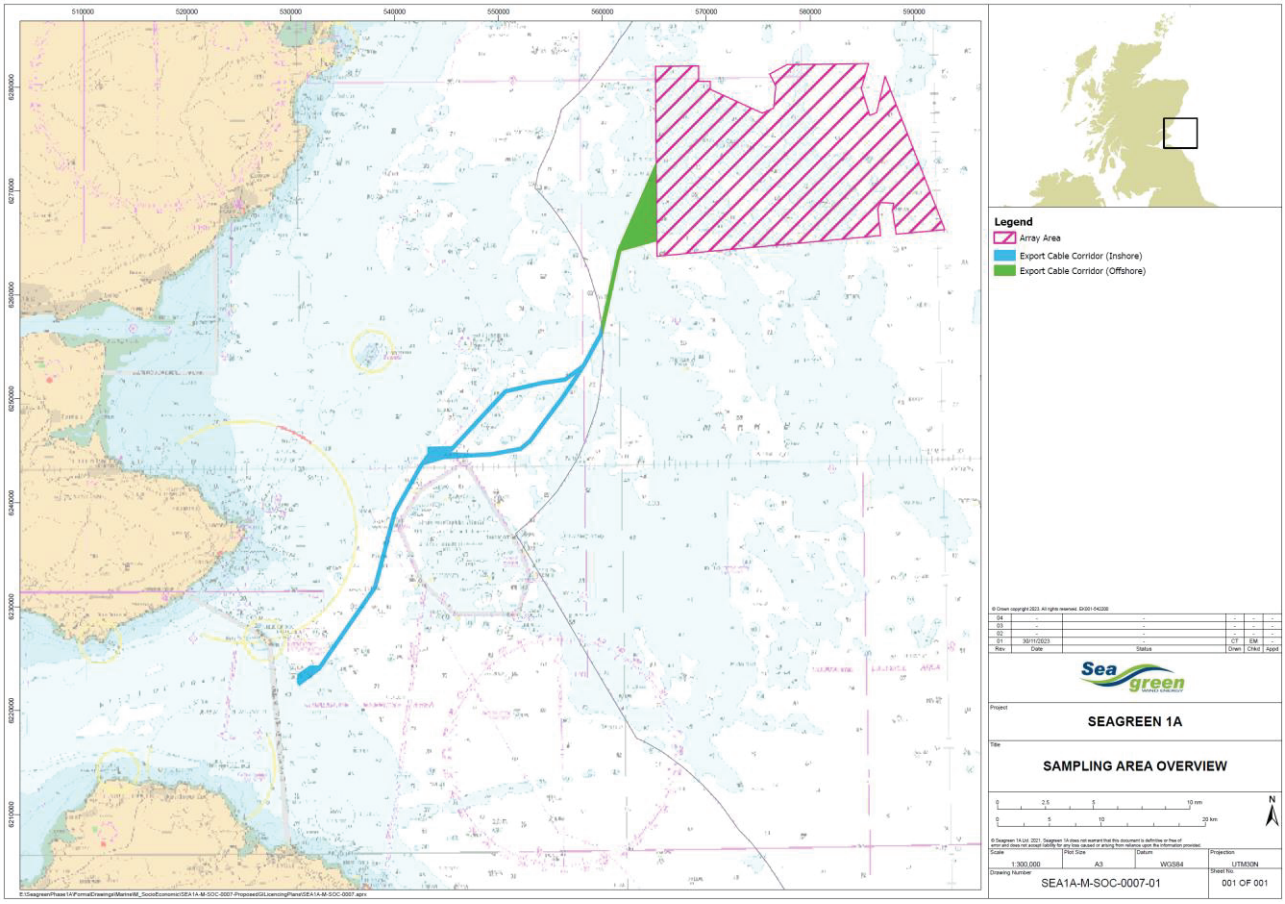

Figure 1.1. The planned survey area, including OWF array area (purple hatched), offshore ECC section (green) and inshore ECC section (blue).

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, along with accompanying guidance, define offences in relation to EPS. These have been retained in domestic law following the exit of the UK from the EU through various EU Exit amendment legislation. Other legislation defines offences related to seals. Regulations of relevance to this risk assessment are described in **Table 1.1**.

Table 1.1. Legislation and offences relating to EPS and seals in Scottish inshore and offshore waters.

Legislation and offences relating to EPS in Scottish inshore and offshore waters
Legislation: *The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)**   **Applicable to:** Scottish inshore waters (<12 nm)   **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.   *Retained in UK law through the *Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations* 2019.
Legislation: *The Conservation of Offshore Marine Habitats and Species Regulations 2017**   **Applicable to:** UK offshore waters (>12 nm)   **Offence(s): Part 3 (Section 45)** states that it is an offence to deliberately capture, kill or injure any wild animal of a European protected species. It is also an offence to deliberately disturb wild animals of any such species, with disturbance defined as that which is likely to impair their ability to: survive, breed, reproduce, or nurture young; migrate or hibernate; or, which might affect significantly its local distribution or abundance.   *Retained in UK law through the *Conservation of Habitats and Species (Amendment) (EU Exit) Regulations* 2019.
Legislation and offences relating to seals in Scottish inshore waters
Legislation: *Marine (Scotland) Act 2010*   **Applicable to:** Scottish inshore waters (< 12 nm)   **Offence(s):** Under **Section 107** it is an offence to intentionally or recklessly kill, injure or take a seal except under licence or to alleviate suffering.   Further, under **Section 117,** harassing a seal (intentionally or recklessly) at a haul-out site is an offence. Haul-out sites are those designated under *The Protection of Seals (Designated Sea Haul-out Sites) (Scotland) Order 2014*.

Should an EPS licence be required, for it 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:

- JNCC et al. (2010). The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area (June 2010 – Draft).
- Marine Scotland (2020). The protection of Marine European Protected Species from injury and disturbance. Guidance for Scottish Inshore Waters (July 2020 Version).
- JNCC (2017) guidelines for minimising the risk of injury to marine mammals from geophysical surveys.

1.3 Existing impact assessments

This EPS Risk Assessment has been informed by impact assessments and a subsequent Environmental Statement (ES) to inform applications for consents to build and operate Seagreen Alpha and Seagreen Bravo offshore wind farms (Seagreen, 2012). The wind farms were subsequently consented in 2014.

In 2015, an Appropriate Assessment (Marine Scotland, 2015) concluded that the Forth and Tay Developments, either alone or in-combination, will not adversely affect the integrity of relevant marine mammals SACs, including the Isle of May SAC, the Berwickshire & North Northumberland Coast SAC, Firth of Tay and Eden Estuary SAC and Moray Firth SAC, subject to compliance with relevant conditions[2]. Further information on these sites is provided in **Section 6**.

This EPS Risk Assessment has also been informed by a subsequent Environmental Impact Assessment Report (EIAR) submitted in 2018 support of consent applications for an optimised design for the same wind farm projects (Seagreen, 2018a), along with previous EPS risk assessments for geophysical and geotechnical surveys related to the Seagreen OWF site and primary export cable corridor, and the planned Seagreen 1A export cable corridor. In particular, given the very similar scope of activities, this Risk Assessment is based on that presented for geotechnical surveys within the OWF site in 2021 (Document Ref. LF00012-CST-OF- LIC-DEV-RAS-0001) and offshore ECC in 2022 (Document Ref. LF000012-CST-OF-RAS-0001; note – the 2022 geotechnical surveys did not take place).

[2] Conditions are listed from page 58 of https://marine.gov.scot/sites/default/files/appropriate_assessment_1.pdf

2. Proposed geotechnical survey

2.1 Purpose

The purpose of the planned survey is to facilitate engineering decisions regarding:

- Siting of an OSP
- Siting of WTGs (and use of 'spare' locations as required)
- Route design and cable protection requirements for the export cable and inter-array cabling

2.2 Survey location and sampling activities

The survey area includes the Seagreen Alpha and Bravo OWF array site (391 km^2), located approximately 30 km off the east coast of Scotland between Montrose and Arbroath, a funnel-shaped adjoining area of the export cable corridor (ECC) to the west of the OWF site (15 km^2), and the ECC to the outer limits of the Firth of Forth (31 km^2) (**Figure 2.1**). The planned survey area is within both offshore and Scottish inshore waters but does not extend to landfall. The minimum distance between the survey area and the Scottish mainland is 13 km, between the ECC and Fife Ness.

Within the survey area, the following sampling is planned:

- **Seabed CPT:** maximum of 189 (140 array; 49 ECC) to a depth of 6-20 m below the seabed.
- **Vibrocore:** maximum 69 samples (20 array; 49 ECC) to a depth of 6 m below the seabed.

All vibrocores are co-located with CPTs, such that there are a maximum of 189 sampling stations. Sampling may take place anywhere within the survey area as required.

The CPT and vibrocore sampling units will be deployed to the seabed from an A-frame or deck-mounted crane and will use a USBL acoustic positioning system to obtain accurate equipment positioning.

2.3 Survey schedule

Survey activities are expected to occur over a 7-8 week period between 15th January (earliest start) and 30th April (latest end date) 2024. To complete CPT and vibrocore sampling, the vessel will be stationed at each survey point for an estimated 3.5 hours. The total duration of work is expected to be 50 days, excluding weather and vessel mobilisation and demobilisation time.

2.4 Survey vessel(s)

Sampling will take place from a DP2-rated offshore supply/survey vessel of approximately 70-80 m in length. The vessel will hold station using dynamic positioning (DP). The exact vessel to be used is subject to contract award and vessel availability.

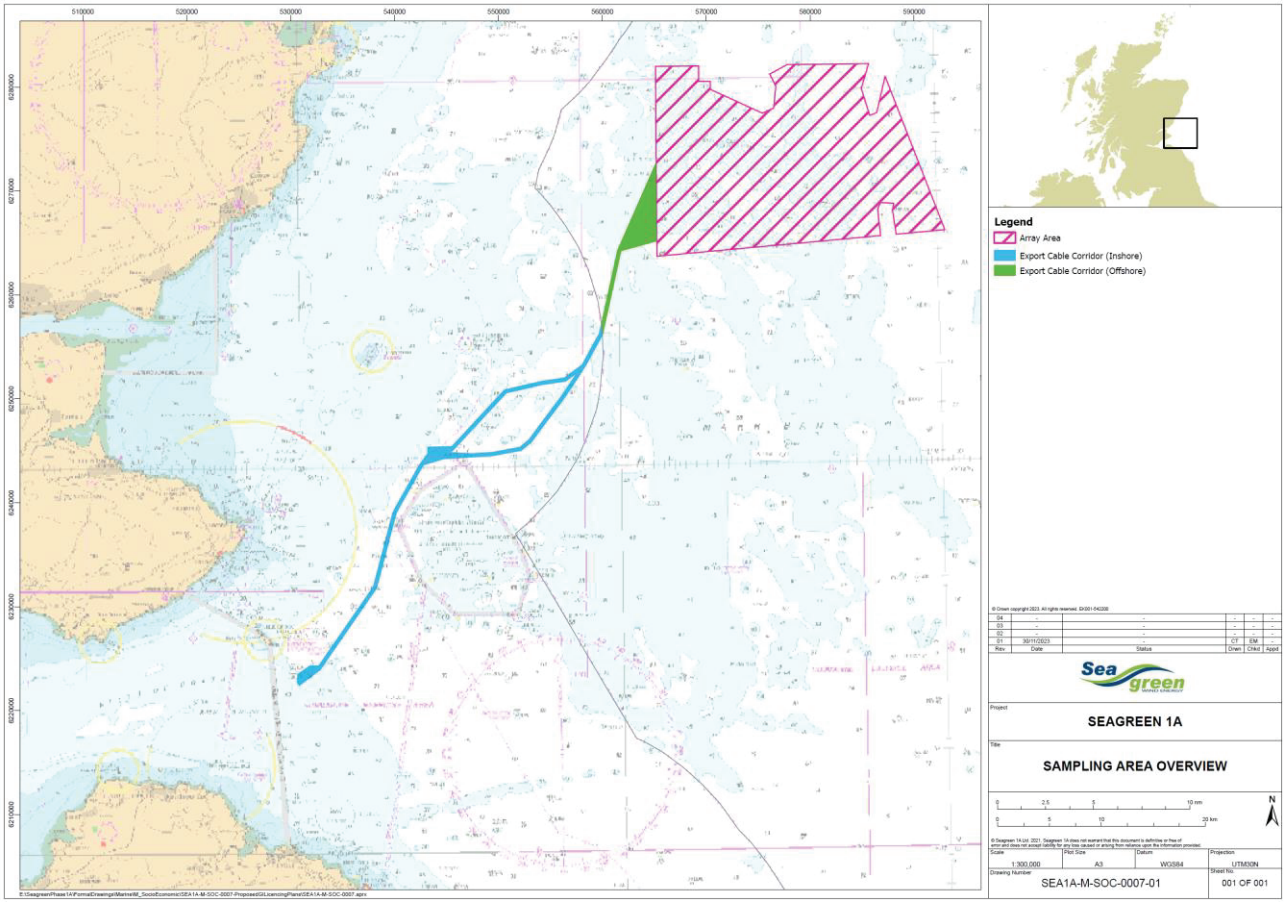

Figure 2.1. The planned survey area, including OWF array area (purple hatched), offshore ECC section (green) and inshore ECC section (blue).

2.5 USBL equipment

A USBL system will be used to obtain accurate equipment positioning during sampling activities. USBL equipment is widely used by offshore industries and scientific research vessels where positional accuracy of deployed equipment is essential, such as cable laying, geophysical/geotechnical surveys and ROV operations.

This system consists of a transceiver mounted under the vessel and a transponder on deployed equipment including tow fish and ROV. The transceiver transmits an acoustic pulse which is detected by the transponder, followed by a reply of an acoustic pulse from the transponder. This pulse is detected by the transceiver and the time from transmission of the initial pulse is measured by the USBL system and converted into a range. The directionality of USBL systems varies, and signals may often be transmitted in a relatively wide beam of ~ 100 to 180° (Jiménez-Arranz et al., 2020). Systems with a wider beam / less directionality generally have lower source levels than the more directional systems.

The exact equipment used will be confirmed following the appointment of a survey contractor, but their specifications will be within the envelope of those presented and assessed here. Acoustic characteristics of some example USBL equipment is provided in **Table 2.1**. These devices generate sound in the frequency range 19-34 kHz with source levels of 182-206 dB re 1 µPa @ 1m (peak). The majority of USBL systems in

commercial use have a source level of ≤ 200 dB re 1 µPa @ 1m, which is a relatively low sound level compared to most geophysical survey equipment (e.g. Hartley Anderson Ltd, 2020; Jiménez-Arranz et al., 2020). At 206 dB re 1 µPa @ 1m SPL, the Kongsberg HiPAP 501 is the equipment with the highest source level of those presented in **Table 2.1**, and therefore can be considered conservative in terms of the likely potential for effects. While the Kongsberg HiPAP 501 system's transducer array allows signals to be transmitted in almost all directions, focused conical beams of c. 10° are directed towards the transponder, regardless of the transponder location relative to the vessel[3]. It is noted that the transponder will be deployed beneath the survey vessel.

Table 2.1. Acoustic characteristics of example USBL equipment

Example device	Planned operational frequency	Estimated source sound pressure level (SPL_{rms} dB re 1 µPa @ 1m)
Kongsberg HiPAP 501	20-32 kHz	190 – 206 (depending on transducer configuration)
Sonardyne Ranger HPT 3000 (MF)	19-34 kHz	194
Sonardyne Compatt 6 (MF)	19-34 kHz	187 – 202 (depending on specific model and depth rating)
Kongsberg cNODE Modem MiniS	21-31 kHz	182 – 197 (depending on beam width)

Notes: Values are derived from manufacturer specifications. The Kongsberg HiPAP is the most likely system to be used in the planned survey.

3. Marine mammal occurrence in the Seagreen area

A relatively wide range of cetacean species can potentially occur in Scottish waters; however, based on the available literature (e.g. that reviewed by Hague et al., 2020), as well as site-specific surveys, the Seagreen EIA (Seagreen, 2012) identified a restricted sub-set of four cetacean (EPS) and two seal species as key marine mammals in relation to the focus of the impact assessment. The same species were the focus of the 2018 EIA Report (Seagreen, 2018a) and 2020 Piling Strategy (Seagreen, 2020). The species are as follows:

- harbour porpoise (*Phocoena phocoena*);
- bottlenose dolphin (*Tursiops truncatus*);

[3] https://www.kongsberg.com/globalassets/maritime/km-products/product-documents/371465_hipap_frequency_plan.pdf

- minke whale (*Balaenoptera acutorostrata*);
- white-beaked dolphin (*Lagenorhynchus albirostris*);
- harbour seal (*Phoca vitulina*); and,
- grey seal (*Halichoerus grypus*).

Although the Risk Assessment focuses upon the above species, it should be noted that together this group includes representatives of all Southall et al. (2019) 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).

Table 3.1 outlines the relevant species-specific density estimates and management unit abundance data for marine mammals used in the 2018 EIAR (presented in Volume 3 Appendix 10A: Marine Mammal Baseline Technical Report (2018), which has been updated where more recent information has become available (IAMMWG, 2022; Gilles et al., 2023; SCOS, 2023).

Table 3.1. Species-specific Management Units (MU) and density estimates used for impact assessment.

Species	MU	MU estimate	MU Source	Density Estimate	Density Source
Harbour porpoise	North Sea	346,601	(IAMMWG, 2022)	SCANS IV Block NS-D 0.599 porpoise/km^2	SCANS IV (Gilles et al., 2023)
Bottlenose dolphin	Coastal East Scotland	224	Arso Civil et al. (2021)	95 bottlenose dolphins spread evenly across the area inshore of 20 m depth contour	Agreed in consultation on Seagreen Optimised project assessment (2017 Scoping Opinion); updated to reflect revised MU size
Minke whale	Celtic and Greater North Seas	20,118	(IAMMWG, 2022)	SCANS IV Block NS-D 0.042 whales/km^2	SCANS IV (Gilles et al., 2023)
White-beaked dolphin	Celtic and Greater North Seas	43,951	(IAMMWG, 2022)	SCANS IV Block NS-D 0.080 dolphins/km^2	SCANS IV (Gilles et al., 2023)
Harbour seal	East Scotland	364	Scaled SCOS (2023) count†	5x5 km grid cell-specific relative density*	Carter et al. (2022)

Species	MU	MU estimate	MU Source	Density Estimate	Density Source
Grey seal	East Scotland	10,783	Scaled SCOS (2023) count†	5x5 km grid cell-specific relative density*	Carter et al. (2022)

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 2,712 and proportion hauled out of 25.15% (SCOS, 2023); for harbour seals a count of 262 (SCOS, 2023) and proportion hauled out of 72% (Lonergan et al., 2013).

**Relative density estimates in Carter et al. (2022) can be scaled to the current at-sea population estimates for the British Isles to provide absolute density.*

3.1 Cetaceans

3.1.1 Harbour porpoise

Harbour porpoise are the smallest and most abundant cetacean species in UK waters (Reid et al., 2003). They are typically sighted in small groups between one and three individuals. Animals are frequently sighted throughout coastal habitats with studies suggesting they are highly mobile and cover large distances (Nabe-Nielsen et al., 2011). The most recent UK assessment of the conservation status of harbour porpoise (in contribution to the fourth Article 17 Habitats Directive Report) concluded an 'Unknown' conservation status, but with 'Favourable' range and future prospects (JNCC, 2019b). An overall 'Unknown' status was concluded for all cetacean species regularly occurring in UK waters, largely due to insufficient data on the status of the population (i.e. trends) and habitat (JNCC, 2019b).

Breeding occurs mainly between May and August, with a peak in June, though some calves can be born as early as March. Social groups often gather in late summer (August-September) for mating (Anderwald and Evans, 2010). The gestation period of the harbour porpoise is ten months, with peak mating activity likely to occur in August. Evidence for social and sexual activity in late summer has been widely reported. Females are believed to nurse their calves for between eight and twelve months. Weaning is a gradual process with young starting to take solid food after a month or two.

Site-specific boat-based survey data presented in 2010 and 2011 showed sightings of harbour porpoise in the Seagreen wind farm area in most months; however, encounter rates were generally highest in the spring and summer and relatively low in autumn and winter. The site-specific surveys and a wide range of other data sources, such as SCANS and ECOMMAS, demonstrate that harbour porpoise are common in the study area and there is potential for animals to be impacted by the planned activities.

3.1.2 Bottlenose dolphin

In the UK, bottlenose dolphins have been assessed as having an 'Unknown' overall conservation status, with 'Favourable' range (JNCC, 2019a). The Coastal East Scotland population of bottlenose dolphins is the only known remaining resident population in the North Sea and it was for this reason that the Moray Firth SAC was established in order to protect this population. The conservation objectives of the Moray Firth SAC are

to avoid the deterioration of the bottlenose dolphin habitat, to achieve a favourable conservation status and to ensure the population size and distribution of the bottlenose dolphins is maintained in the long-term.

The number of individuals using the SAC between 2001 and 2015 has remained stable, albeit with some inter-annual variability, whilst an assessment of the total abundance of the east coast population indicates that the overall population is increasing (Cheney et al., 2018). This means that the proportion of the population that uses the SAC has declined (Graham et al., 2016). Whilst the Moray Firth is clearly 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; Quick et al., 2014; Arso Civil et al., 2019).

The resident Coastal East Scotland (CES) bottlenose dolphin population is strictly coastal with most animals encountered in waters less than 20 m deep and within 2 km from the coastline. Activities within the planned survey area, which is a minimum of 13 km from the nearest point of mainland and 9 km from the 20 m depth contour, are unlikely to have potential to impact upon the CES bottlenose dolphins.

3.1.3 Minke whale

Minke whales are widely distributed around the UK, with higher densities recorded on the west coast of Scotland and the western North Sea (Reid et al., 2003). They occur mainly on the continental shelf in water depths less than 200 m and are sighted more frequently in the summer months between May and September. Minke whales in the UK are considered to be part of a single, large MU: the Celtic and Greater North Seas MU (IAMMWG, 2021); their overall conservation status has been assessed as 'Unknown' with 'Favourable' range (JNCC, 2019e).

During site-specific boat-based surveys in 2010 and 2011 minke whale were seen throughout the Seagreen wind farm area. A strong seasonal pattern was recorded, with most minke whales encountered during the spring and summer months in 2010 and 2011, with high rates in May 2010 and June 2011. This seasonal pattern is supported by Anderwald and Evans (2010).

Site-specific surveys, together with other information sources such as SCANS, confirm that although minke whale are present at low densities they have been sighted relatively often in the study area, and more frequently in the summer months. Therefore, they have the potential to be impacted by the planned activities, although the use of summer density values (SCANS) will over-estimate the numbers of animals in the area in winter-spring.

3.1.4 White-beaked dolphin

White-beaked dolphins are wide-spread across the northern European continental shelf. The species is the most abundant cetacean in the North Sea after the harbour porpoise (Banhuera-Hinestroza et al., 2009), and the waters off the coast of Scotland and north-east England are one of the four global centres of peak abundance. The species occurs mainly in waters of 50-100 m depth (Reid et al., 2003). Evidence supports the assumption that white-beaked dolphins from around the British Isles and North Sea represent one population, with movement between Scottish waters and the Danish North Sea and Skagerrak (Banhuera-Hinestroza et al., 2009).

During site-specific boat-based surveys of the Seagreen wind farm site, white-beaked dolphins were recorded most often during the summer in both 2010 and 2011. Site-specific surveys, together with other information sources such as SCANS, confirm that white-beaked dolphins have been sighted occasionally in the wind farm area, and, similar to minke whales, are seen more frequently in the summer months. Although present at low densities, they have the potential to be impacted by the planned activities.

3.2 Pinnipeds

3.2.1 Harbour seal

The harbour seal is the smaller of the two seal species resident in UK waters. Seals forage at sea and haul-out on land to rest, moult and breed. Harbour seals normally feed within 40 to 50 km around their haul-out sites and take a wide variety of prey including sandeels, gadoids, herring and sprat, flatfish, octopus and squid (SCOS, 2019).

Harbour seals come ashore in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas. They give birth to their pups in June and July and moult in August. At these, as well as other times of the year, harbour seals haul-out on land regularly in a pattern that is often related to the tidal cycle.

Harbour seals are widespread around the west coast of Scotland and throughout the Hebrides and Northern Isles. On the east coast, their distribution is more restricted with concentrations in the major estuaries of the Thames, The Wash, the Moray Firth and the Firth of Forth. The harbour seal is a qualifying feature of the Firth of Tay and Eden Estuary SAC, located a minimum of 26 km from the survey area (ECC).

Harbour seals were recorded in low numbers during the boat-based surveys of the wind farm site in 2010-2011. Modelled at-sea densities in the wind farm and adjacent areas are estimated to be low (< 1 seal per 5x5 km grid cell); higher densities are estimated closer to the coast, within inshore waters, particularly in the Firth of Forth (Russell et al., 2017). Recently published habitat preference-based modelling of harbour seal at-sea distribution (Carter et al., 2022) show a similar pattern, with areas closer to the coast of greater importance to harbour seal and very low estimated densities of ≤ 0.1 seals per 5x5 km grid cell across the wind farm site.

In the UK, the harbour seal has been assessed as having an overall conservation status of 'Unfavourable – Inadequate' (JNCC, 2019d). Population trajectories vary considerably between regions around the UK; however, populations in the East Scotland MU (and North Coast & Orkney MU) have declined considerably over the past two decades and are continuing to decline (SCOS, 2020).

Harbour seals have the potential to be impacted by the survey activities, although they are present in very low numbers in the survey area, consistent with the distance from the principal haul-out sites in the region.

3.2.2 Grey seal

The grey seal is the larger of the two seal species resident in UK waters. Grey seals haul-out on land to rest, moult and breed and forage at sea where they range widely, frequently travelling for up to 30 days with over 100 km between haul-out sites (SCOS, 2019). Approximately 38% of the worlds grey seal population breeds in the UK with 86% of these breeding in Scotland. Grey seal population data are assessed using pup counts during the autumn breeding season when females haul-out to give birth. The number of pups throughout

Britain has grown steadily since the 1960s but there is clear evidence that the population growth is levelling off in all areas, except the central and southern North Sea where growth rates remain high. The grey seal is considered to have a Favourable Conservation Status in the UK (JNCC, 2019c).

The grey seal is a qualifying feature of the Isle of May SAC, located a minimum of 3.3 km north-west of the survey area (ECC), and the Berwickshire and North Northumberland Coast SAC, located 27 km south of the survey area (ECC).

Grey seals were recorded in the wind farm site throughout the boat-based surveys in 2010 and 2011, with highest encounter rates in June in both years. Modelled at-sea densities in the wind farm and immediately adjacent areas are estimated to be variable, ranging between 3 and 44 seals per 5x5 km grid cell, and averaging ~11 seals per grid cell (Russell et al., 2017). Higher densities are estimated closer to the coast within the Firth of Tay and St Andrews Bay. Recently published habitat preference-based modelling of grey seal at-sea distribution (Carter et al., 2022) show a similar pattern, with density estimates ranging between 10 and 38 seals per 5x5 km grid cell across the wind farm site and immediately adjacent areas. Predicted densities in the survey area covering the ECC export cable route are comparable to or lower than those in the wind farm site. Densities of grey seals will be particularly high in closer proximity to the Isle of May during the breeding season (Oct-Dec).

It is therefore likely that grey seals will be present throughout the survey area and there is potential for animals to be impacted by the effects of underwater noise from survey equipment.

4. Assessment

4.1 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 auditory injury criteria from Southall et al. (2019), and corresponding species of relevance to this assessment, are summarised in **Table 4.1**. 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 4.1**, for functional hearing groups, anatomical modelling specifically for minke whale suggests 10 Hz to 34 Hz, 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 4.1. Marine mammal functional hearing groups, estimated hearing range and sensitivity, 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_{peak} dB re 1 µPa (unweighted)	SEL_{cum} dB re 1 $µPa^2s$ (weighted)
Low-frequency (LF) cetaceans (minke whale)			
7 Hz – 35 kHz	200 Hz – 19 kHz	219	183
High-frequency (HF) cetaceans (white-beaked dolphin, bottlenose dolphin)			
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 low-frequency (F_1) and high-frequency (F_2) inflection points, while peak sensitivity is the frequency at which the lowest threshold was measured (T_0) (Southall et al., 2019).

4.2 Evidence of noise levels, propagation and potential for effects on marine mammals

Open water noise measurements from USBL equipment are very limited in the public domain. A recent sound source verification exercise in the Danish North Sea reported measured noise levels from several active acoustic sources at sampling stations with closest points of approach of 0 m, 100 m and between 500 m and 2 km (Pace et al., 2021). In the study, Pace et al. (2021) reported noise levels for a USBL operating at 25-40 kHz attached to a SSS operating at a dual 300/600 kHz frequency, the latter being above the recording capabilities of the noise loggers used. The effective source level was estimated as 184 dB re 1 $µPa^2$ @1 m (SPL_{rms}). At 100 m distance, broadband received levels in the 20-30 kHz band were 147.9 dB re 1 $µPa^2$ (SPL_{rms}). The USBL appeared fairly omnidirectional with an estimated transmission loss of c. 15logR. When the USBL was active, the combined source was detectable above background noise at the maximum recording distance of 2 km; however, at a distance of c. 1 km from the source, broadband received levels were ≤ 140 dB re 1 $µPa^2$ (SPL_{peak}), ≤ 130 dB re 1 $µPa^2$ (SPL_{peak}), and application of VHF cetacean (harbour porpoise) frequency weighting indicated noise levels of < 120 dB re 1 $µPa^2$ ($SPL_{rms,}$ VHF frequency-weighted). These results illustrate no potential for instantaneous PTS-onset from the USBL source tested, and the potential for behavioural disturbance within a limited spatial extent (i.e. a few hundred metres).

4.3 Assessment of potential for auditory injury

While there is potential for USBL to be operated at a theoretical source level which exceeds the minimum threshold for instantaneous injury in a relevant marine mammal species (harbour porpoise; 202 dB) by up to 4 dB, such noise levels are unlikely to be realised. As illustrated by Appendix 1, noise levels from the USBL are expected to rapidly attenuate with distance from source to drop below 200 dB within 10 m or less of the source, even when assuming an omnidirectional source.

Considering these indicative estimates of noise propagation, in combination with the limited open water measurements described above (**Section 4.2**) and the low anticipated densities of marine mammals in the survey area, the risk of injury to any EPS or seals from operation of the USBL is assessed as negligible.

Therefore, it is proposed that an EPS licence for injury is not required for either offshore waters or inshore waters.

4.4 Assessment of potential for behavioural disturbance

The central operating frequencies of the USBL are such that there is potential for disturbance effects to occur through use of USBL to all relevant EPS and seals, although it is noted that the frequency overlap with minke whale hearing is likely to be limited.

There are currently no empirical data available on the behavioural responses of marine mammals to USBL usage specifically. However, as illustrated in **Appendix 1** and evidence presented in **Section 4.2**, the noise emitted from the USBL will be rapidly attenuated with distance from source. Considering the characteristics of the noise emitted, the risk of disturbance is considered to be less than that of several geophysical survey sources (often accompanied by USBL) which operate at higher source levels and lower frequencies (therefore propagating more widely), such as sparkers, boomers, and some other sub-bottom profilers (SBPs). 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.*"

Therefore, considering the nature of the USBL source, disturbance is likely to be of a very localised spatial extent which is unlikely to extend much beyond that of temporary avoidance associated with the concurrent presence of the survey vessel(s). For example, support and supply vessels of 50-100 m (which encompasses the indicative survey vessels of 70-80 m length) are expected to have broadband source levels in the range 165-180 dB re 1µPa, with the majority of energy below 1 kHz (OSPAR 2009). When using use of thrusters for DP to hold station during sampling activities, increased sound generation in the order of c. 10 dB over levels when in transit may be expected (Rutenko and Ushchipovskii, 2015). Therefore, the noise generated by the survey vessel while holding station on DP is likely to be approaching a similar amplitude to that of the USBL system, albeit with dominant energy at lower frequencies.

While there is no agreed noise threshold level for behavioural disturbance to marine mammals currently in use in the UK, the threshold of 160 dB re 1µPa (SPL_{rms}) as used by the US National Marine Fisheries Service for 'Level B harassment' from impulsive sound provides one option for assessing the potential extent of

behavioural disturbance arising from USBL use. Based on the simple noise propagation calculations provided in **Appendix 1**, a noise level of 160 dB would be expected to occur to a distance of approximately between 500 m and 1,000 m. Therefore, a precautionary disturbance radius of 1,000 m can be used to provide an estimate of the number of individual EPS which may be disturbed at any one time by the USBL activities.

It is also noted that while the planned surveys will take place within a period of approximately 3.5 months, the total duration of activities involving USBL are expected to be 50 days. Within these, the period of active USBL use is expected to be an average of 3.5 hours per CPT/vibrocore station (up to 189 stations). Consequently, disturbance will be short-term, temporary, and transient as the survey vessel moves between stations.

4.4.1 Estimated number of animals to be disturbed across the entire survey area

The USBL will be detectable to all species of EPS and seal, and so may elicit behavioural responses such as avoidance. However, considering the evidence discussed above, this is likely to be short-term, temporary and of a spatial extent unlikely to exceed a few hundred metres of the source. While survey activities will take place over several weeks, disturbance will be short-term and transient as activities move between different sampling locations in the area, temporarily affecting no more than a few animals at any one time. Example numbers of animals which may be disturbed by the activities for a precautionary disturbance range of 1 km are provided in **Table 4.1**; for all species, the number of individuals which may be disturbed are ≤ 2, representing < 0.01% of the relevant management unit for each species.

Table 4.1. Estimated numbers of EPS disturbed and proportion of the management unit for a nominal precautionary disturbance range of 1 km from USBL operation.

Species	Density (animals per km^2) - see Table 3.1	Estimated number disturbed [% relevant MU] in a 1 km disturbance radius
Bottlenose dolphin†	0	0
Harbour porpoise	0.599	2 [<0.01]
Minke whale	0.042	< 1 [<0.01]
White-beaked dolphin	0.080	1 [<0.01]

Notes: † Bottlenose dolphin are only likely to be present within coastal waters generally of 20 m water depth or less, and therefore are not expected to be present within the survey area in offshore waters. The minimum distance between the mainland 20 m depth contour and the survey area is approximately 9 km.

It is acknowledged that there is uncertainty over the range of disturbance effects which may occur from the survey activities, and that activities are planned to occur at a number of locations throughout the survey area. As a highly conservative measure of the total number of individuals of EPS which could potentially be

disturbed throughout the survey campaign, the OWF array area (391 km^2), plus the ECC including a 1 km buffer (193 km^2) (a total combined area of 584 km^2) has been combined with cetacean density estimates and MU sizes (**Table 3.1**) to estimate the total number of animals which may experience disturbance at some point during the survey activities (**Table 4.2**). A 1 km buffer has not been applied to the OWF array area as sampling is only expected to occur within a subset of this. For all species, the proportion of the corresponding MU is ≤ 0.12%.

Table 4.2. Estimated numbers of animals disturbed and proportion of the management unit assuming all animals within the survey area (OWF array area, and ECC plus 1 km buffer) (total 584 km^2) are disturbed at some point over the duration of survey activities.

Species	Density (animals per km^2) - see Table 3.1	Estimated number disturbed	Proportion of MU (%)
Bottlenose dolphin†	0	0	0
Harbour porpoise	0.599	350	0.10
Minke whale	0.042	25	0.12
White-beaked dolphin	0.080	47	0.11

Notes: † Bottlenose dolphin are only likely to be present within coastal waters generally of 20 m water depth or less, and therefore are not expected to be present within the survey area. The minimum distance between the mainland 20 m depth contour and the survey area is approximately 9 km.

The values in **Table 4.2** are highly conservative in that they likely over-estimate the number of animals which will be disturbed – for example, by over-estimating the extent over which disturbance effects may occur, assuming that all animals within this area will be disturbed, and by not accounting for a potential temporarily reduced local density of animals (particularly harbour porpoise) in response to survey vessel presence.

Seals lie outside EPS permitting and are considered in relation to protected sites in **Section 6**.

Conclusion

The approach to estimating the total number of animals which may be disturbed at some point over the duration of the survey activities is very precautionary as it likely over-estimates the number of animals which may be disturbed. Disturbance will be a localised avoidance of the source, likely affecting only a few individuals at any one time and for a short period. Such effects would not be likely to impair the ability of an animal to survive or reproduce and, for all species, the number of animals which may be disturbed are not significant from a population perspective. **Therefore, it is proposed that an EPS licence is not required for disturbance within offshore waters.**

4.4.1 Extent of potential disturbance – Scottish inshore waters (<12 nm)

Notwithstanding that disturbance effects are predicted to be limited in extent, some disturbance of EPS within inshore waters 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 and are considered in relation to protected sites in **Section 6**). It has been conservatively assumed that over the course of the benthic survey campaign, all cetaceans in the inshore portion of the surveyed area could potentially be disturbed at some point. The total surveyed area over which disturbance is estimated to take place within Scottish inshore waters is 147 km^2.

This inshore portion of the survey area is combined with the cetacean density estimates to provide a precautionary estimate of the number of animals for European Protected Species that might potentially be disturbed over the duration of a survey campaign .

Table 4.3. Estimated numbers of animals disturbed and proportion of the management unit assuming all animals within the survey area lying within Scottish inshore waters (ECC plus 1 km buffer, total 147 km^2) are disturbed at some point over the duration of survey activities.

Species	Density (animals per km^2) - see Table 3.1	Estimated number disturbed	Proportion of MU (%)
Bottlenose dolphin†	0	0	0
Harbour porpoise	0.599	88	0.03
Minke whale	0.042	6	0.03
White-beaked dolphin	0.080	12	0.03

Notes: † Bottlenose dolphin are only likely to be present within coastal waters generally of 20 m water depth or less, and therefore are not expected to be present within the survey area. The minimum distance between the mainland 20 m depth contour and the survey area is approximately 9 km.

This approach is considered to be precautionary as it over-estimates the area over which disturbance may occur. It is noted that the disturbance effects will be temporary and localised to a transient source, such that the number of animals disturbed by a single survey vessel/source at any one time will be very low; for example, based on the average anticipated density of harbour porpoise in the survey area (the highest density species), approximately 1-2 individuals might occur within a 1 km radius of the survey source at any one time (**Table 4.1**).

Less common species

For other cetacean species, those potentially occurring, but unlikely to be present, are short-beaked common dolphin; white-sided dolphin; Risso's dolphin; killer whale; sperm whale; long-finned pilot whale; fin whale; humpback whale (Marine Scotland, 2014). A range of additional species, as listed in Marine Scotland (2020) EPS Guidance, may occur very rarely or as vagrants. It is probable that no individuals of these species will be present in the vicinity of the survey and therefore subject to disturbance; however, should they be present

and be disturbed by the planned survey activities, the number of animals present and nature of the disturbance would not be considered significant. It is conservatively estimated that up to 10 individuals of less common species (total for all species) could be disturbed over the course of the survey.

4.5 Consideration of cumulative effects

Other noise-generating activities may be occurring in the Seagreen area concurrent to (or in close temporal proximity to) the planned survey activities:

- OWF site and primary ECC: Outstanding construction activities scheduled for 2024 (IAC rock protection placement), potential geophysical surveys and ROV inspection as part of routine for operations and maintenance activities (see risk assessment - LF000009-CST-OF-LIC-REP-0016, submitted October 2023).

Appropriate mitigation will be in place to reduce the risk of injury from these other activities, where applicable. While these activities may result in disturbance to individuals of EPS in the Seagreen area, in all cases the associated risk assessments concluded that disturbance effects would comprise temporary displacement of animals representing a very low proportion of the corresponding MUs, and that there would be no population-level effects or impacts on the favourable conservation status of EPS. Consequently, significant cumulative effects from other activities at the Seagreen site are not anticipated.

There is also the potential for the planned survey to overlap temporally with noise-generating activities at other offshore developments in the wider region, such as ongoing construction activity at Neart na Gaoithe OWF. However, the predicted extent of disturbance effects from the planned geotechnical survey activities is considerably less than those predicted for other elements of the Seagreen Project, such as pile-driving of OSP and WTG foundations, and a detailed assessment of the potential for cumulative disturbance effects from pile driving activities across multiple offshore developments (including Neart na Gaoithe, Inch Cape, Aberdeen Harbour Expansion Project, Moray East and Moray West) in the 2018 EIAR concluded no significant cumulative impact of disturbance for any marine mammal species.

4.1 Assessment of potential impact on favourable conservation status

Considering the numbers of animals which are predicted to be disturbed, the nature of the disturbance (i.e. temporary avoidance), and the spatial and temporal extent over which activities will occur, it is concluded that the planned survey activities will not result in impacts which might damage the status of any EPS in the long-term, either alone or in-combination with other relevant activities, and therefore there will be no impact on the favourable conservation status of any EPS.

5. Mitigation Measures

Marine Scotland (2020) guidance states that mitigation measures should be put in place whenever there is concern that an activity is likely to cause an offence and should be proportionate to the risk of injury or disturbance. Considering that this assessment has concluded a negligible risk of an injury offence to all species of marine mammals, mitigation measures are not considered necessary to further reduce the risk of

injury. Specifically, the planned surveys will not implement measures specified in the JNCC (2017) guidelines for minimising the risk of injury to marine mammals from geophysical surveys.

To minimise the potential for disturbance, the USBL equipment will be operated at the lowest practicable sound levels and over the shortest period of time to achieve the survey objectives. Additionally, survey vessel crew will be briefed on the Scottish Marine Wildlife Watching Code in relation to vessel operations in the vicinity of marine mammals, especially during transit to/from the survey area.

6. Protected sites

6.1 Special Areas of Conservation

Under the *Conservation (Natural Habitats, &c.) Regulations 1994* (the 'Habitats Regulations'), all competent authorities must consider whether any plan or project, either alone or in combination with other plans or proposal, will have a 'likely significant effect' on a European site (including SACs and SPAs). If so, they must carry out carry out an 'appropriate assessment' (AA) to determine if the planned activities will have an adverse effect on site integrity, in terms of its conservation objectives. The conservation objectives relate to the long-term maintenance of the quality of the site such that it continues to make an appropriate contribution to the qualifying features achieving or maintaining a favourable conservation status. This process is known as Habitats Regulations Appraisal (HRA)[4]. Here, information is provided to assist the competent authority (Marine Scotland) and their advisors (NatureScot) in undertaking HRA of the proposed survey activities.

A number of SACs supporting certain marine mammal species that are potentially sensitive to underwater noise were identified during the 2012 ES (Seagreen, 2012) and these remained unchanged in the 2018 EIAR (Seagreen, 2018a); these sites are detailed in **Table 6.1**.

Table 6.1 Special Areas of Conservation considered in EPS Risk Assessment

SAC	Site Features of relevance to this risk assessment	Minimum distance to planned survey area
Isle of May	Annex II species: Grey Seal	3.3 km
Berwickshire and North Northumberland Coast	Annex II species: Grey seal	27 km
Firth of Tay and Eden Estuary	Annex II species: Harbour seal	26 km
Moray Firth	Annex II species: Bottlenose Dolphin	~ 200 km (26 km to coastal 20 m depth contour)

[4] Further information is available at: https://www.nature.scot/professional-advice/planning-and-development/environmental-assessment/habitats-regulations-appraisal-hra

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). The planned survey area is approximately 26 km from the Firth of Tay and Eden Estuary SAC, designated for breeding harbour seal; however, habitat preference models predict low occurrence of harbour seals within the survey area (see **Section 3**).

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[5]. Habitat preference models predict low to moderate densities of grey seals in the survey area during the main foraging season, with this area supporting lower numbers of animals than coastal waters and offshore waters to the south. Grey seals present in the planned survey area may include individuals associated with the Isle of May SAC (3.3 km distant), Berwickshire and North Northumberland Coast SAC (27 km distant), along with more distant colony SACs in the North Sea and other sites in the adjacent Forth and Tay region. Higher densities of seals area expected to occur in and adjacent to the ECC part of the survey area which lies within a few kilometres of the Isle of May SAC, designated for breeding grey seal; however, the timing of the planned survey (mid-January to end April) is outside of the breeding season (Oct-Dec) when animals are present in particularly high densities around the island.

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). In this region, the population is understood to be strictly coastal with most animals encountered in waters less than 20 m deep and within 2 km from the coastline. Therefore, bottlenose dolphins associated with the Moray Firth SAC are no expected to be present in the survey area.

6.1.1 Previous relevant HRAs

In 2015, an Appropriate Assessment (Marine Scotland, 2015) concluded that the Forth and Tay Developments, either alone or in-combination, will not adversely affect the integrity of relevant marine mammals SACs, including the Isle of May SAC, the Berwickshire & North Northumberland Coast SAC, Firth of Tay and Eden Estuary SAC and Moray Firth SAC, subject to compliance with relevant conditions[6]. A Habitats Regulations Appraisal within the 2018 EIA Report for the optimised design reached the same conclusion (Seagreen, 2018b). It is also noted that an Appropriate Assessment accompanied the application to construct the Seagreen 1A export cable, including an assessment of the potential for geophysical survey activities (using louder noise soures than USBL) to cause disturbance to grey and harbour seal features of the Isle of May SAC and Firth of Tay and Eden Estuary SAC, respectively. For both sites, the assessment concluded that significant

[5] NatureScot advice received on previous EPS applications for the Seagreen site is that grey seals tend to stay within 20 km of breeding colonies during the breeding season.

[6] Conditions are listed from page 58 of https://marine.gov.scot/sites/default/files/appropriate_assessment_1.pdf

disturbance was unlikely due to the short-term localised nature of the geophysical survey activities (Marine Scotland, 2021).

6.2 Designated seal haul-outs

It is also noted that under Section 117 of the *Marine (Scotland) Act 2010*, it is an offence to harass seals at haul-out sites in Scotland designated under *The Protection of Seals (Designated Sea Haul-out Sites) (Scotland) Order 2014*. However, considering the location of the planned activities relative to the nearest designated haul-out site (> 15 km), there is no potential for harassment of seals at designated haul-out sites.

7. References

Ainslie, M. A., and J. G. McColm. 1998. A simplified formula for viscous and chemical absorption in sea water. The Journal of the Acoustical Society of America 103(3):1671-1672. doi: 10.1121/1.421258

Arso Civil, M., N. Quick, B. Cheney, E. Pirotta, P. Thompson, and P. Hammond. 2019. Changing distribution of the east coast of Scotland bottlenose dolphin population and the challenges of area-based management. Aquatic Conservation Marine and Freshwater Ecosystems. 29(S1):178-196.

Carter, M. I. D., L. Boehme, M. A. Cronin, C. D. Duck, W. J. Grecian, G. D. Hastie, M. Jessopp, J. Matthiopoulos, B. J. McConnell, D. L. Miller, C. D. Morris, S. E. W. Moss, D. Thompson, P. M. Thompson, and D. J. F. Russell. 2022. Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management. Frontiers in Marine Science 9doi: 10.3389/fmars.2022.875869

Cheney, B., P. M. Thompson, S. N. Ingram, P. S. Hammond, P. T. Stevick, J. W. Durban, R. M. Culloch, S. H. Elwen, L. Mandleberg, V. M. Janik, N. J. Quick, V. Islas-Villanueva, K. P. Robinson, M. Costa, S. M. Eisfeld, A. Walters, C. Phillips, C. R. Weir, P. G. Evans, P. Anderwald, R. J. Reid, J. B. Reid, and B. Wilson. 2013. Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins Tursiops truncatus in Scottish waters. Mammal Review 43(1):71-88.

Hartley Anderson Ltd. 2020. Underwater acoustic surveys: review of source characteristics, impacts on marine species, current regulatory framework and recommendations for potential management options., NRW Evidence Report No: 448, 119pp, NRW, Bangor, UK.

Jiménez-Arranz, G., N. Banda, S. Cook, and R. Wyatt. 2020. Review on Existing Data on Underwater Sounds Produced by the Oil and Gas Industry., Report prepared by Seiche Ltd for the Joint Industry Programme on E&P Sound and Marine Life.

JNCC. 2017. JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys.

JNCC, NE, and CCW. 2010. The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area.

Jones, E. L., B. J. McConnell, S. Smout, P. S. Hammond, C. D. Duck, C. D. Morris, D. Thompson, D. J. Russell, C. Vincent, and M. Cronin. 2015. Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. Marine Ecology Progress Series 534:235-249.

Marine Scotland. 2014. The protection of Marine European Protected Species from injury and disturbance. Guidance for Scottish Inshore Waters.

Marine Scotland. 2015. Appropriate Assessment: Marine Scotland's Consideration of a Proposal Affecting Designated Special Areas of Conservation ("SACs") or Special Protection Areas ("SPAs"), Marine Scotland Licensing and Operations Team, Scottish Government.

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

Marine Scotland. 2021. Marine Scotland - Licensing Operations Team's Assessment of the Project's Implications for Designated Special Areas of Conservation and Special Protection Areas in view of the Site's Conservation Objectives. Seagreen 1A Export Cable.

Pace, F., C. Robinson, C. E. Lumsden, and S. B. Martin. 2021. Underwater Sound Sources Characterisation Study: Energy Island, Denmark. Document 02539, Version 2.1. Technical report by JASCO Applied Sciences for Fugro Netherlands Marine B.V.:152.

Quick, N. J., M. Arso Civil, B. Cheney, V. Islas, V. Janik, P. M. Thompson, and P. S. Hammond. 2014. The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC, This document was produced as part of the UK Department of Energy and Climate Change's offshore energy Strategic Environmental Assessment programme.

Russell, D. J. F., B. McConnell, D. Thompson, C. Duck, C. Morris, J. Harwood, and J. Matthiopoulos. 2013. Uncovering the links between foraging and breeding regions in a highly mobile mammal. Journal of Applied Ecology 50(2):499-509.

Rutenko, A. N., and V. G. Ushchipovskii. 2015. Estimates of acoustic noise generated by supply vessels working with oil-drilling platforms. Acoustical Physics 61(5):556-563. doi: 10.1134/s1063771015040107

Seagreen. 2012. Environmental Statement Volume I.

Seagreen. 2018a. Seagreen Alpha and Bravo - EIA Report Volume 1, Chapter 10 Marine Mammals, Seagreen Wind Energy Ltd, 103pp.

Seagreen. 2018b. Seagreen Alpha and Bravo - EIA Report Volume 1, Chapter 16: Habitats Regulations Appraisal, Seagreen Wind Energy Ltd, 103pp.

Southall, B., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. Nowacek, and P. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45(2):125-232. doi: 10.1578/AM.45.2.2019.125

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

In the table overleaf (**Table 8.1**), some simple calculations are provided, to illustrate how simple geometric spreading and absorption loss may influence single pulse sound pressure levels (SPLs) from USBL equipment to a horizontal distance of up to 1 km from the source. No information is provided on the more complex calculation of sound energy levels (SEL), either from single pulses of frequency-weighted cumulative exposure levels.

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 these factors, and so should not be used to quantify the potential impact range for 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 conservative in terms of horizontal propagation, particularly where the USBL system shows directionality (as may be the case in the planned surveys) and the transponder is positioned beneath the transceiver on the vessel (as will be the case in the planned surveys).

Nonetheless, by applying a commonly-used geometric spreading law of $15\log R$ (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 sound pressure levels reduce within a few hundred metres of the source, and the relative influence of source level and signal frequency.

Table 8.1 Illustration of approximate estimated reduction in noise levels within 1 km of source for different indicative USBL systems (source levels and minimum operating frequencies)

		Equipment / source		
		USBL	**USBL**	**USBL**
Assumed source sound pressure level (dB re 1 µPa @ 1m)		194	202	206
Assumed frequency of signal (kHz) for absorption loss [1]		19	19	20
Assumed absorption loss (dB/km) [2]		3.31	3.31	3.63
Assumed geometric spreading law [3]		15log*R*	15log*R*	15log*R*
Estimated sound pressure levels at distance from source (dB re 1 µPa)	10 m	179	187	191
	50 m	168	176	180
	100 m	164	172	176
	250 m	157	165	169
	500 m	152	160	164
	1,000 m	146	154	157

Notes: 1 The assumed frequency is taken as the lowest of the range of values provided for each source; 2 Absorption loss calculated following Ainslie & McColm (1998) and assuming seawater at zero metres depth and a precautionary temperature of 8 degrees (see http://resource.npl.co.uk/acoustics/techguides/seaabsorption/); 3 For all calculations, a geometric spreading loss factor of 15logR is used; this is intermediate to spherical (20logR) and cylindrical (10logR) spreading loss often used for waters depths deeper than and shallower than R, respectively Richardson (1995), and a value of 15logR was reported from open water noise level measurements of USBL to a distance of 2 km by Pace et al. (2021).