Department for
Business, Energy
& Industrial Strategy

# RECORD OF THE HABITATS REGULATIONS ASSESSMENT UNDERTAKEN UNDER REGULATION 5 OF THE OFFSHORE PETROLEUM ACTIVITIES (CONSERVATION of HABITATS) REGULATIONS 2001 (As Amended).

***Multi-Client Geophysical Regional Deep Imaging Seismic Survey 2021***

***Issued June 2021***
**Rev 2.0**

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# 1 INTRODUCTION

1.1 This is a record of the Habitats Regulations Assessment (HRA) undertaken by the Department for Business Energy and Industrial Strategy (BEIS) in respect of a planned seismic survey to be undertaken by Multiclient Geophysical, Filial Av Geoex Ltd (Hereafter referred to as GEOEX).

1.2 This HRA covers a planned 2D seismic survey off the east coast of England and Scotland in Quadrants 19, 20, 21, 22, 23, 26, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 39, 41, 42 and 43.

1.3 An application to undertake a Marine Survey was submitted to BEIS on 17 March 2021. GS/1199/0 (Version 1) and was supported by an environmental assessment (GEOEX 2021a).

1.4 BEIS is the competent authority for applications submitted under the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (S.I. 2001/1754) (As Amended) (referred to as the Offshore Habitats Regulations).

1.5 BEIS recognises that there is potential for activities to impact on sites designated under the European Habitats 92/43/EC and Birds Directives 209/147 EC. Consequently, as the competent authority, BEIS has undertaken an assessment to determine whether the potential impacts from the proposed seismic survey as identified in the application may cause likely significant or adverse effects to the qualifying features of designated sites and thereby affect the integrity of the sites.

1.6 As part of the assessment, potential in-combination impacts from future plans or projects within the designated sites have been assessed to determine whether there is potential for likely significant or adverse effects on the integrity of the sites. The in-combination assessment may include potential future activities that are not the subject of any currently submitted projects or plans. By doing so it does not pre-empt the requirement to undertake HRA when future licence applications are submitted. It does not pre-determine any decision regarding future programmes or projects. However, where possible, it does provide a strategic overview of potential in-combination impacts from forecast activities.

1.7 This document presents the finding of the assessment undertaken by BEIS.

### *Habitats Regulations Assessment*

1.8 Council Directive 92/43/EC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) and Council Directive 2009/147/EC on the conservation of wild birds (the Birds Directive) aim to ensure the long-term survival of certain habitats and species by protecting them from the adverse effects of plans and projects.

1.9 The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended) transposed the Directives into UK law for activities consented under the Petroleum Act 1998.

The Offshore Petroleum Activities (Conservation of Habitats) (Amendment) Regulations 2007 extended certain provisions of the 2001 regulations.

1.10 Regulation 5(1) of the 2001 Regulations provides that: *The Secretary of State shall, before granting any Petroleum Act licence, any consent, any authorisation, or any approval, where he considers that anything that might be done or any activity which might be carried on pursuant to such a licence, consent, authorisation or approval is likely to have a significant effect on a relevant site, whether individually or in-combination with any other plan or project, including but not limited to any other relevant project, make an appropriate assessment of the implications for the site in view of the site's conservation objectives*.

1.11 The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 make changes to three statutory instruments including the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (the Offshore Habitats Regulations), which is relevant to this assessment. The 2019 regulations ensure that the protection provided under the existing regulations, including the 2001 regulations remain as they were prior to the UK's exit of the EU. This includes the continued protection of designated sites along with their qualifying features and the requirement for a competent authority to undertake an assessment of any plans or projects that could impact on the sites or their features.

1.12 The Conservation of Habitats and Species Regulations 2017 (as amended) and The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) provide for the designation of sites for the protection of habitats and species of national importance; these sites are called Special Areas of Conservation (SACs). For the protection of birds, these sites are called Special Protection Areas (SPAs). Collectively, all existing and future SACs and SPAs form a national site network[1].

1.13 Possible SACs (pSACs), candidate SACs (cSACs) and potential SPAs (pSPAs) are afforded the same levels of protection by the UK Government as sites that have already been designated. Sites designated under the Ramsar Convention are also afforded the same level of protection as a designated site.

1.14 Any plan or project, which either alone or in-combination with other plans or projects would be likely to have a significant effect on a qualifying site must be subject to an Appropriate Assessment to determine the implications for a site's integrity and conservation objectives. Such a plan or project may only be agreed after ascertaining that it will not adversely affect the integrity of a European/National Site unless there are imperative reasons of overriding public interest for carrying out the plan or project.

[1] Prior to 1 January 2021 national sites were referred to as European sites.

# 2 SURVEY DESCRIPTION

2.1 The following is a summary of the proposed GEOEX seismic survey, further details may be found within the application (GEOEX 2021a,EPI 2021).

2.2 The proposed survey that is subject to this HRA is Phase II of a wider regional survey to be undertaken across the North Sea[2]. The planned Phase II of the survey is located within UKCS Blocks:

- 19/ 7, 9, 13, 17, 18, 22, 24, 26, 30
- 20/ 6, 9, 22, 24, 27, 30
- 21/ 6, 11, 14, 16, 22, 23, 28
- 22/ 6, 8, 11, 13, 26
- 23/ 6, 11, 16, 21, 26
- 26/ 1, 5, 11, 15, 16, 25, 27, 28
- 27/ 1, 3, 5
- 28/ 1, 4, 6, 21, 25, 26
- 29/ 1, 18, 21, 24, 26
- 30/ 1, 6, 11, 16, 26
- 31/ 21, 26
- 34/ 2, 8, 13, 19, 24, 25, 30
- 35/ 1, 6, 9, 11, 15, 16, 17, 28
- 36/ 1, 2, 6, 20, 22, 26, 28
- 37/ 1, 12, 14, 16, 17, 29
- 38/ 1, 18, 21, 26
- 39/ 1, 3, 6, 11
- 41/ 1, 8, 10, 14, 15
- 42/ 1, 9, 10, 12, 16
- 43/ 1, 2, 6, 7

2.3 The whole of the Phase I and Phase survey Greater Working Area in UK waters covers an area of 237,501 km2 with a total length of survey line of 6,235 km (Figure 1). Phase II of the survey encompasses a Greater Working Area of 84,705 km (Figure 2) (EPI 2021, GEOEX 2021a).

[2] Note Phase I of the survey was subject to a separate application and a separate HRA assessment (GEOEX 2021b).

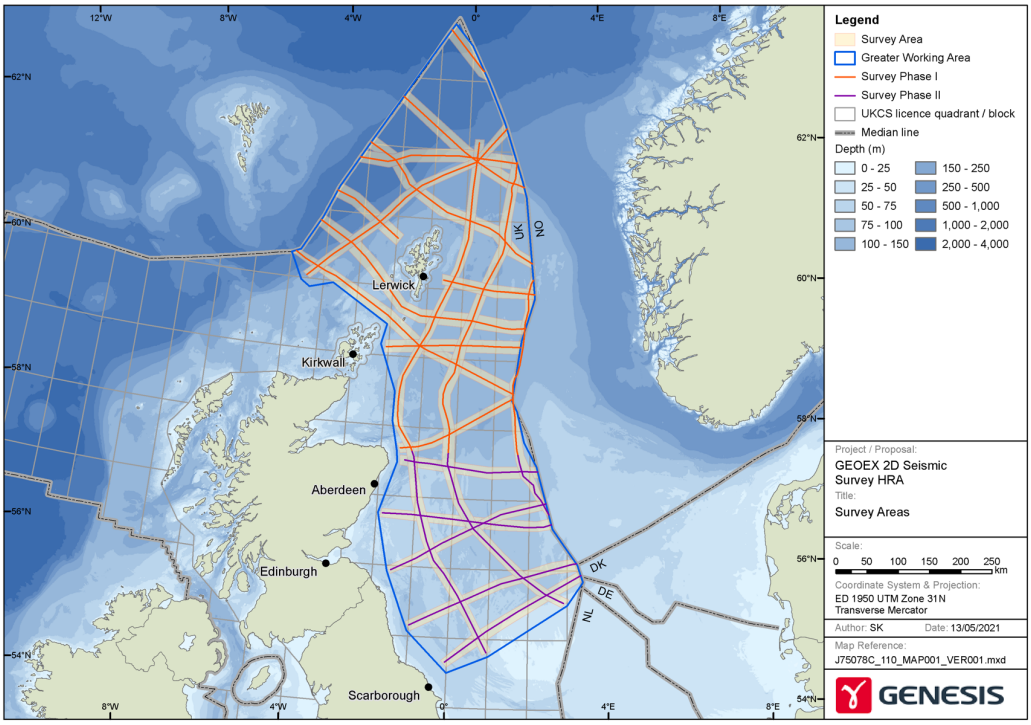



**Figure 1: Location of the proposed Phase I and Phase II GEOEX 2D seismic showing Greater Working Area and survey lines.**

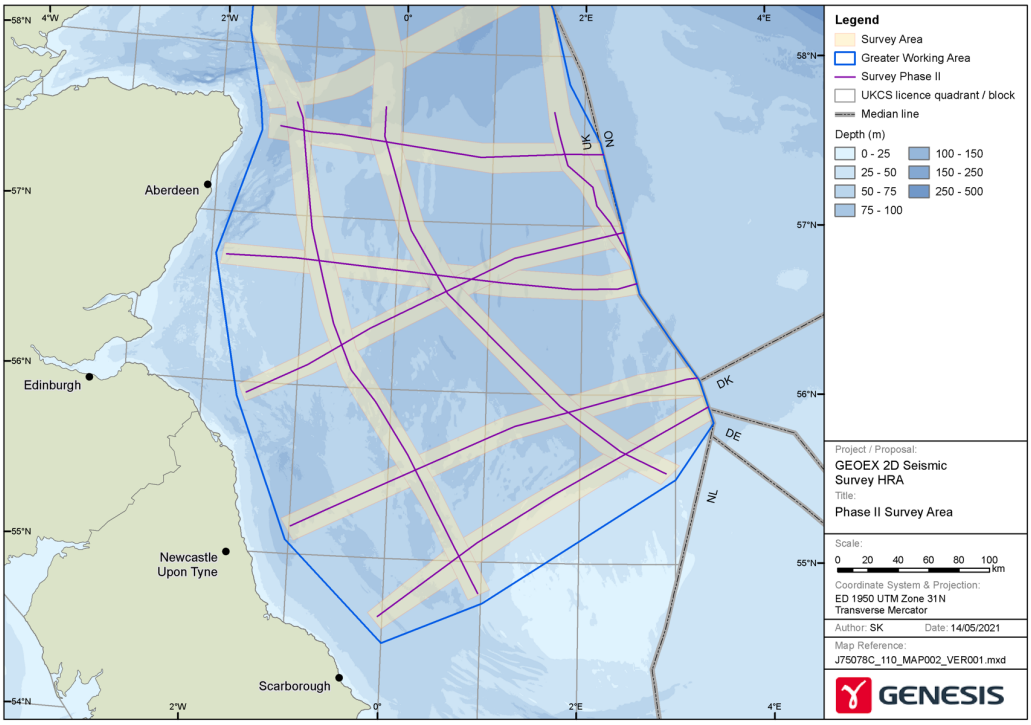



**Figure 2: Location of the proposed Phase II GEOEX 2D seismic showing Greater Working Area and survey lines.**

2.4 Phase II of the survey is scheduled to take place no sooner than 10 June 2021 and be completed no later than 30 September 2021. The duration of the actual survey is anticipated to last 21 days (EPI 2021, GEOEX 2021a).

2.5 The proposed survey will be undertaken by a seismic survey vessel (*M/V Akademik Lazarev*) towing a single 12,000 m streamer at an average depth of 17 metres and at a speed of between 4.5 knots (8.3 km/h) and 5 knots (9.3 km/h) (EPI 2021, GEOEX 2021a). The total volume of the single airgun to be operated will be 6,270 cu. in. and be fired at intervals of every 15 seconds.

2.6 The Greater Working Area for Phase II is 84,705 km$^2$, although the Survey Area (the area within which airguns will be operating) is considerably smaller and comprises of eight survey lines (Figure 2 and Figure 3)(GEOEX 2021a). A summary of the proposed survey specifications is presented in Table 1.

2.7 The airguns will be switched off at the end of each survey line and prior to the commencement of using any airguns a 'soft-start' will be undertaken as per the JNCC guidance (JNCC 2017a).

2.8 The specifications for the seismic array, as presented in the application, are presented in Table 2.

**Table 1: Phase II survey parameters.**

| Survey Parameter | Application |
|---|---|
| Start date and End date | 10 June – 30 September 2021 |
| Total duration of survey (days) | 21 |
| Greater Working Area (km$^2$) | 84,705 |
| No. of survey lines | 8 |
| No. of survey turns | 7 |
| Longest survey line (km) | 350 (line 1540) |
| Length of line in SAC (km) | 64 km |
| Longest single survey line in SAC (km) | 56.1 km |

1 – excludes the Greater Working Area where no airguns will be operated

**Table 2: Proposed seismic array parameters (Source: GEOEX 2021a).**

| Array Parameter | Array Option |
|---|---|
| Total volume (cu. In). | 6,270 |
| Sound pressure - dB re 1 µPa (0-p) | 260 |
| Sound exposure level - dB re 1 µPa$^2$s | 238 |
| Pulse rate (Seconds) | 15 |
| Towed depth (m) | 15 - 30 |
| Vessel speed (knots) | 4.5 - 5 |

# 3 DESIGNATED SITES

3.1 The proposed seismic survey is being undertaken in waters within or adjacent to several European designated sites and it is recognised that potential impacts that could cause a likely significant effect could occur to a number of qualifying species both within and out with designated sites.

3.2 The applicant has identified two SACs (Southern North Sea SAC and Berwickshire and North Northumberland Coast SAC), that have qualifying features that could be impacted by the proposed Phase II of the survey.

3.3 This assessment has considered a broad range of designated sites on the basis of them having qualifying features that could be impacted by the proposed survey (Figure 3). This includes SPAs for which there are breeding seabirds that could occur within the Greater Working Area. It does not include features that will not be impacted, i.e. physical features such as sand banks and biogenic reefs,

3.4 Based on the information presented within the application, including the results from the noise modelling undertaken in support of the application, sites identified as having qualifying features that could be impacted by the proposed survey and their distance from the nearest survey line are presented in Table 3 and Table 4.

3.5 Table 5 identifies the SPAs for which there is potential for qualifying species to occur within the survey area based on the mean maximum foraging range of breeding seabirds (Woodward *et al*. 2019). Sites that are designated for birds that are very unlikely to be impacted, e.g. waterfowl and Ramsar designated sites are not included.

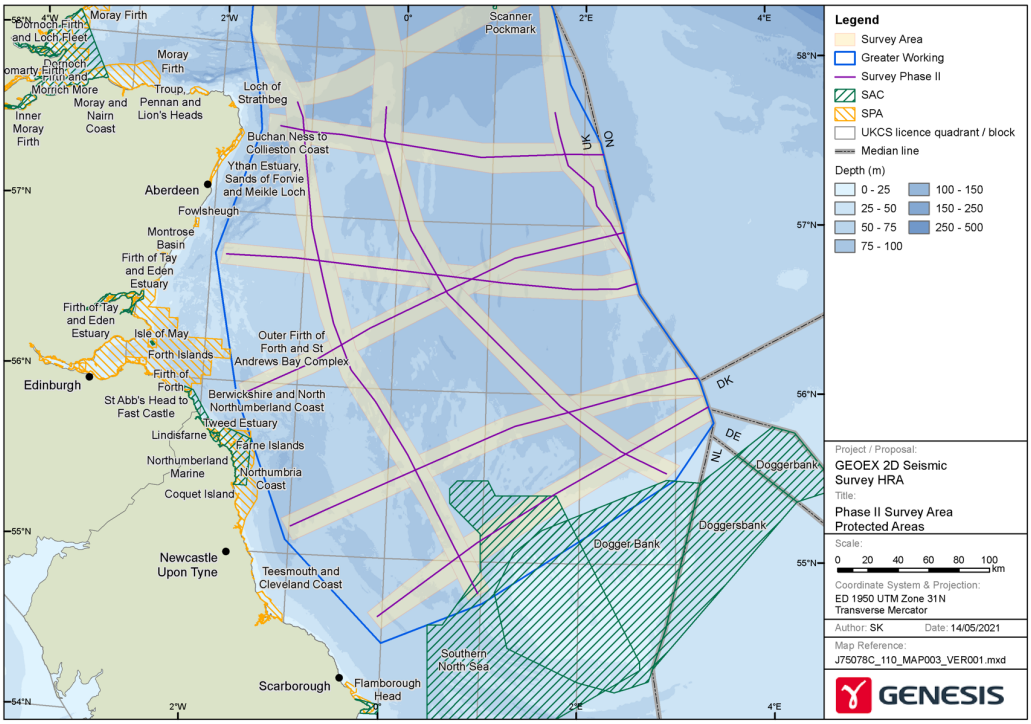



**Figure 3: Location of proposed GEOEX survey and relevant designated sites.**

**Table 3: SAC designated sites and their qualifying features that were identified as having potential to be impacted by the proposed survey.**

| Designated site | Distance from closest survey line (km) | Qualifying features |
|---|---|---|
| Southern North Sea SAC | 0 | Harbour porpoise. |
| Doggersbank SAC (Dutch sector) | 23.1 | Harbour porpoise, Grey seal, Harbour seal. |
| Berwickshire and North Northumberland Coast SAC | 26.5 | Grey seal. |
| Tweed Estuary SAC | 34.4 | Sea lamprey, River lamprey |
| Dogger Bank SAC (German sector) | 36.6 | Harbour porpoise, Harbour seal. |
| Firth of Tay and Eden Estuary SAC | 59.7 | Harbour seal. |
| Isle of May SAC | 68.1 | Grey seal. |
| Humber Estuary SAC | 101.0 | Grey seal, Sea lamprey, River lamprey. |
| Moray Firth SAC | 117.9 | Bottlenose dolphin |

**Table 4: SPA and Ramsar designated sites and their qualifying features that were identified as having potential to be impacted by the proposed survey.**

| Designated site | Distance from closest survey line (km) | Qualifying features |
|---|---|---|
| Buchan Ness to Collieston Coast SPA | 24.5 | Fulmar, Herring gull, Kittiwake, Shag Guillemot, Seabird assemblage. |
| Outer Firth of Forth and St Andrews Bay Complex SPA | 24.6 | Arctic tern, Black-headed gull, Common gull, Common scoter, Common tern, Eider, Gannet , Goldeneye, Guillemot, Herring gull, Kittiwake, Little gull, Long-tailed duck, Manx shearwater, Puffin, Razorbill, Red-breasted merganser, Red-throated diver, Shag, Slavonian grebe, Velvet scoter. |
| Northumberland Marine SPA | 25.5 | Arctic tern, Common tern, Little tern, Roseate tern, Sandwich tern, Guillemot, Puffin, plus seabird assemblage. |
| Fowlsheugh SPA | 25.7 | Fulmar, Herring gull, Kittiwake, Guillemot, Razorbill, seabird assemblage. |
| Northumbria Coast SPA / Ramsar | 31.2 | Little Tern, Arctic Tern, Purple Sandpiper, Turnstone. |
| Ythan Estuary, Sands of Forvie and Meikle Loch SPA / Ramsar | 31.7 | Common Tern, Little Tern, Sandwich Tern, Redshank, Lapwing, Eider, Pink-footed Goose. |
| Loch of Strathbeg SPA / Ramsar | 31.8 | Sandwich tern, pink-footed goose, greylag goose, Barnacle goose, Whooper swan, Teal. |
| Lindisfarne SPA / Ramsar | 32.0 | Little tern, Roseate Tern, Pink-footed Goose, Golden Plover, Bar-tailed Godwit, Greylag Goose, Light-bellied Brent Goose, Wigeon, Whooper Swan, Knot, Redshank, Shelduck, Eider, Common Scoter, Ringed Plover, Lapwing, Dunlin, Grey Plover. |
| Farne Islands SPA | 32.3 | Kittiwake, Shag, Cormorant, Puffin, Guillemot, Arctic Tern, Common Tern, Roseate Tern, Sandwich Tern. |
| St Abb's Head to Fast Castle SPA | 36.3 | Herring gull, Kittiwake, Guillemot, Razorbill, Shag, seabird assemblage. |
| Coquet Island SPA | 39.7 | Black-headed Gull, Puffin, Arctic Tern, Common Tern, Roseate Tern, Sandwich Tern, Fulmar, Lesser Black-backed Gull, Herring Gull, Kittiwake. |
| Teesmouth and Cleveland Coast SPA | 46.7 | Little tern, Sandwich tern |
| Flamborough and Filey Coast SPA | 47.4 | Gannet, Kittiwake, Herring gull, Puffin, Razorbill and Guillemot, plus seabird assemblage. |
| Troup, Pennan and Lion's Heads SPA | 52.2 | Razorbill, Kittiwake, Herring Gull, Fulmar, Guillemot. |
| Firth of Tay and Eden Estuary SPA / Ramsar | 60.7 | Little tern, Marsh Harrier, Velvet Scoter, Pink-footed Goose, Greylag Goose, Redshank, Cormorant, Shelduck, Eider, Bar-tailed Godwit, Common Scoter, Black-tailed Godwit, Goldeneye, Red-breasted Merganser, Goosander, Oystercatcher, Grey Plover, Sanderling, Dunlin, Long-tailed duck. |
| Firth of Forth SPA / Ramsar | 62.1 | Sandwich tern, Scaup, Slavonian Grebe, Golden Plover, Bar-tailed Godwit, Pink-footed Goose, Shelduck, Knot, Redshank, |

| Designated site | Distance from closest survey line (km) | Qualifying features |
|---|---|---|
| | | Turnstone, Great Crested Grebe, Cormorant, Red-throated Diver, Mallard, Curlew, Eider, Long-tailed duck, Common Scoter, Velvet Scoter, Goldeneye, Red-breasted Merganser, Oystercatcher, Ringed Plover, Grey Plover, Lapwing, Dunlin, Wigeon. |
| Forth Islands SPA | 66.1 | Arctic tern, Common tern, Cormorant, Fulmar, Gannet, Guillemot, Herring gull, Kittiwake, Lesser black-backed gull, Puffin, Razorbill, Roseate tern, Sandwich tern, Shag and Seabird assemblage. |
| Greater Wash SPA | 71.1 | Sandwich tern, Little tern, Common tern, Red-throated diver, Little gull, Common scoter. |
| Inner Moray Firth SPA | 83.9 | Common Tern, Osprey, Scaup, Curlew, Oystercatcher, Goosander, Goldeneye, Teal, Wigeon, Cormorant, Redshank, Red-breasted Merganser, Greylag Goose, Bar-tailed Godwit. |

**Table 5: Mean maximum foraging ranges of breeding seabirds relevant to the HRA**

| Species | Mean maximum foraging range (km) | SPA |
|---|---|---|
| Fulmar | 542.3 ± 657.9 | Buchan Ness to Collieston Coast,<br>Coquet Island,<br>Forth Islands,<br>Fowlsheugh,<br>Troup, Pennan and Lion's Heads, |
| Manx shearwater | 1,346.8 ± 1,018.7 | Outer Firth of Forth and St Andrews Bay Complex |
| Gannet | 315.2 ± 194.2 3 | Flamborough and Filey Coast,<br>Forth Islands,<br>Outer Firth of Forth and St Andrews Bay Complex, |
| Shag | 13.2 ± 10.5 | Buchan Ness to Collieston Coast,<br>Farne Islands,<br>Forth Islands,<br>Outer Firth of Forth and St Andrews Bay Complex,<br>St Abb's Head to Fast Castle, |
| Cormorant | 25.6 ± 8.3 | Farne Islands,<br>Forth Islands, |
| Little gull | n/a | Greater Wash,<br>Outer Firth of Forth and St Andrews Bay Complex, |
| Kittiwake | 156.1 ±144.5 | Buchan Ness to Collieston Coast,<br>Coquet Island,<br>Farne Islands,<br>Flamborough and Filey Coast,<br>Forth Islands,<br>Fowlsheugh,<br>Outer Firth of Forth and St Andrews Bay Complex,<br>St Abb's Head to Fast Castle,<br>Troup, Pennan and Lion's Heads, |
| Black-headed gull | 18.5 | Coquet Island,<br>Outer Firth of Forth and St Andrews Bay Complex, |
| Common gull | 50 | Outer Firth of Forth and St Andrews Bay Complex, |

| Species | Mean maximum foraging range (km) | SPA |
|---|---|---|
| Herring gull | 61.1 ± 44 | Buchan Ness to Collieston Coast,<br>Coquet Island,<br>Flamborough and Filey Coast,<br>Forth Islands,<br>Fowlsheugh,<br>Outer Firth of Forth and St Andrews Bay Complex,<br>St Abb's Head to Fast Castle,<br>Troup, Pennan and Lion's Heads, |
| Lesser black-backed gull | 127 ± 109 | Coquet Island,<br>Forth Islands, |
| Little tern | 5 | Firth of Tay and Eden Estuary,<br>Greater Wash,<br>Lindisfarne,<br>Northumberland Marine,<br>Northumbria Coast,<br>Teesmouth and Cleveland Coast,<br>Ythan Estuary, Sands of Forvie and Meikle Loch, |
| Roseate tern | 12.6 ± 10.6 | Coquet Island,<br>Farne Islands,<br>Forth Islands,<br>Lindisfarne,<br>Northumberland Marine, |
| Common tern | 18.0 ± 8.9 | Coquet Island,<br>Farne Islands,<br>Forth Islands,<br>Greater Wash,<br>Inner Moray Firth,<br>Northumberland Marine,<br>Outer Firth of Forth and St Andrews Bay Complex,<br>Teesmouth and Cleveland Coast,<br>Ythan Estuary, Sands of Forvie and Meikle Loch, |
| Arctic tern | 25.7 ± 14.8 | Coquet Island,<br>Farne Islands,<br>Forth Islands,<br>Northumbria Coast,<br>Northumberland Marine<br>Outer Firth of Forth and St Andrews Bay Complex, |
| Sandwich tern | 34.3 ± 23.2 | Coquet Island,<br>Farne Islands,<br>Firth of Forth,<br>Forth Islands,<br>Greater Wash,<br>Loch of Strathbeg,<br>Northumberland Marine,<br>Teesmouth and Cleveland Coast,<br>Ythan Estuary, Sands of Forvie and Meikle Loch, |
| Puffin | 137.1 ± 128.3 | Coquet Island,<br>Farne Islands,<br>Flamborough and Filey Coast,<br>Forth Islands,<br>Northumberland Marine,<br>Outer Firth of Forth and St Andrews Bay Complex, |
| Razorbill | 88.7 ± 75.9 | Flamborough and Filey Coast,<br>Forth Islands,<br>Fowlsheugh,<br>Outer Firth of Forth and St Andrews Bay Complex,<br>St Abb's Head to Fast Castle,<br>Troup, Pennan and Lion's Heads, |
| Guillemot | 73.2 ± 80.5 | Buchan Ness to Collieston Coast, |

| Species | Mean maximum foraging range (km) | SPA |
|---|---|---|
| | | Farne Islands,<br>Flamborough and Filey Coast,<br>Forth Islands,<br>Fowlsheugh,<br>Northumberland Marine,<br>Outer Firth of Forth and St Andrews Bay Complex,<br>St Abb's Head to Fast Castle,<br>Troup, Pennan and Lion's Heads, |

3.6 Based on the likelihood of the species being present in the area of potential impact, the qualifying sites and species identified as being relevant to this HRA are:

- Southern North Sea SAC (Harbour porpoise),
- Humber Estuary SAC (Grey seal, Sea lamprey, River lamprey),
- Berwickshire and North Northumberland Coast SAC (Grey seal),
- Doggersbank SAC – Dutch sector (Harbour porpoise, Grey seal, Harbour seal),
- Isle of May SAC (Grey seal),
- Moray Firth SAC (Bottlenose dolphin),
- Flamborough and Filey Coast SPA (Gannet, Kittiwake, Herring gull, Puffin, Razorbill and Guillemot, plus seabird assemblage),
- Northumberland Marine SPA (Arctic tern, Sandwich tern, Guillemot, Puffin, plus seabird assemblage).
- Buchan Ness to Collieston Coast SPA (Fulmar, Herring gull, Kittiwake, Shag, Guillemot, Seabird assemblage).
- Outer Firth of Forth and St Andrews Bay Complex SPA (Arctic tern, Common tern, Gannet, Guillemot, Herring gull, Kittiwake, Little gull, Manx shearwater, Puffin, Razorbill, Shag).
- Fowlsheugh SPA (Fulmar, Herring gull, Kittiwake, Guillemot, Razorbill, seabird assemblage).
- Northumbria Coast SPA / Ramsar (Arctic tern),,
- Ythan Estuary, Sands of Forvie and Meikle Loch SPA / Ramsar (Sandwich tern),
- Loch of Strathbeg SPA (Sandwich tern),
- Farne Islands SPA (Kittiwake, Puffin, Guillemot, Sandwich Tern),
- St Abb's Head to Fast Castle SPA (Herring gull, Kittiwake, Guillemot, Razorbill, Shag, Seabird assemblage),

- Coquet Island SPA (Puffin, Fulmar, Lesser Black-backed Gull, Herring Gull, Kittiwake),
- Flamborough and Filey Coast SPA (Gannet, Kittiwake, Herring gull, Puffin, Razorbill and Guillemot, plus seabird assemblage)
- Troup, Pennan and Lion's Heads SPA (Razorbill, Kittiwake, Herring Gull, Fulmar, Guillemot),
- Forth Islands SPA (Fulmar, Gannet, Guillemot, Kittiwake, Lesser black-backed gull, Puffin, Razorbill, and Seabird assemblage).

3.7 For all other species and habitats it is concluded that there are either no direct or indirect impact pathways to the qualifying feature or that the species are unlikely to be present in areas where there is potential for any impact.

### *Qualifying features*

3.8 Based on the information presented within the application it has been determined that the HRA should consider alone and in-combination the potential direct and indirect impacts on:

- Harbour porpoise,
- Bottlenose dolphin,
- Grey seal,
- Harbour seal,
- Seabirds (Fulmar, Manx shearwater, Gannet, Shag, Kittiwake, Herring gull, Lesser black-backed gull, Arctic tern, Common tern, Sandwich tern Puffin, Razorbill and Guillemot),
- Sea lamprey and River lamprey,
- Fish (prey) species.

#### *Harbour porpoise*

3.9 The harbour porpoise (*phocoena phocoena*) is a qualifying species for the:

- Southern North Sea SAC,
- Doggersbank SAC.

3.10 The harbour porpoise is the smallest and most abundant cetacean species in UK waters. They occur widely across shelf waters predominantly either individually or in small groups. Larger aggregations have been reported (Defra 2015), with group sizes varying with season (Clark 2005). Harbour porpoise have a very broad distribution occurring predominantly over the continental shelf. Higher densities occur in areas of up-wellings and strong tidal currents and in water depths of predominantly between 20 and 40 m (Clark 2005, Whaley 2004). Their

distribution may also be strongly correlated with seabed type, with areas of sandy gravel being preferred and this may be linked to prey availability (Clark 2005).

3.11 Harbour porpoise occur widely across the North Sea. Data from the three Small Cetacean Abundance in the North Sea (SCANS) surveys indicate that that there may have been a southward shift in the distribution of harbour porpoise in the North Sea. In the early 1990's harbour porpoise were widespread but appear to have occurred predominantly around eastern Scotland and the northern North Sea to the southern North Sea (Figure 4) (Hammond *et al*. 2013). Since the 1990's harbour porpoise continue to be widespread across the North Sea but densities have increased in the southern and central North Sea. The cause of this apparent change in the distribution of harbour porpoises across the North Sea is unclear but may be related to changes in prey availability (IAMMWG *et al.* 2015).

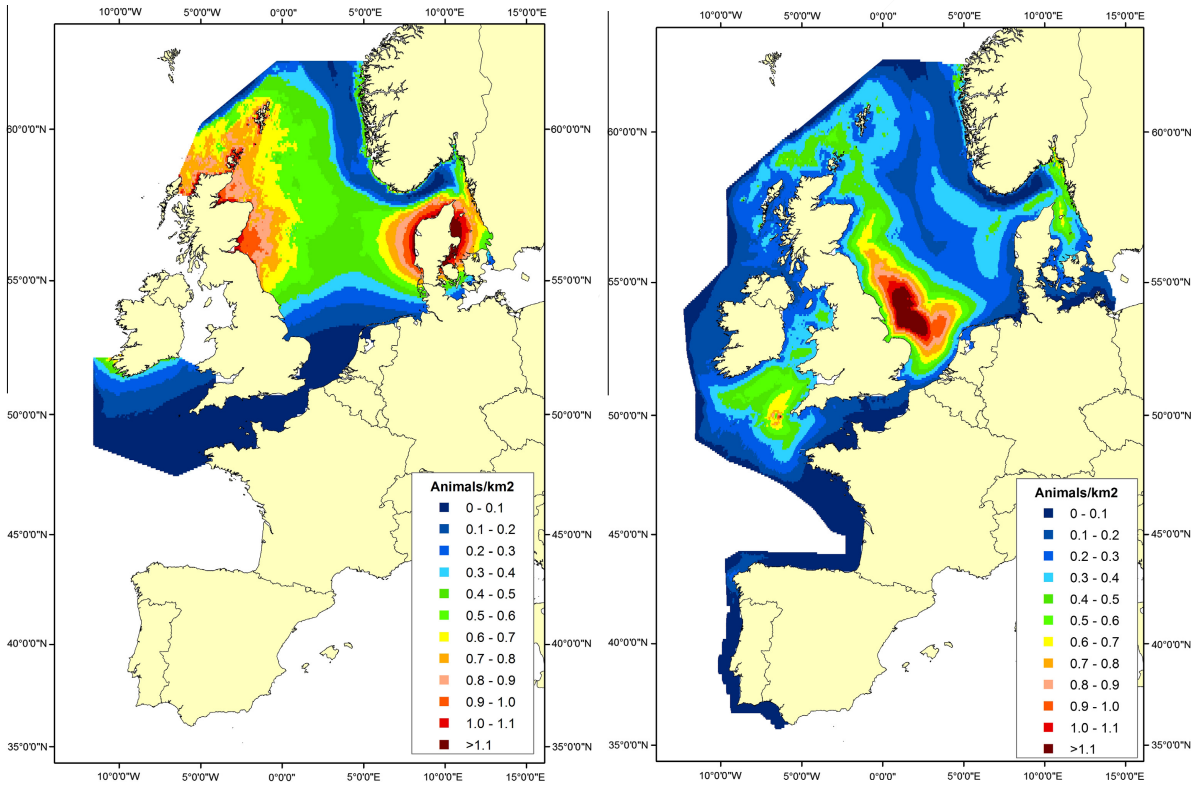



Figure a. Figure b.

**Figure 4: a) Predicted surface density for harbour porpoise in 1994. b) Predicted surface density for harbour porpoise in 2005 (Source Hammond *et al.* 2013).**

3.12 Following the completion of the most recent SCANS survey (SCANS III), the latest estimated harbour porpoise populations within the whole of the SCANS survey area is 424,245 (CV 313,151 – 596,827). Since 1994 the population of harbour porpoises within the SCANS surveyed area has remained relatively stable (Hammond *et al*. 1995, Hammond 2006, Hammond *et al.* 2017).

3.13 There are three Management Units identified for harbour porpoise in the north-east Atlantic, of which, the Southern North Sea SAC and the Doggersbank SAC lie within the North Sea Management Unit. The harbour porpoise population within the North Sea Management Unit was originally estimated to be 227,298 (176,360 – 292,948) individuals (IAMMWG 2015). However, following the revision of the regional SCANS harbour porpoise population, the population of harbour porpoise within the North Sea Management Unit has also been revised and is now estimated to be 333,808 individuals (JNCC 2017b).

3.14 The SAC selection assessment document estimates that the site holds 18,500 harbour porpoise (98% C.I. 11,864 – 28,899) (JNCC 2017c, 2019a), which was 8.1% of the North Sea Management Unit population at the time the estimate was made (Hammond *et al*. 2013, IAMMWG 2015). Based on the latest North Sea Management Unit population of 308,666 individuals, the harbour porpoise population within the SAC may be 26,237 individuals. This estimated population of harbour porpoise is recognised to have been derived from data collected in 2005 and 2016 during a single month and that the harbour porpoise population within the SAC will vary across seasons and years. The population estimated from the Joint Cetacean Protocol (JCP), where abundance and distribution data from multiple sources collected over a period of time have been integrated, is 333,808 individuals (JNCC 2017b). This population estimate has been used for the purposes of this assessment.

3.15 Harbour porpoise densities vary seasonally and across the Southern North Sea SAC (Evans and Teilmann 2009). Site-specific surveys undertaken by wind farm developers have shown considerable variation in the spatial and temporal distribution of harbour porpoises across years (e.g. Forewind 2013, SMart Wind 2017). Typically, peak abundance has been reported to occur between May and July at sites across the Dogger Bank area and between September and April at sites further south (e.g. Forewind 2014, SMart Wind 2015, EAOWL 2015). Lowest reported abundance across nearly all wind farm sites occurs between November and February, although the poorer survey conditions that occur predominantly during the winter months may be a contributing factor in the lower number of harbour porpoise recorded during this period.

3.16 Densities of harbour porpoise within the Doggersbank SAC also vary seasonally with highest reported densities of 1.029 ind./km$^2$ recorded during March and lower densities of 0.396 ind./km$^2$ and 0.391 ind./km$^2$ recorded in July and October respectively (Geelhoed *et al*. 2013).

3.17 Based on data in the JCP database, highest densities in the central and northern area of the SAC occur during the summer period with modelled harbour porpoise densities greater than 3.0 per km$^2$ occurring widely (Figure 5a). During the winter period the distribution of harbour porpoise in the southern North Sea changes, with reduced densities over the central and northern area but an increase in densities in nearshore waters and the southern part of the SAC (Figure 5b) (Heinänen and Skov 2015). A winter survey undertaken across the Central North Sea in

November 2011 reported an average density across the whole surveyed area of 0.63 ind./km$^2$ (Cucknell *et al*. 2016).

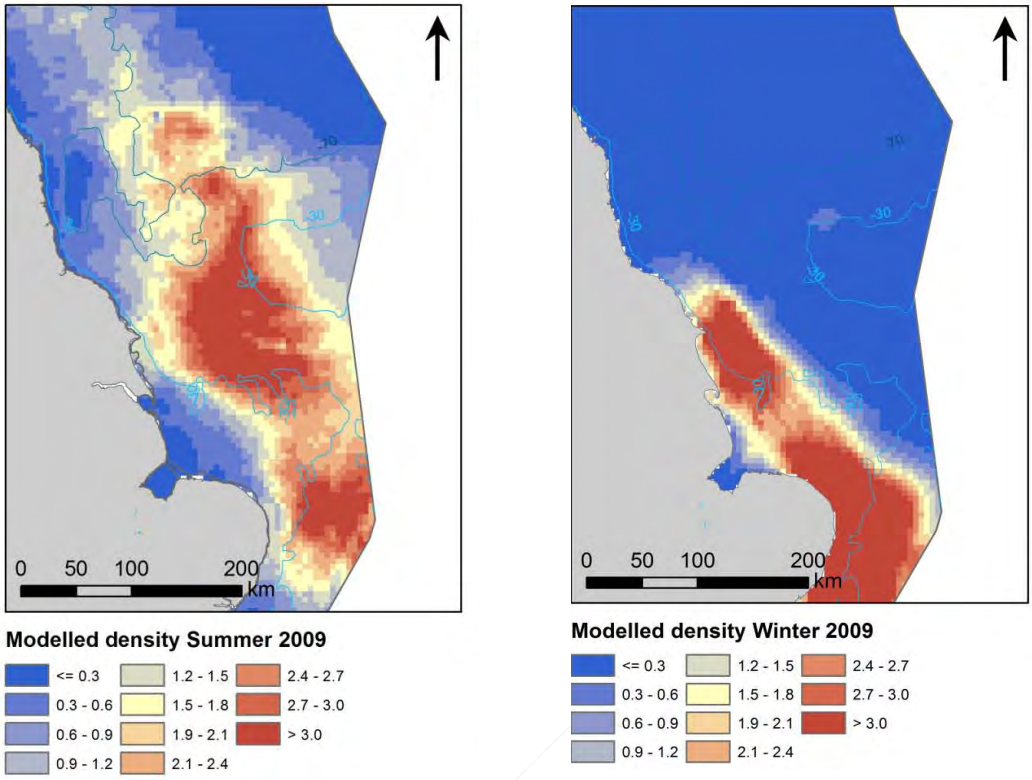



Figure a. Figure b.

**Figure 5: a) Estimated summer densities of harbour porpoise in the southern North Sea. b) Estimated winter densities of harbour porpoise in the southern North Sea. (Source: Heinänen and Skov 2015).**

3.18 Surveys undertaken across the southern North Sea, including areas within and encompassing the SAC, have reported lower densities of harbour porpoise than modelled estimates. Densities reported from SCANS III surveys are from between 0.888 ind./km$^2$ in SCANS block O and 0.607 ind./km$^2$ in SCANS block L (Hammond *et al.* 2017). Similarly, data obtained across the Dogger Bank area including the Southern North Sea SAC and the Doggersbank SAC, in 2011 recorded a density of 1.88 ind./km$^2$ (Gilles *et al.* 2012). Data obtained from surveys undertaken at proposed offshore wind farms located within or adjacent to the SAC indicate densities vary across the site and across seasons. Mean densities reported from surveys undertaken by offshore wind farm developers range from 0.11 ind./km$^2$ at Triton Knoll offshore wind farm including a 1 km buffer to 2.87 ind./km$^2$ within the Hornsea subzone 3 wind farm area plus a 4 km buffer (TKOWFL 2011, SMart Wind 2017).

3.19 Tagging studies undertaken in Denmark indicate that harbour porpoises are highly mobile and range widely in the North Sea, with individuals tagged in the Skagerrak travelling up to 100 km

per day, with a mean distance of 24.5 km per day. Individuals tagged in Danish waters were recorded off the east coasts of England and Scotland (Sveegaard 2011).

3.20 Harbour porpoise swimming speeds vary with the highest recorded swimming speeds being 4.3 m/s (Otani *et al.* 2000). Mean recorded speeds are typically around 1 m/s (Otani *et al.* 2000, Kastelein *et al.* 2018). When disturbed by noise harbour porpoise can increase swimming speeds with increasing sound levels. Studies using playback experiments of pile-driving sounds have reported increases in swimming speed from an average of 1.2 m/s to 2.0 m/s at sound levels of 154 dB re 1 µPa that were sustained for at least 30 minutes (Kastelein *et al*. 2018).

3.21 Although harbour porpoises may dive to depths of up to 226 m and remain submerged for up to five minutes, they more frequently undertake relatively shallow dives of a short duration, with a mean depth of 14 m and duration of 44 seconds (Santos and Pierce 2003, Otani *et al*. 1998, 2000). Studies undertaken on 14 tagged harbour porpoise in Danish and adjacent waters reported that on average harbour porpoise spend 55% of the time in the upper 2 m of the surface waters. The most frequent dive depths were between 14 m and 32 m, with the maximum depth dived of 132 m. The number of dives per hour increased from an average of 29 dives $hr^{-1}$ between April and August to 43 dives $hr^{-1}$ in October and November when it was presumed that higher levels of foraging activity occurred to compensate for the higher energy requirements required during the cooler winter period (Teilmann *et al*. 2007).

3.22 Harbour porpoise use echolocation to detect and track individual prey and are opportunistic feeders, foraging close to the seabed or near the sea surface, preying on a wide range of fish species including, herring (*Clupea harengus*), whiting (*Merlandius merlangus*), Gadoids spp. sprats (*Sprattus sprattus*), gobi (*Pomatoschistus minutus*) and sandeels (*Ammodytes* spp.), and their prey will vary during and between seasons (DeRuiter 2008, Santos and Pierce 2003, IAMMWG *et al.* 2015). The prey of harbour porpoise may change over time with a reported long-term shift in prey from clupeid species to sandeels and gadoid species (IAMMWG *et al*. 2015), indicating that harbour porpoise may be opportunistic feeders capable of feeding on a variety of species.

3.23 Studies undertaken in Denmark indicate that their local distribution may be correlated with prey availability (Sveegaard 2011). Due to the relatively high metabolic rate of harbour porpoise and the relatively small size of their predominant prey it has been suggested that harbour porpoise require a reliable source of food and frequent food consumption in order to maintain their body weight, with increased consumption in cooler environments (Kastelein *et al*. 1997, Wisniewska *et al*. 2016, 2018).

3.24 Harbour porpoise have a maximum life expectancy of 24 years, with an average life expectancy of around 12 years in UK waters (Lockyer 2003, Learmouth *et al.* 2014). Females become sexually mature at between three and five years old (Lockyer 2003, Learmouth *et al*. 2014).

Breeding is thought to occur primarily during the summer months between May and September, particularly in August, with calving 10 months later. Calves are nursed for eight to ten months but may remain with the mother until a new calf is born (Defra 2015, Lockyer 2003, Weir *et al*. 2007).

3.25 The range at which marine mammals, including harbour porpoise, may be able to detect sound arising from offshore activities depends on the hearing ability of the species and the frequency of the sound. Other factors that can affect the potential impact include ambient background noise, which can vary depending on water depth, seabed topography and sediment type. Natural conditions such as weather and sea state and existing sources of human produced sound can also reduce the auditory range.

3.26 Porpoises are generally considered to be 'high frequency' or 'very high frequency' specialists with a relatively poor ability to detect lower frequency sounds (Southall *et al.* 2007, 2019). Studies undertaken on captive harbour porpoises indicate that porpoises have a functional hearing range of between 250 Hz and 180 kHz with their best hearing between 16 to 140 kHz and their maximum sensitivity between 100 and 140 kHz. It is within the frequency range of 130 to 140 kHz that harbour porpoise echolocate (Miller and Wahlberg 2013).

3.27 Their ability to detect sound below 16 kHz or above 140 kHz falls sharply (Kastelein *et al.* 2012, 2015, Southall *et al*. 2007). Harbour porpoise are therefore most sensitive to sound sources between 16 to 140 kHz and, although potentially audible, they are unlikely to be sensitive to sound either above or below those frequencies.

3.28 Harbour porpoise use echolocation to communicate and detect prey. Reported sound levels produced range from between 166 to 194 re. 1 µPa (rms SPL) and 178 and 205 dB re. 1 µPa (peak – peak SPL), with a mean level of 191 dB re. 1 µPa (peak – peak SPL) and within the peak frequency range of 110 to 150 kHz (Villadsgaard, *et al*. 2007, Miller and Wahlberg 2013, MMO 2015).

### *Bottlenose dolphin*

3.29 The bottlenose dolphin is a qualifying species for the:

- Moray Firth SAC.

3.30 The proposed survey is outwith the boundary of the SAC but bottlenose dolphins from the Moray Firth SAC occur widely in coastal waters along the east coast of Scotland and north-east England throughout the year (Arso Civil *et al.* 2019; Brereton *et al*. 2010, 2013; Quick *et al*. 2014).

3.31 Nearly all sightings of bottlenose dolphin occur within 2 km of the coast and in water depths of less than 20 m (Brereton *et al*. 2010; Quick *et al.* 2014; Thompson and Brookes 2011). The species is rarely recorded in offshore waters in the North Sea (e.g. Reid *et al*. 2003, Macleod and Sparling 2011).

3.32 The estimated population of bottlenose dolphins in the Moray Firth and the east coast of Scotland is 209 individuals (95% CI 189 - 230), of which around 52% of the population occur within the St Andrews Bay and Tay Estuary (Arso Civil *et al.* 2019). Photo-identification studies undertaken off north-east England indicate that approximately 25% of the Moray Firth bottlenose dolphin population also occur in this region (Aynsley 2017).

3.33 Although bottlenose dolphin can occur in any of the coastal waters adjacent to the proposed survey they are not distributed equally within the coastal strip, with main areas of their distribution occurring in the Moray Firth, Aberdeen Bay, Firth of Tay and, to a lesser extent, off the north-east coast of England (Arso Civil *et al.* 2019).

3.34 In the Moray Firth bottlenose dolphin densities have been estimated to be of 0.26 ind./km$^2$ in coastal waters and 0.066 ind. / km$^2$ for the wider Firth area (Thompson 2011; Thompson and Brookes 2011). In the Firth of Tay area densities of between 0.28 and 0.35 ind. / km$^2$ have been estimated. However, it is recognised that the density of 0.35 ind. / km$^2$ estimated for the Firth of Tay is unrealistically high (Quick and Cheyney 2011). The only other estimated densities of bottlenose dolphins in the area of the proposed survey are derived from the SCANS III surveys that covered a wider area of offshore waters. Estimated densities from the SCANS III surveys in the Greater Working Area are 0.03 ind./km$^2$ in SCANS block R (off the east coast of Scotland and north-east England) and no bottlenose dolphins were recorded in SCANS Block O (off the east coast of England) (Hammond *et al*. 2017). However, these densities relate to estimates derived from a single, largely offshore survey, where the population is significantly lower and is reported as effectively zero in the greater North Sea (IAMMWG 2015).

3.35 Sound arising from the proposed seismic survey has the potential to significantly affect bottlenose dolphins due to permanent or temporary physical hearing damage and or displacement and disturbance. The proposed survey is outwith the Moray Firth SAC but sound arising from the airguns could occur in areas where there is the potential for bottlenose dolphins from this SAC to be present.

3.36 The main prey items for bottlenose dolphins in the Moray Firth have been reported to be cod, saithe and whiting with some salmon, haddock and cephalopods (Santos *et al*. 2001).

3.37 The survey could therefore affect bottlenose dolphins or their prey within and outwith the Moray Firth SAC.

### *Grey seal*

3.38 The grey seal (*Halichoerus grypus*) is an Annex II qualifying species for the:

- Humber Estuary SAC,
- Isle of May SAC,
- Berwickshire and North Northumberland Coast SAC,
- Doggersbank SAC.

3.39 Grey seals occur widely around the waters off eastern England and Scotland with most activity in the nearshore waters. Relatively higher densities occur to the south of the Humber Estuary, off Berwick upon Tweed and in the Firth of Tay and North-east Scotland.

3.40 The latest counts within the Humber Estuary SAC recorded 6,288 grey seals, giving an estimated population of 24,271[3] (SCOS 2019). The latest count for the Berwickshire and North Northumberland Coast SAC is 6,427 individuals (SCOS 2019) and therefore an estimated population of 24,808 individuals. The east coast of Scotland grey seal population, which includes those from the Isle of May SAC, is estimated to be 14,216 individuals (Morris *et al*. 2021).

3.41 Their distribution offshore comprises predominantly of short-range return trips from haul-out sites to local foraging areas (Figure 6). However, longer movements between distant haul-out sites also regularly occur. Foraging trips from haul-out sites usually last between one and thirty days with most trips within 100 km of the haul out site, although they can go further and individuals often make repeated trips to the same region offshore (SMRU 2004, SCOS 2015, Russell 2017). Tagging study data indicates that grey seals from Donna Nook forage across a broad area and are not restricted to localised patches and their distribution has changed since 2005 with more regular foraging now occurring further offshore (SCOS 2016, Russell 2017). Similar tracking studies undertaken on grey seals from the Isle of May SAC and the Berwickshire and Northumberland Coast SAC show that grey seals from these sites could occur within the proposed survey area (Sparling *et. al.* 2011). Offshore, grey seals prefer shallower waters in areas of increasing sand and decreasing levels of gravel (Jones *et al*. 2015, Russell 2017).

3.42 Densities of grey seals across the area vary, with highest densities located to the south of the survey and nearer shore. Within the Greater Working Area densities are predominantly relatively low and are less than 2.0 ind/km$^2$ (Figure 6). Densities of grey seals recorded at the Dogger Bank offshore wind farms (Creyke Beck A and B, Teesside A and B), across which part of the the proposed survey will be undertaken, reported highest peak density of 0.93 ind./km$^2$ at Creyke Beck A, with peak densities across the wind farm zone as a whole of 0.25 ind./km$^2$ (Forewind 2013).

[3] As not all grey seals are at haul-out sites at the same time the counted population is adjusted using a scalar multiplier of 3.86 to provide an estimated population (Morris *et al.* 2021).

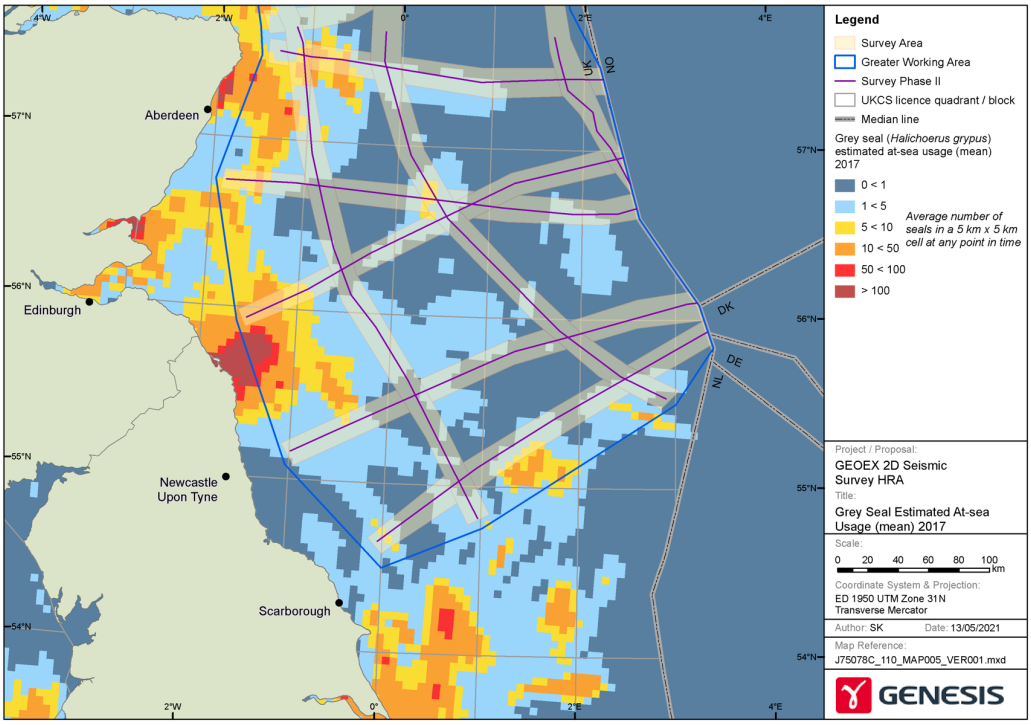



**Figure 6: Distribution of grey seals in waters off Eastern England and Scotland.**

3.43 Grey seals breed in the region between late October and December when they will spend a greater proportion of time onshore compared with other times of year. Following pupping the females will remain onshore for approximately two weeks (SCOS 2015). Grey seals moult between December and April during which time they spend a greater proportion of their time at their haul out sites (SCOS 2015). Grey seals forage on a range of fish species with sandeels, gadoids, flatfish and cephalopods being dominant prey items (SMRU 2011, Pierce *et al.* 1991).

3.44 Sound arising from the proposed seismic survey has the potential to significantly affect grey seals due to permanent or temporary physical hearing damage and or displacement and disturbance. Consequently, the proposed survey could affect grey seals or their prey outwith designated sites.

### *Harbour seal*

3.45 The harbour seal (*Phoca vitulina*) is an Annex II qualifying species for the:

- Doggersbank SAC,

3.46 Harbour seals occur widely around the waters off eastern England and in Dutch waters with most activity in the nearshore waters (Figure 7 and Figure 8). Harbour seals occur in sheltered bays, inlets and enclosed estuaries and foraging trips are not as extensive as those of grey seals, remaining largely in nearshore waters. Breeding in the region takes place between June and

July and pups are nursed for a few weeks. During this period harbour seals will remain predominantly within nearshore waters.

3.47 Tracking studies undertaken on harbour seals in the UK indicate that they occur primarily in nearshore waters but can travel up to between 50 km and 100 km offshore Figure 7. Tracking of 229 harbour seals in Dutch waters between 2007 and 2015 showed that nearly all movements were within 100 km of the coast and between April and October over 90% of movements were less than 60 km (Figure 8). Longer movements offshore occurred primarily between December and March (Aarts *et al*. 2016). Similarly, in Danish waters, between May and August nearly all harbour seals are close to their breeding sites with adults in particular remaining in the proximity of their breeding sites throughout the year. Non-adult harbour seals have been shown to range more widely, particularly between December and April (Dietz *et al*. 2013).

3.48 Harbour seals are opportunistic feeders preying on a wide range of fish species including sandeels, gadoids, flatfish, scorpion fish, sandy benthic fish, pelagic fish and cephalopods (SCOS 2015).

3.49 Tracking studies of harbour seals from both the UK and the Netherlands indicate that harbour seals do not occur regularly within the Greater Working Area. However, the Doggersbank SAC is located 23.1 km from the nearest survey line and noise from the seismic survey could therefore impact on harbour seals, or their prey, within the SAC.

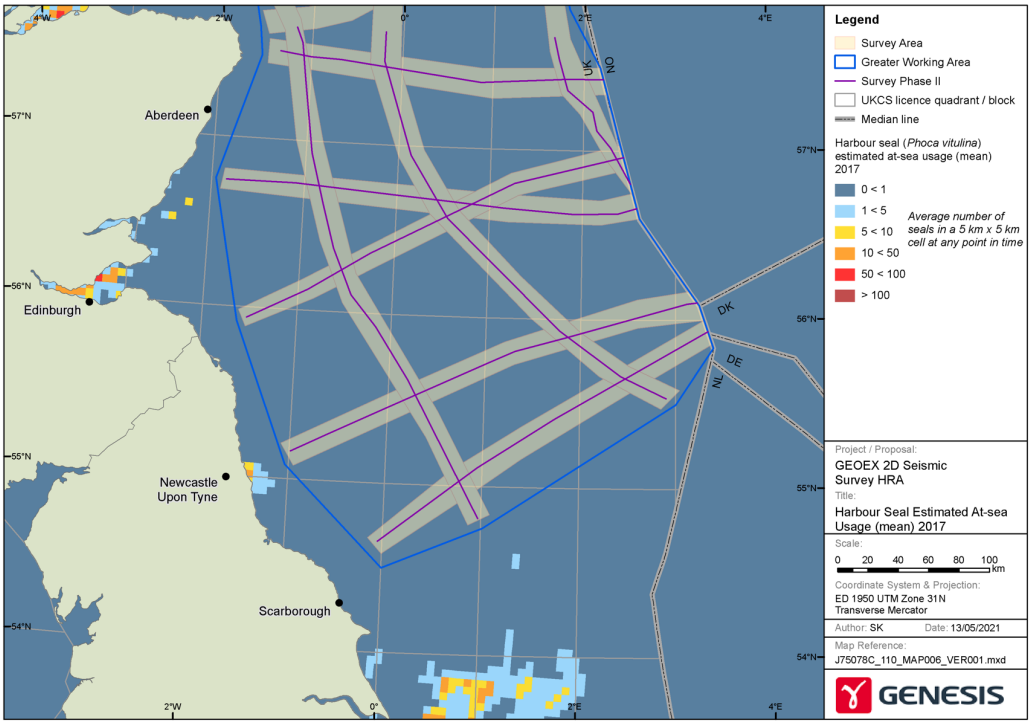



**Figure 7: Distribution of harbour seals in waters off Eastern England.**

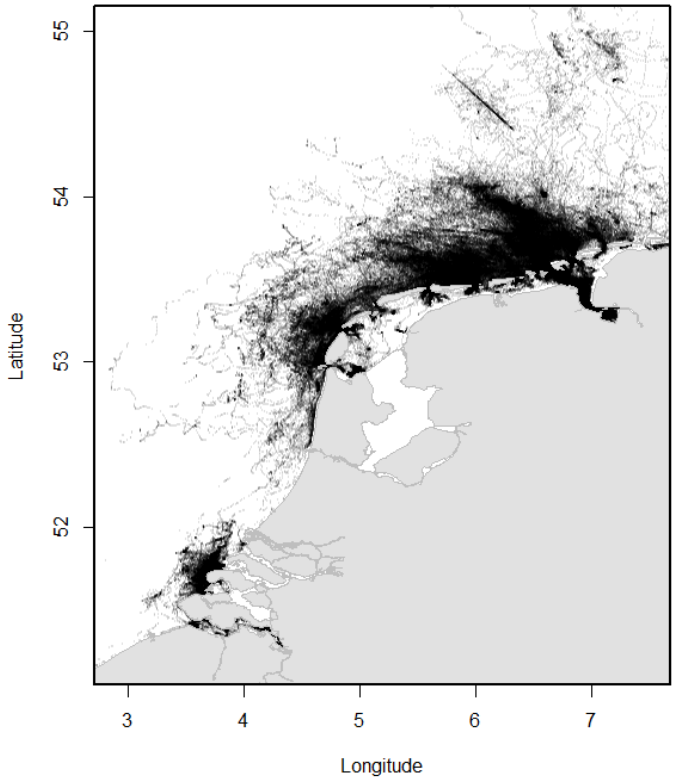



**Figure 8: Distribution of tagged harbour seals in Dutch waters (Source: Aarts *et al*. 2016).**

### *Seabirds*

3.50 The survey is planned to occur in offshore waters during the seabird breeding season, during which time birds within the area of the proposed survey may originate from SPAs designated for breeding seabirds. The mean maximum foraging ranges of seabirds that could be impacted by the proposed survey are presented in Table 5 (Woodward 2019).

3.51 Based on the mean maximum foraging ranges, thirteen species of seabird from a total of fourteen SPAs are identified as being at risk from the proposed survey during the breeding period (See paras 3.6 and 3.8).

3.52 It is also recognised that seabirds from other SPA colonies may also occur in the proposed Survey Area, particularly those with extensive foraging ranges, e.g. Manx shearwater, fulmar and gannet. However, it is not possible to determine which designated sites these birds may originate from and consequently the sites cannot be considered within this assessment.

3.53 The breeding season for seabirds varies between species but broadly extends between April and August, with the core breeding period between May and July, during which time their distribution offshore is constrained by the requirement to return to their breeding sites. Following breeding, seabirds disperse away from their colonies to their wintering areas, either west into the Atlantic or southwards into the North Sea. Guillemots and razorbills disperse from the colonies during

July and August. Adults become flightless during their post-breeding moult and the males are accompanied by flightless chicks. The highest numbers of flightless birds initially occur near the breeding colonies during July and early August. However, the birds rapidly disperse and can travel 50 km per day away from the coastal waters (Camphuysen 2002). From September onwards the number of Auks in nearshore waters decreases.

3.54 At sea, seabirds forage either predominantly by surface feeding, e.g. Gulls and Petrels; surface diving, e.g. Auks or plunge diving, e.g. Terns and Gannets. Surface feeders and plunge diving species are largely aerial and spend relatively short periods of time, if any, below the sea surface, e.g. plunge diving gannets spend on average 4.7 (±2.8) seconds below the sea surface, although individual dives may last longer with occasional dives recorded lasting up to 39 seconds (Garthe *et al.* 2000, Ropert-Coudert. 2009, Cox *et al*. 2016). Surface feeders spend relatively longer periods of time below the sea surface. In shallow waters guillemots have been reported to spend on average 46.4 (±27.4) seconds below the sea surface and shags 61 seconds (Thaxter *et al.* 2009, Wanless *et al.* 1993). Consequently, surface diving seabirds (e.g. guillemot, razorbill, puffin) are at more risk of impacts from underwater noise than other species of seabird predicted to be present in the Greater Working Area. See Table 6 for reported dive durations for a range of relevant species.

**Table 6: Reported seabird dive durations.**

| Species | Average dive duration (seconds) |
|---|---|
| Tern Spp. | 1 to 2 [1] |
| Gannet | 4.6 to 6 [2, 6, 8] |
| Razorbill | 19 to 40 [3,6] |
| Puffin | 40 [4, 6] |
| Shag | 47 to 96 [,5 - 6] |
| Guillemot | 35 to 119 [6,7] |

1 Eglington and Perrow 2014, 2 - Ropert-Coudert 2009, 3 - Wanless *et al.* 1988, 4 - Thaxter *et al*. 2009, , 5 - Wanless *et al.* 1993, 6 – MeyGen 2011, 7 - Thaxter *et al*. 2009, 8 - Garthe *et al*. 2000.

3.55 Seabirds forage on a wide range of fish species. Sandeels are the dominant prey item in many areas (e.g. Monaghan 1992, Daunt *et al.* 2008). However, other fish species, particularly juvenile gadids (cod, whiting, haddock and Norway pout) may also be important components of their diets (Anderson *et al.* 2014).

3.56 It is recognised that the noise from the proposed survey could affect seabirds that dive below the sea surface when foraging and also their prey both within and outwith designated sites. There is also a risk of disturbance to seabirds from the physical presence of the seismic survey vessel.

### *Lamprey (Sea lamprey, River lamprey)*

3.57 Sea lamprey (*Petromyzon marinus*) and River lamprey (*Lampetra fluviatilis*) are qualifying features of the Humber Estuary SAC.

3.58 Sea lamprey spend their adult life in the sea or estuaries but spawn and spend the juvenile part of their life cycle in fresh water rivers. Adult sea lamprey migrate from the sea to the rivers during late spring and the young (ammococetes) return to the sea from September onwards.

3.59 River lampreys occur in coastal waters, estuaries and rivers. After one to two years in estuaries river lampreys stop feeding in the autumn and move upstream from the river mouth between October and December (Maitland 2003).

3.60 Very little is known about the distribution of lampreys offshore but being parasitic, lampreys will occur wherever their host goes. They have a broad range of host species including marine mammals, basking sharks and other fish species so could occur over a very wide geographical area.

3.61 Sea lampreys have poor hearing ability. Studies indicate that sea lamprey respond to sound at frequencies of between 20 Hz and 100 Hz (Lenhardt and Sismour 1995) and show low sensitivity to low frequency sounds (Maes *et al*. 2004).

### *Prey species*

3.62 Aside from lampreys, fish are not qualifying species for any of the designated sites considered within this assessment. However, potential impacts on fish that are prey for marine mammals and seabirds could affect the integrity of the sites by reducing their prey base (JNCC and NE 2019).

3.63 Sandeels are one of the main prey items for harbour porpoise, grey seals and seabirds and are also an important prey species for predatory fish such as whiting, cod and haddock, some of which may also be prey for harbour porpoise and seals (Greenstreet *et al*. 2006).

3.64 Sandeels are one of the most abundant fish in the North Sea occurring widely over suitable sandy substrates where, once the larvae have settled, they remain in the area (Heath *et al.* 2011). Although widespread, sandeel distribution is highly substrate specific as they depend on seabed habitat comprising a high proportion of medium and coarse sands (particle size 0.25 - <2 mm) with low silt content (Holland *et al*. 2005).

3.65 Between September and April sandeels remain largely buried in the seabed except when spawning during December and January and when feeding during the late spring and summer (Greenstreet *et al.* 2006, Van der Kooij *et al*. 2008).

3.66 Within the Southern North Sea SAC sandeels occur across the site with their main spawning area over the Dogger Bank and a wider nursery area across most of the SAC (Judd *et al.* 2011).

3.67 Both harbour porpoise and grey seals, along with seabirds, prey on a variety of fish species that could be impacted by the proposed survey including gobies, Sandeel Spp., whiting, herring and sprat (JNCC and NE 2019).

3.68 Fish hearing is based on detecting particle motion directly stimulating the inner ear. However, those with swim bladders are also able to detect pressure waves and can detect a wider range of frequencies and sounds of lower intensity than fishes without swim bladders (Popper 2003). Fish with swim bladders that possess a coupling mechanism between the swim bladder and the auditory system, e.g. herring and sprats, are recognised to be hearing specialists. Fish that have swim bladders but lack a mechanised coupling mechanism or do not have swim bladders, e.g. sandeel spp. are considered hearing generalists and have a relatively lower sensitivity to sound than fish that have swim bladders and a coupling mechanism.

3.69 Studies on the behaviour of fish from noise, largely using play-back experiments, have reported a range of behavioural responses including avoidance behaviour, changes in swimming speed and direction (e.g. Hawkins 2014, Mueller-Blenkle *et al.* 2010) and reduced antipredator responses (Everley *et al.* 2016).

3.70 Sandeels are not considered to have sensitive hearing (Popper *et al.* 2014). Studies undertaken using airguns indicate that sandeels have distinct but weak reactions to seismic airguns with initial startle responses reducing in frequency with on-going noise, and no increased mortality was detected (Hassel *et al.* 2004).

3.71 There are limited studies assessing potential impacts on eggs and larvae. Results indicate that there is potential for increase in mortality when larvae are exposed to an airgun sound source with peak sound pressure levels of 220-242 dB re 1 $\mu Pa^2$ (unknown measure), but only within 5 m of the airgun (Popper *et al*. 2014).

### *Information Sources*

3.72 This HRA draws on several information sources relating to the proposed project and the site designation which should be read in conjunction with this report including,

- GEOEX (2021a). Application to carry out a Marine Survey Application GS/1199/0 (Version 2). 17 March 2021.
- GEOEX (2021b). Application to carry out a Marine Survey Application GS/1205/0 (Version 2). 19 April 2021.
- EPI (2021). 2D Marine Seismic Survey: Environmental Impact Assessment Marine Seismic Survey. EPI Report No. 2085.
- Natura 2000 – Standard Data Form. Site: UK0030395. Southern North Sea. JNCC (2019b).

- Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs. (England, Wales & Northern Ireland). JNCC (2020a).
- Harbour Porpoise (*Phocoena phocoena*) possible Special Area of Conservation: Southern North Sea. Draft Conservation Objectives and Advice on Activities. JNCC and NE (2019).
- A potential approach to assessing the significance of disturbance against conservation objectives of the harbour porpoise cSACs. Version 3.0. Discussion document JNCC (2017d).
- Noise assessment and management in harbour porpoise SACs. Briefing note: Use of thresholds to assess and manage the effects of noise on site integrity. JNCC. (2017e).

3.73 References to technical papers and other documents are given in the text, as necessary.

# 4 POTENTIAL IMPACTS

4.1 The potential impacts arising from the proposed survey are sound from the airguns and the physical presence of the vessel. No other sources of potential impact that could affect qualifying habitats or species have been identified.

4.2 The airguns used in the seismic surveys are pneumatically-driven impulsive transducers that generate high intensity, low frequency, short duration sound pulses at regular intervals of typically between every 10 to 15 seconds. The seismic source geometry is designed to focus the output from the array vertically downwards minimising any horizontally propagating sounds (OGP/IAGC 2004). The level of sound generated by an airgun array depends on various factors including gun volume, array design, the number of airguns, spacing and air pressure. Field measurements of the sound emitted by airgun arrays used by the oil and gas industry show that levels of source intensity expressed as peak SPL range from 235 to 259 dB re 1µPa- m (Richardson *et al*. 1995, OSPAR 2009). The frequency range of emitted energy is typically in the 5 Hz to 500 Hz range and strongest from 10 to 120 Hz, but with some energy in the 500 Hz to 1 kHz range (Richardson *et al*. 1995, Hermannsen *et al.* 2015).

### *Marine Mammals*

4.3 There is a substantial volume of literature describing the potential effects of sound on marine mammals, and summarised in e.g. Thomsen *et al.* (2006), Southall *et al.* (2007), OSPAR (2009) and Erbe *et al*. (2018).

4.4 There are four main types of potential effect from noise that are recognised within the marine environment:

- *Fatal effects* caused by significant levels of noise in close proximity to the receptor.
- *Physical injury*, specifically hearing impairment, which can be permanent or temporary. These effects can impact on the ability of marine mammals to communicate, forage or avoid predators.
- *Behavioural effects* such as avoidance, resulting in displacement from suitable feeding or breeding areas, and changes in travelling routes.
- *Secondary impacts* caused by the direct effects of noise on potential prey causing a reduction in prey availability.

4.5 The range at which marine mammals may be able to detect sound arising from offshore activities depends on the hearing ability of the species and the frequency of the sound. Pinnipeds (seals) are potentially more sensitive to low frequency sounds than cetaceans and harbour porpoise may be more sensitive to relatively high frequencies. Other factors which may affect the potential impact of sound on marine mammals includes ambient background noise, which can vary

depending on water depth, seabed topography and sediment type. Natural conditions such as weather and sea state and other existing sources of human produced sound, e.g. shipping, can also reduce the auditory range.

### *Fatal effects*

4.6 If source peak pressure levels from the proposed operations are high enough there is the potential for a lethal effect on marine mammals. Studies suggest that potentially lethal effects can occur to marine mammals when the peak pressure level is greater than 246 or 252 dB re. 1 µPa (Parvin *et al.* 2007). Damage to soft organs and tissues can occur when the peak pressure level is greater than 220 dB re. 1 µPa.

### *Physical injury*

4.7 Underwater sound has the potential to cause hearing damage in marine mammals, either permanently or temporarily. The potential for either of these conditions to occur is dependent on the hearing bandwidth of the animal, the duty cycle of the sound source and duration of the exposure (Southall *et al*. 2019, OSPAR 2009).

### *Behavioural Change*

4.8 Potential changes in behaviour may occur depending on the sound source levels and the species and individuals sensitivities. Behavioural changes can include changes in swimming direction, diving duration, avoidance of an area and reduced communication.

4.9 Masking effects may also cause changes in the behaviour as the level of sound may impair the detection of echolocation clicks and other sounds that species use to communicate or detect prey, thus causing them to alter their behaviour.

## *Seabirds*

4.10 The physical presence of the seismic survey vessel could cause disturbance to seabirds with the potential behaviour of seabirds towards vessel activity varying across species. Gannets, shags, guillemots, razorbills and puffins are moderately tolerant of vessels (Furness and Wade 2012) but will largely avoid vessels at close distances by flying, swimming or diving. Evidence from offshore activities indicates that these species are not significantly impacted by vessel disturbance with Furness and Wade (2012) indicating a moderate sensitivity for Auk species towards vessel disturbance.

4.11 There are limited studies on the impacts from seismic surveys on seabirds. However, studies undertaken on African penguins during the breeding season indicate that birds may avoid areas within *c.* 70 km of a seismic survey, causing a change in foraging location and an increase in the distance birds forage (Pichegru *et al.* 2017).

4.12 There is limited information on the ability of seabirds to hear underwater. Reviews undertaken indicate that birds may have relatively poor hearing ability below the sea surface with peak hearing sensitivity below 2 kHz (Dooling and Therrien 2012). However, studies on great cormorant indicate that at 2 kHz they have relatively good hearing ability (Hansen *et al*. 2016). Studies on two species of diving sea-duck: long-tailed duck and surf scoter, indicated hearing ability underwater of between 0.5 and 2.86 kHz for long-tailed duck and a peak sensitivity at 1 kHz for surf scoter (Therrien 2014, James *et al*. 2018).

4.13 The US Fisheries and Wildlife Service have published recommended thresholds of 202 dB SEL at which hearing injury could occur for a species of Auklet (Marbled Murrelet) and 208 dB SEL at which barotrauma injuries may occur (USFWS 2011).

### *Lampreys*

4.14 There is no information on the potential impacts sound from an airgun may have on Lamprey. However, they do not have any specialist hearing structures, they lack otolith organs and swim bladders and are likely to have poor hearing sensitivity. Therefore, behavioural or physiological effects are only likely to occur when they are very close to a powerful sound source (Franco *et al*. 2011).

### *Secondary Effects*

4.15 There is potential for impacts on prey species to affect marine mammals and seabirds, in particular possible impacts of noise on fish species.

# 5 NOISE MODELLING

5.1 To assess the potential environmental impacts from the proposed survey the applicant has undertaken noise modelling (EPI 2021). Results from the modelling indicate the extent at which the onset of a Permanent Threshold Shift (PTS), Temporary Threshold Shift (TTS) or disturbance could occur from the seismic airguns during the proposed survey on marine mammals.

5.2 The modelling indicates that, based on the weighted SEL metric, there is a risk of the onset of PTS to harbour porpoise within 100 m of the airguns and less than 10 m for bottlenose dolphin., The onset of PTS in pinnipeds only arises within 40 m of the airgun (EPI 2021).

5.3 The results from the modelling indicate that there is a risk of behavioural effects, e.g. displacement and disturbance to marine mammals from within an area of 6.0 km based on a SPL threshold of 160 dB re 1µPa $_{(rms)}$ (EPI 2021).

5.4 To undertake the HRA further information from existing noise modelling has been used to support the assessment. A comparison between the results from the modelling undertaken within the application and existing noise modelling results provides a greater degree of confidence in the conclusions drawn in this HRA.

5.5 Noise modelling has been undertaken for BEIS to assess the potential impacts to harbour porpoise from a seismic survey within the Southern North Sea SAC (BEIS *in prep.,* 2020). The modelling was undertaken at three locations within the Southern North Sea SAC and was based on a 3,220 cu. in. airgun array, comprising four sub-arrays each with eight individual airguns ranging in volume of between 40 cu in and 150 cu. in. The maximum SPL was 261 dB *re* 1 µPa$^2$s $_{(0\text{-peak})}$. The modelling undertaken by BEIS is therefore based on a smaller airgun array than that proposed for the GEOEX survey but a similar maximum SPL of 261 compared with 260 dB *re* 1 µPa$^2$s $_{(0\text{-peak})}$ from the 6,270 cu. in. airgun to be used by the proposed survey. Of the three location for which modelling has been undertaken within the Southern North Sea, results from the location closest to the proposed survey have been used in this assessment.

5.6 The modelling undertaken for BEIS differs from that undertaken for the proposed survey in that it includes the use of a soft-start the airguns start operating and assumes that the marine mammal will move away from the sound source. Furthermore, it is unclear whether the modelling undertaken for the application includes movement of the vessel, which is included in the modelling undertaken for BEIS. These additional elements to the noise modelling undertaken for BEIS provide more realistic results.

5.7 It is also noted that the threshold used within the application for assessing the extent of disturbance to harbour porpoise is 160 dB re 1µPa $_{(rms)}$. This threshold is considered to be too high for assessing disturbance impacts on Very High Frequency cetaceans, such as harbour

porpoise. BEIS has used a lower threshold of 145 dB re 1µPa (rms) which is based on published evidence that indicates Very High Frequency cetaceans may be more sensitive to disturbance noise than other marine mammals (Lucke *et al*. 2008, Thompson *et al*. 2013). The use of the lower threshold increases the extent at which disturbance is predicted to occur.

5.8 The results from both sets of noise modelling for harbour porpoise are presented in Table 7.

**Table 7: Harbour porpoise estimated areas of physical injury and disturbance.**

| Harbour porpoise | EPI (6,270 cu. in. airgun) | | BEIS (3,220 cu. in. airgun) | |
|---|---|---|---|---|
| | Distance (m) | Maximum area ($km^2$) | Distance (m) | Maximum area ($km^2$) |
| PTS (no soft-start) | 100 | 0.10 | - | - |
| PTS (with soft-start) | - | - | 320 | 0.32 |
| Disturbance | 6,000 | 113 | 7,800 | 301 |

PTS SEL Threshold weighted 155 re 1 $\mu Pa^2s$.
Disturbance – 160 dB re 1 µPa (rms). (EPI); 145 dB re 1 µPa (rms) (BEIS)

5.9 Noise modelling undertaken by the applicant for bottlenose dolphin indicate that the onset of PTS could arise if the dolphin is within 10 m of the airgun and disturbance could occur out to 6,000 m. Previous noise modelling undertaken by BEIS based on an airgun array of up to 6,000 cu in. has indicated that the onset of PTS will occur within 6 m of the airgun and disturbance could occur out to 11 km, impacting an area of up to 210 $km^2$ (Table 8) (BEIS 2016a).

**Table 8: Bottlenose dolphin estimated areas of physical injury and disturbance.**

| Harbour porpoise | EPI (6,270 cu. in. airgun) | | BEIS (3,220 cu. in. airgun) | |
|---|---|---|---|---|
| | Distance (m) | Maximum area ($km^2$) | Distance (m) | Maximum area ($km^2$) |
| PTS (no soft-start) | <10 | <0.001 | - | - |
| PTS (with soft-start) | - | - | 6 | <0.001 |
| Disturbance | 6,000 | 113 | 11,000 | 210 |

PTS SEL Threshold weighted 185 re 1 $\mu Pa^2s$.
Disturbance – 160 dB re 1 µPa (rms).

5.10 Noise modelling to assess potential impacts to grey seals from seismic surveys has previously been undertaken by BEIS at three locations in nearshore waters around north-east Scotland, Orkney and Shetland (BEIS 2016b). Although not directly comparable due to the different geographic location, the previous modelling was based on a 5,000 cu. in. airgun array with a maximum SPL of 259 dB *re* 1 $\mu Pa^2s$ (0-peak) compared with 261 dB *re* 1 $\mu Pa^2s$ (0-peak). Consequently, a larger area of potential impact might be predicted by the modelling previously undertaken for BEIS.

5.11 The results from the two sets of noise modelling undertaken for grey seal are presented Table 9.

**Table 9: Grey and harbour seal estimated areas of physical injury and disturbance.**

| Pinneped | EPI (6,270 cu. in. airgun) | | BEIS (5,000 cu. in. airgun) | |
|---|---|---|---|---|
| | Distance (m) | Maximum area ($km^2$) | Distance (m) | Maximum area ($km^2$) |
| PTS (no soft-start) | 40 | 0.005 | - | - |
| PTS (with soft-start) | - | - | 99 | 0.031 |
| Disturbance | 6,000 | 113 | 17,000 | 383 |

PTS SEL Threshold weighted 185 re 1 $\mu Pa^2s$.
'mild' disturbance - 160 dB re 1 $\mu Pa_{(rms)}$.

### *Potential impacts on harbour porpoise*

5.12 The results from the two sources of noise modelling indicate that noise levels that have the potential to cause the onset of auditory injury (PTS) to harbour porpoise occur out to between 100 and 320 m from the airguns (Table 7).

5.13 There is potential for levels of noise at which disturbance could occur to extend from between 6.0 km and 7.8 km from the airguns and encompass an area of between 113 $km^2$ and 301 $km^2$ (Table 7).

### *Potential impacts on bottlenose dolphin*

5.14 The results from the two sources of noise modelling indicate that noise levels that have the potential to cause the onset of auditory injury (PTS) to bottlenose dolphin occur within 10 m of the airguns (Table 8).

5.15 There is potential for levels of noise at which disturbance could occur to extend from between 6.0 km and 11 km from the airguns and encompass an area of between 113 $km^2$ and 210 $km^2$ (Table 8).

### *Potential area of impact on grey and harbour seals*

5.16 The results from the modelling indicate that noise levels that have the potential to cause the onset of auditory injury (PTS) to seals will occur between 40 m and 99 m from the airguns (Table 9).

5.17 There is potential for levels of noise at which disturbance could occur to extend between 6.0 km and 17.0 km from the airguns and encompass an area of between113 $km^2$ and 383 $km^2$ (Table 9).

### *Potential impacts on fish*

5.18 No noise modelling on the potential impact on fish have been undertaken by the applicant. Results from the noise modelling previously undertaken by BEIS are presented in Table 10. Noise levels that have the potential to cause mortality to fish species with swim bladders could occur out to 302 m. For fish without swim bladders, e.g. Lampreys, mortality could occur out to 140 m from a seismic survey (BEIS 2016b).

**Table 10: Maximum distances at which mortality and disturbance to fish, eggs and larvae could occur.**

| Distance (m) | | | |
|---|---|---|---|
| **Fish: swim bladder involved in hearing [-1]**<br>Allis shad<br>Twaite Shad, | **Fish: no swim bladder [-2]**<br>Sea Lamprey, River lamprey<br>Plaice, lemon sole | **Eggs and Larvae**<br>All species | **Disturbance**<br>All species |
| 302 | 140 | 302 | - |

1 - 213 Unweighted peak SPL (dB re 1 µPa)

2- 207 Unweighted peak SPL (dB re 1 µPa)

# 6 EFFECTIVE DETERRENT RADIUS / RANGE

6.1 The Effective Deterrent Radius / Range (EDR) has been proposed by the Statutory Nature Conservation Bodies (SNCBs) as a means to measure potential impacts on harbour porpoise within the Southern North Sea SAC (JNCC 2017d,e; JNCC 2020a). The EDR is an empirically derived generic distance within which deterrence, i.e. displacement, of harbour porpoise is predicted to occur. The EDR are based on published studies that have monitored the effects on harbour porpoise from various activities and reflects the overall loss of habitat if all animals vacate the area (e.g. Defra 2015). It is an area of displacement as opposed to disturbance, which may be greater.

6.2 The published precautionary EDR are presented in Table 11 (JNCC 2020a). Relevant to this assessment is the EDR for seismic surveys which is 12 km. This is based on recent evidence indicating that harbour porpoise can be displaced up to 12 km from seismic survey (Sarnocińska *et al*. 2020).

6.3 The use of a 26 km EDR has been used for pile-driving and the detonation of unexploded ordnance (UXO) and 5 km for the geophysical surveys when considered in the in-combination assessment. For the purposes of this assessment a 15 km EDR has been used for UXO with bubble curtains, this follows the EDR proposed for pile-driving with noise abatement.

**Table 11: Precautionary Effective Deterrent Ranges (EDR) (Source: JNCC 2020a).**

| Activity | Effective Deterrent Range (km) |
|---|---|
| Monopile | 26 |
| Unexploded Ordnance | 26 |
| Pin-pile [1] | 15 |
| Monopile with noise abatement | 15 |
| Conductor piling | 15 |
| Seismic survey | 12 |
| High Resolution Geophysical Surveys | 5 |

[1] Pin-piles are '*smaller diameter piles that secure jacket structures'* although no definition as to what diameter a pin-pile should be has been provided in published advice (JNCC 2020a).

6.4 The SNCBs recognise that future data may require the suitability of the EDR to be reconsidered if it is found to be inappropriate (JNCC 2017e).

# 7 CONSERVATION OBJECTIVES

7.1 Conservation Objectives constitute a necessary reference for identifying site-based conservation measures and for carrying out HRAs of the implications of plans or projects (JNCC and NE 2019). They outline the desired state for any European site, in terms of the features for which it has been designated. If these features are being managed in a way which maintains their nature conservation value, they are assessed as being in a 'favourable condition'. An adverse effect on the integrity of a site is likely to be one which prevents the site from making the same contribution to favourable conservation status for the relevant feature as it did at the time of its designation (English Nature 1997).

7.2 The purpose of an Appropriate Assessment is to determine whether a plan or project adversely affects a site's integrity. The critical consideration in relation to site integrity is whether the plan or project affecting a site, either individually or in-combination, affects the site's ability to achieve its conservation objectives and favourable conservation status (JNCC and NE 2019).

### *Southern North Sea SAC*

7.3 The Southern North Sea SAC was designated as a SAC in 2019. The site covers an area of 36,951 $km^2$ and is designated for harbour porpoise.

7.4 Harbour porpoise are also protected throughout European waters under the provisions of Annex IV and Article 12 of the Habitats Directive, which are outwith the scope of this assessment. Harbour porpoise in UK waters are considered part of a wider European population and the mobile nature of this species means that the concept of a 'site population' is not thought to be appropriate for this species. Site based conservation measures therefore aim to complement wider ranging measures that are in place for the harbour porpoise (JNCC and NE 2019).

7.5 The Conservation Objectives for harbour porpoise are designed to ensure that human activities do not, in the context of maintaining site integrity:

- kill, or injure harbour porpoise (directly or indirectly),
- prevent their use of significant parts of the site (disturbance / displacement),
- significantly damage relevant habitats, or
- significantly reduce the availability of prey.

***Southern North Sea SAC Conservation Objectives:***

To ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining Favourable Conservation Status for Harbour Porpoise in UK waters.

In the context of natural change, this will be achieved by ensuring that:

1. Harbour porpoise is a viable component of the site,

2. There is no significant disturbance of the species, and

3. The condition of supporting habitats and processes, and the availability of prey is maintained.

*Source: JNCC and NE 2019*

7.6 Harbour porpoises are considered to be a 'viable component' of the site if they can survive and live successfully within it. The first Conservation Objective aims to minimise the risk from activities that cause unacceptable levels of impact on harbour porpoise using the site, specifically those that could impact on the Favourable Conservation Status of harbour porpoise (JNCC and NE 2019).

7.7 The '*integrity of the site*' is not defined in the Conservation Objectives. However, EU and UK Government guidance defines the integrity of a site as ''*the coherence of the site's ecological structure and function, across its whole area, or the habitats, complex of habitats and/or populations of species for which the site is or will be classified*' (Defra 2012). Therefore, the integrity of the site applies to the whole of the site and it is the potential impacts across the whole of the site that are required to be appropriately assessed. Pressures that would affect site integrity include,

- killing or injuring harbour porpoise (directly or indirectly),
- preventing their use of significant parts of the site (disturbance / displacement),
- significantly damaging relevant habitats,
- significantly reducing the availability of prey. (JNCC and NE 2019).

7.8 The second Conservation Objective states that there should be '…*no significant disturbance of the species'* and that '*Disturbance is considered significant if it leads to the exclusion of harbour porpoise from a significant portion of the site'* (JNCC and NE 2019).

7.9 *'Supporting habitats and processes'* relate to the seabed and water column along with the harbour porpoise prey.

7.10 JNCC advise that it is not appropriate to use the site population estimates in any assessments of effects of plans or projects (i.e. Habitats Regulation Assessments), as it is necessary to take into consideration population estimates at the Management Unit level to account for daily and seasonal movements of the animals (JNCC 2017c; JNCC and NE 2019), .

7.11 There are no formal thresholds at which impacts on site integrity are considered to be adverse. However, a threshold of 1.7% of the relevant harbour porpoise population above which a population decline is inevitable has been agreed with Parties to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), with an intermediate precautionary objective of reducing the impact to less than 1% of the population (Defra 2003, ASCOBANS 2015). This threshold relates to impacts from fisheries by-catch on harbour porpoise where the impact on the harbour porpoise is permanent, i.e. up to 1.7% of the population may be caught as by-catch before a population decline is inevitable. An equivalent level of impact from disturbance, which is temporary and non-lethal, on a population will have a lower level of impact on the population compared to that from a fisheries by-catch.

7.12 The lack of agreed population thresholds either at the Management Unit level or site level, below which evidence demonstrates there would not be an adverse effect, does not prevent objective judgements to be made on site integrity.

7.13 Draft thresholds to assess and manage the effects of noise on site integrity have been proposed by the JNCC and NE (JNCC 2017d,e; JNCC and NE 2019, JNCC 2020a). The proposed approach is not based on a population level impact but is instead based on a temporal and spatial level where a proportion of the area within the SAC may be affected over a period of time.

7.14 The JNCC and NE advice is that *'noise disturbance within the site should not exclude harbour porpoise from more than 20% of the site on any given day. Over a season, the advice is that an average loss of access to more than 10% of the SAC should be considered significant, recognising that within the SAC the abundance of harbour porpoise per unit habitat is generally higher than the equivalent sized habitat in the rest of the relevant Management Unit. Management of temporary habitat 'loss' to below defined area/time thresholds is therefore designed to ensure that it continues to contribute in the best possible way to the maintenance of the species at FCS.'* (JNCC 2020a).

7.15 The potential extent of noise causing disturbance that would meet these proposed thresholds and therefore impact on the integrity of the site is presented in Table 12. The results indicate that should the impact occur wholly inside the SAC that, within the 'summer' area a sound source alone or in-combination causing disturbance for one day over an area of 7,390 $km^2$ would risk impacting site integrity. This is equivalent to a circular radius of noise out to 41.5 km. To exceed the threshold for the 'winter' area, noise in any one day should not extend over an area of more than 2,537 $km^2$: equivalent to a circular radius of 28.4 km.

7.16 Over the course of a season the total extent of potential disturbance on average per day should, in the 'summer' area, not extend over an area of more than 2,701 km$^2$; equivalent to a radius of noise of 29.3 km and in the 'winter' area should not extend over an area of more than 1,269 km$^2$, equivalent to a radius of 20.1 km.

**Table 12: Estimated extent sound levels capable of causing displacement disturbance occur in order to impact on site integrity.**

| Site | Area (km$^2$) | 1 day threshold | | Seasonal threshold | |
|---|---|---|---|---|---|
| | | 20% of area (km$^2$) | Distance to threshold (km) | 10% of area (km$^2$) | Distance to threshold (km) |
| Southern North Sea SAC | 36,951 | 7,390 | 48.5 | 3,695 | 34.3 |
| 'summer' area<br>April - September | 27,028 | 5,406 | 41.5 | 2,701 | 29.3 |
| 'winter' area<br>October - March | 12,696 | 2,539 | 28.4 | 1,269 | 20.1 |

The 'Distance to threshold' presumes sound propagation is circular in shape, i.e. the distance is the equivalent to a radius of circular noise.

7.17 Unlike the daily threshold, the area of the SAC that can be affected over the course of a season is an average over the season. The seasonal average is calculated by summing the proportion of the site impacted (for the relevant season) over the number of days the impact will occur and then averaging across the total number of days within that season, i.e. 183 days in the summer period and 182 days in the winter period. This provides a seasonal average spatial effect.

7.18 This assessment is based on both the potential impact on the North Sea Management Unit population using both the ASCOBANS thresholds and the proposed SNCB threshold approach.

7.19 To undertake any meaningful assessment using the threshold approach accurate information on the timing, duration and extent of activities being undertaken is required. Where this information is lacking or where speculative 'worst-case' scenarios are used there is little or no confidence that the results will bear any resemblance to the true extent of impact within the SAC on any single day or across the course of a season. The threshold approach proposed by the SNCBs has not been fully adopted by all the competent authorities. However, the thresholds have been noted within the assessment as a high-level management tool to limit the spatial distribution of noise from offshore activities within a large offshore SAC, such as the Southern North Sea SAC.

7.20 The HRA has been carried out in light of best scientific knowledge with reference to the Conservation Objectives of the SAC and the potential impacts on the integrity of the site (EC 2018).

### *The Humber Estuary SAC*

7.21 The Humber Estuary SAC was designated as a SAC in 2009. The site comprises a number of habitat types including sandbanks, mudflats and coastal lagoons and river lamprey, sea lamprey and grey seal are qualifying species for the site (Natural England 2018a).

***Humber Estuary SAC Conservation Objectives***

Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring;

- The extent and distribution of qualifying natural habitats and habitats of qualifying species,
- The structure and function (including typical species) of qualifying natural habitats,
- The structure and function of the habitats of qualifying species,
- The supporting processes on which qualifying natural habitats and habitats of qualifying species rely,
- The populations of qualifying species, and,
- The distribution of qualifying species within the site.

*Source: Natural England 2018a*

### *Berwickshire and North Northumberland Coast SAC*

7.22 The Berwickshire and North Northumberland Coast SAC was designated as a SAC in 2005. The site covers an area of 652 $km^2$ and comprises a number of habitats primarily of marine areas, sea inlets, tidal rivers, estuaries mudflats sand flats and lagoons. Grey seal is a qualifying species and the site supports 2.5% of the annual pup production (JNCC 2020b).

7.23 The Berwickshire and North Northumberland Coast SAC Conservation Objectives are the same as those for the Humber Estuary SAC.

### *Isle of May SAC*

7.24 The Isle of May SAC was designated as a SAC in 2005. The site covers an area of 3.5 $km^2$. The site is designated for reefs and grey seal (NatureScot 2021a). The Conservation Objectives relating to grey seal are presented below.

***Isle of May SAC Conservation Objectives*:**

To avoid deterioration of the habitats of the qualifying species (listed below) or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and:

To ensure for the qualifying species that the following are maintained in the long term:

- Population of the species as a viable component of the site,
- Distribution of the species within site,
- Distribution and extent of habitats supporting the species,
- Structure, function and supporting processes of habitats supporting the species,
- No significant disturbance of the species,

Source NatureScot 2021a

## *Moray Firth SAC*

7.25 The Moray Firth SAC was designated as a SAC in 2005. The site covers an area of 1,513 km$^2$. The site is designated for sub-tidal sandbanks and bottlenose dolphin (NatureScot 2021b). The Conservation Objectives relating to bottlenose dolphin are presented below.

***Moray Firth SAC Conservation Objectives:***

1. To ensure that the qualifying features of Moray Firth SAC are in favourable condition and make an appropriate contribution to achieving Favourable Conservation Status.
2. To ensure that the integrity of Moray Firth SAC is maintained or restored in the context of environmental changes by meeting objectives 2a, 2b and 2c for each qualifying feature:

- 2a. The population of bottlenose dolphin is a viable component of the site.
- 2b. The distribution of bottlenose dolphin throughout the site is maintained by avoiding significant disturbance.
- 2c. The supporting habitats and processes relevant to bottlenose dolphin and the availability of prey for bottlenose dolphin are maintained.

Source: Nature Scot 2021b

## Doggersbank SAC

7.26 The Doggersbank SAC lies within Dutch waters encompassing an area of 4,735 km$^2$. The site became a SAC in 2016. Qualifying species for the site include harbour porpoise, grey and harbour seals (Jak *et al.* 2009).

***Doggersbank SAC Conservation Objectives***

- Maintain the distribution, extent and quality of habitat for the purposes of maintaining the population.
- Maintain the extent and quality of habitat in order to maintain the population.

*Source: Jak et al. 2009*

## SPA Conservation Objectives

7.27 The Conservation Objectives for English SPAs are the same for all the SPAs identified as having qualifying species that could be impacted are the same for each site. Similarly, the Conservation Objectives for Scottish SPAs are the same for each site and although differ from those for English sites, they are broadly similar. The Conservation Objectives for both regions are presented below.

***English SPA Conservation Objectives***

Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

- The extent and distribution of the habitats of the qualifying features,
- The structure and function of the habitats of the qualifying features,
- The supporting processes on which the habitats of the qualifying features rely,
- The population of each of the qualifying features, and,
- The distribution of the qualifying features within the site.

*Source: Natural England 2019*

***Scottish SPA Conservation Objectives***

To avoid deterioration of the habitats of the qualifying species (listed below) or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and
To ensure for the qualifying species that the following are maintained in the long term:

- Population of the species as a viable component of the site,
- Distribution of the species within site,
- Distribution and extent of habitats supporting the species,
- Structure, function and supporting processes of habitats supporting the species
- No significant disturbance of the species.

*Source: NatureScot 2021a*

# 8 IN-COMBINATION IMPACTS

8.1 Under the Habitats Regulations, it is necessary to consider the in-combination effects of plans or projects on European Sites. These refer to effects, which may or may not interact with each other, but which could affect the same receptor or interest feature (i.e. a habitat or species for which a European site is designated).

8.2 The in-combination assessment includes plans or projects that are,

- Under construction,
- Permitted application(s), but not yet implemented,
- Submitted application(s), not yet determined,
- Projects identified in the relevant Development Plan (and emerging Development Plans),
- Sites identified in other policy documents, as development reasonably likely to come forward.

### *Renewable energy activity*

8.3 A source of potentially significant in-combination underwater noise impact is from pile driving activity occurring during the construction of offshore renewable developments, particularly offshore wind farms.

8.4 Wind farms identified as having potential to cause an in-combination impact are presented in Table 13.

8.5 There are 20 UK offshore wind farms that lie wholly within the Southern North Sea SAC or are within 26 km of the boundary which is identified by the JNCC as an area that harbour porpoises may be displaced from by noise arising from pile-driving activities (JNCC 2017d, JNCC 2020a). Two wind farms (Triton Knoll and Hornsea Two) are currently undertaking offshore construction. All other wind farms are either operating, consented but not started offshore construction or have submitted applications and are awaiting determination. Elsewhere, there are three offshore wind farms in Scotland that are currently undertaking offshore construction: Moray East, Kincardine and Neart na Gaoithe and could cause an in-combination impact to bottlenose dolphin from the Moray Firth SAC and grey seal from the Isle of May SAC.

8.6 There are further additional wind farms located in Dutch and Belgium waters that could during construction impact on the Southern North Sea SAC. In Belgium, the SeaMade wind farms: Mermaid and Seastar are under construction. However, all the monopile foundations have been installed.

**Table 13: UK offshore wind farms with potential for in-combination impact.**

| Wind farm | Status |
|---|---|
| **England** | |
| Scroby Sands | Operating |
| Dudgeon | Operating |
| Galloper | Operating |
| Greater Gabbard | Operating |
| Gunfleet Sands II | Operating |
| Humber Gateway | Operating |
| Thanet | Operating |
| Triton Knoll | Offshore construction started |
| Westermost Rough | Operating |
| Creyke Beck A | Onshore construction started |
| Creyke Beck B | Onshore construction started |
| East Anglia One | Operating |
| East Anglia Two | Application submitted |
| East Anglia Three | Consented |
| Hornsea Project One | Operating |
| Hornsea Project Two | Offshore construction started |
| Hornsea Project Three | Consented |
| Norfolk Vanguard | Application submitted |
| Teesside A (Sofia) | Consented |
| Teesside B | Onshore construction started |
| Blyth Demonstrator Phase 1 | Operating |
| Blyth Demonstrator Phase 2 | Pre-application |
| **Scotland** | |
| Beatrice | Operating |
| Moray West | Consented |
| Moray East | Under construction |
| Hywind | Operating |
| Aberdeen OWF | Operating |
| Kincardine | Offshore construction started |
| Neart na Gaoithe | Offshore construction started |
| Inch Cape | Consented |
| Seagreen | Onshore construction started |

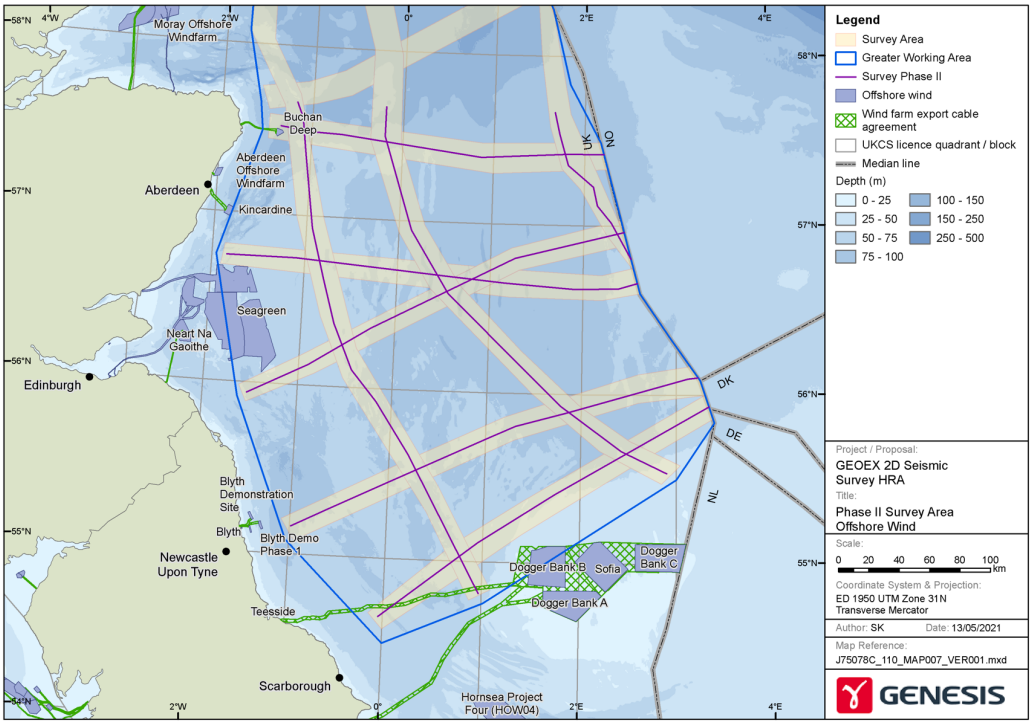



**Figure 9: Offshore wind farms located within the area of the proposed survey.**

8.7 It is recognised that during construction, pile-driving will likely occur and that, if undertaken simultaneously as the proposed seismic survey, there is the potential to cause an adverse effect in-combination. Of the offshore wind farms that are relevant to the in-combination assessment the Hornsea Two offshore wind farm could be pile-driving during the period of the proposed seismic survey in 2021 (Ørsted 2020). The Triton Knoll offshore wind farm has completed installing the foundations and therefore no further pile-driving is anticipated. The Neart na Gaoithe offshore wind farms is under construction. However, the wind turbine foundations are being drilled into position and no pile-driving is being undertaken. The Kincardine offshore wind farm is a floating wind farm and therefore not predicted to be undertaking any pile-driving.

8.8 Other offshore wind farm activities that could cause an impact on qualifying features include the clearance of UXO and geophysical surveys. An application has been submitted to the Marine Management Organisation to undertake the clearance of up to 25 items of UXO at the Dogger A and Dogger B wind farms, including export cable routes, between May and December 2021 (DBWF 2021, MMO 2021).

8.9 No consent is required by the offshore wind farm industry for undertaking geophysical surveys. Consequently, there is no information available regarding potential geophysical surveys that could cause an in-combination impact. However, the Supporting Environmental Information submitted by Dogger Bank Wind Farm in support of the proposed UXO clearance being

undertaken at Dogger A and Dogger B wind farms, reports up to six geophysical surveys to be undertaken at Dogger A, B and C, Sofia and at Hornsea Three and Hornsea Four during 2021. There is little or no published information on when, where or how the six proposed geophysical surveys will be undertaken.

### *Cable laying activity*

8.10 The Viking Link project is a high voltage direct current (HVDC) electrical interconnector between Denmark and the UK. The 762 km long cable will be laid between Jutland in Denmark and Bicker Fen in Lincolnshire and crosses the Southern North Sea SAC (NGVL 2018a). Four items of unexploded ordnance were identified along the cable route within 26 km of the Southern North Sea SAC boundary, of which one was in the SAC; these were to be cleared in 2020. No other UXO clearance activities are associated with this project are known of (NGVL 2018b, NGVL 2019, MMO 2020).

### *Aggregate and dredging activity*

8.11 Existing localised aggregate dredging occurs primarily in the southern half of the Southern North Sea SAC, along the east coast. In 2019 there were 29 aggregate production areas and five Exploration and Option areas covering an area of 579.2 $km^2$. Five of the aggregate areas occur in the 'summer' area of SAC covering 77.7 $km^2$ and the rest occur in the 'winter' area of the SAC and cover an area 533.8 $km^2$, with some sites occurring in both the 'winter' and 'summer' areas.

8.12 Studies have indicated that harbour porpoise may be displaced by dredging operations within 600 m of the activities (Diederichs *et al*. 2010). Noise modelling previously undertaken for aggregate assessments have predicted significant levels of avoidance at ranges of 500 m from suction dredging (Parvin *et al* 2008 (referenced in Hanson Aggregates Marine Ltd 2013).

8.13 On a precautionary assumption that there is a level of behavioural displacement out to 600 m, there is potential for an area of 1.13 $km^2$ to be affected at each active dredging location. There are currently three aggregate production areas in the 'summer' area and 26 in the 'winter' area. Although the level of dredging activity within each of the active licence areas is unknown, as a worst-case scenario, with dredging occurring within each dredging area, porpoise may be displaced from an area of 3.39 $km^2$ in the 'summer' area and 29.38 $km^2$ in the 'winter' area. Therefore, a very small proportion (0.01% of the summer area and 0.2% of the summer area) of the SAC may be impacted by noise arising from dredging activities.

### *Oil and gas activity*

8.14 There is a long history of oil and gas activities within the Greater Working Area (Figure 10).

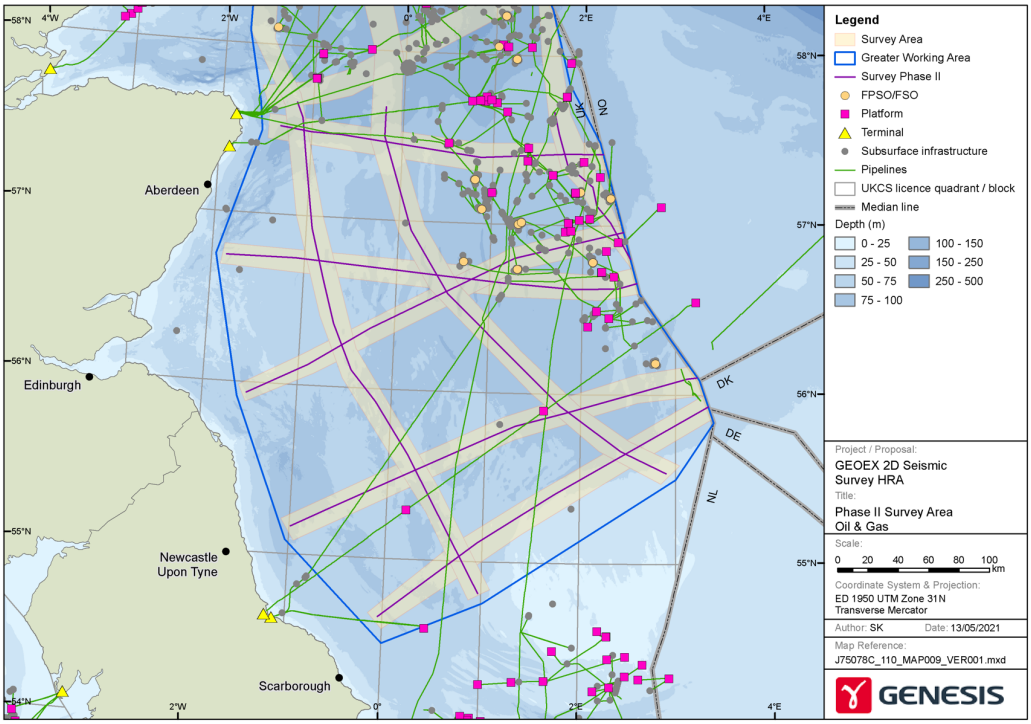



**Figure 10: Existing oil and gas infrastructure within the Greater Working Area.**

8.15 BEIS are aware of a number of planned oil and gas related activities within the Greater Working Area during the period the proposed survey will be undertaken that could cause an in-combination effect including a seismic survey in Quadrants 35, 36, 37, 38, 41, 42, 43 and 44 off the east coast of England (Table 14).

8.16 The proposed operations include drilling activities. Noise from drilling activities is largely dependent on the type of drilling platform being used. Jack-up rigs are the most frequently used drilling platform in the Southern North Sea and produce the lowest levels of sound. Studies in Danish waters reported sound source levels of 148 re 1µPa-m $_{(rms)}$ from drilling activities undertaken from a fixed platform (Bach *et al.* 2010). The level of sound arising from drilling is relatively low and occurs predominantly at a low frequency and is a continuous sound source (Greene 1987; McCauley 1998; Nedwell and Edwards 2004). Sound arising from drilling is outwith the main hearing frequencies for harbour porpoise.

8.17 Studies using Passive Acoustic Monitoring (PAM) at platforms located on the Dogger Bank did not record any decrease in harbour porpoise activity at the platforms when drilling was being undertaken and indicated that harbour porpoises appeared to use oil and gas platforms as feeding refuges (Todd *et al.* 2007, Todd *et al*. 2009). Similar results have been reported from studies undertaken at two platforms in Danish waters (Bach *et al.* 2010).

8.18 The placement of oil and gas infrastructure will be undertaken using vessels and is not predicted to cause any significant increase in the level of vessel activity within the SAC above which currently occurs within the site.

**Table 14: Planned oil and gas survey activities during 2021 within or adjacent to the Greater Working Area that have potential to cause an in-combination impact.**

| Applicant | Licence Reference No. | Licence Block(s) | Start and End Dates | Planned Activity |
|---|---|---|---|---|
| ION | GS/1163/1 | Multiple | 15 April – 31 October | 3D Seismic survey |
| Ithaca | GS/1236/0 | 29/10 | 15 June – 31 July | Geophysical survey (Sub-bottom Profiler Pinger Survey) |
| Jersey Petroleum | GS/1234/0 | 19/17 | 7 June – 30 September | Geophysical survey (Sub-bottom Profiler Sparker Survey, Sub-bottom Profiler Pinger Survey, Gravity Survey (e.g. Gradiometric Survey) |
| CGG Services | GS/1230/0 | 21/30 | 25 May – 30 September | OBC/OBS Seismic, 3D Seismic. |
| CGG Services | GS/1191/0 | 19/8 | 1 April – 30 June | 3D Seismic |
| CGG services | GS/1200/1 | 21/15 | 31 May – 31 July | 3D Seismic |
| Total | GS/1204/1 | 22/25a | 13 April – 30 October | Vertical Seismic Profile |
| Nautical Petroleum | GS/1166/1 | 22/11b | 18 January – 30 June | 2D Seismic Survey, Sub-bottom Profiler CHIRP Survey |

OBC = Ocean Bottom Cable, OBS = Ocean Bottom seismic

### *Shipping*

8.19 Impacts from shipping on harbour porpoise within the Southern North Sea SAC have been identified as arising from shipping noise and collision impacts. Shipping noise is the predominant anthropogenic source of noise within the marine environment and is reported to have a negative effect on harbour porpoise within the Southern North Sea SAC when vessel traffic exceeds 80 vessels per day (Heinänen and Skov 2015). Shipping has been on-going in the southern North Sea for many hundreds of years and the area is important for shipping, with relatively high numbers of vessels occurring within it. Based on vessel track lines, in 2015 a total of 269,018 vessels track lines were recorded transiting across the SAC; an average of 737 vessels per day (MMO 2017a).

8.20 There is relatively widespread vessel activity in low densities across the Greater working Area, with higher density of traffic in nearshore waters, in particular in waters between Aberdeen and Fraserburgh and along the east coast of England (Figure 11).

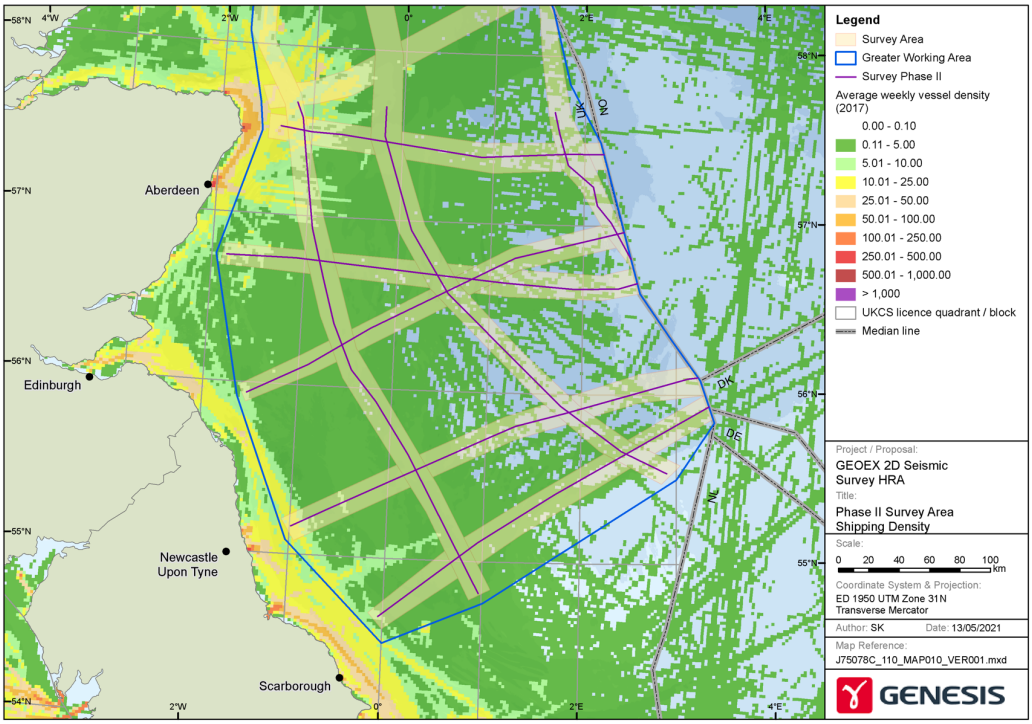



**Figure 11: Shipping density within the Greater Working Area during 2017.**

## *Fishing activity*

8.21 Fishing occurs widely across the southern North Sea and has also been on-going in the area for many hundreds of years. Most current fish landings are obtained from areas adjacent to the Southern North Sea SAC but there is widespread fishing activity in the southern half and north-eastern edge of the SAC and relatively moderate to high levels of fishing activity along the western edge of the central part of the SAC (Figure 12) (MMO 2017b). Note however, this does not include the activities of non-UK registered vessels that will occur within the site or vessels greater than 15 m in length.

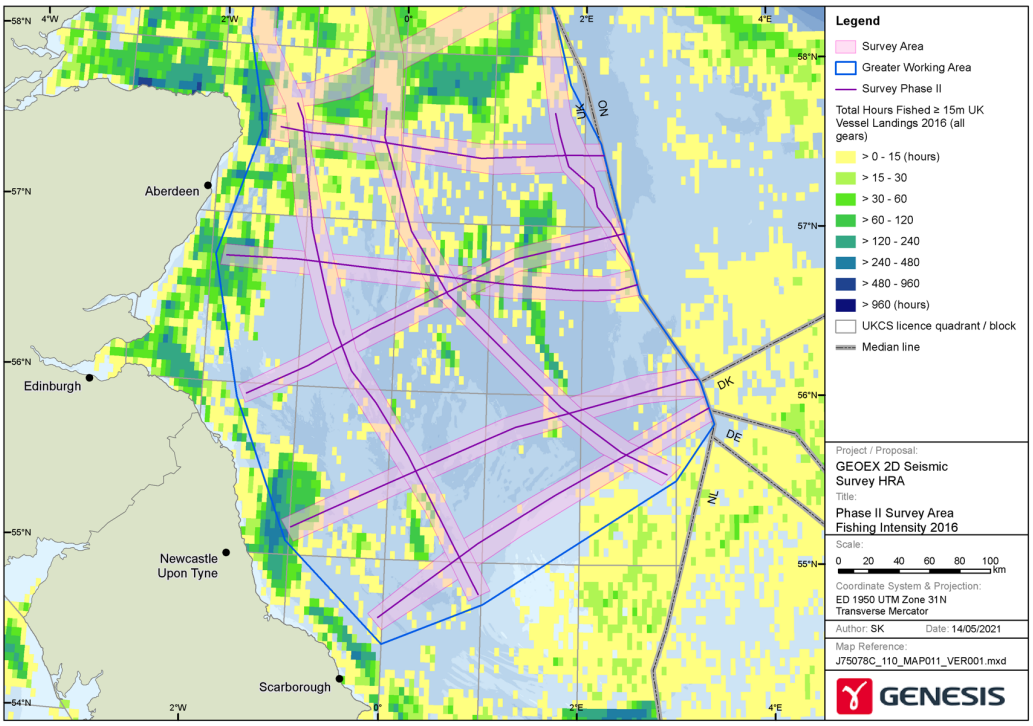



**Figure 12: Fishing intensity across the SAC during 2016 by UK registered vessels**

8.22 There is a high risk of an impact from bycatch associated with the fishing industry to harbour porpoise across the North Sea, i.e. there is good evidence of a significant impact. There is a medium risk of an impact from removal of prey (JNCC and NE 2019).

8.23 The bycatch of harbour porpoise in fishing gear is reported to be one of the most significant anthropogenic pressures impacting on the harbour porpoise population (JNCC and NE 2019). It is estimated that between 1,235 and 1,990 harbour porpoise die each year in the North Sea due to bycatch, predominantly in gill nets (ICES 2016, Mitchell *et al*. 2018, OSPAR 2017). This is approximately 0.6% of the North Sea Management Unit population.

Noise modelling predicts that the proposed seismic survey will not cause any direct mortality to any harbour porpoise and therefore there will be no in-combination impact between fishing and the survey.

### *In-combination conclusion*

8.24 Following consideration of all known developments that may cause a likely significant effect, BEIS considers that there are plans or projects likely to cause an in-combination likely significant effect. The activities likely to cause an in-combination impact considered within this HRA are:

- Construction pile-driving at Hornsea Two offshore wind farm,
- UXO clearance at Dogger A and Dogger B offshore wind farms,
- Geophysical Survey at Dogger A offshore wind farm,
- Geophysical Survey at Dogger B offshore wind farm,
- Geophysical Survey at Dogger C offshore wind farm,
- Geophysical Survey at Sofia offshore wind farm,
- Geophysical Survey at Hornsea Three offshore wind farm,
- Geophysical Survey at Hornsea Four offshore wind farm,
- Multiple Seismic and Geophysical Surveys (See Table 14),

# 9 LIKELY SIGNIFICANT EFFECTS TEST

9.1 Regulation 5 of the 2001 Regulations requires the Competent Authority to consider whether a development will have a likely significant effect on a European site, either alone or in combination with other plans or projects. A likely significant effect is, in this context, any effect that may be reasonably predicted as a consequence of a plan or project that may affect the Conservation Objectives of the features for which the site was designated but excluding trivial or inconsequential effects. An Appropriate Assessment is required if a plan or project is likely to have a significant effect on a European site, either alone or in combination with other plans or projects. A judgement of likely significant effect in no way pre-supposes a judgement of adverse effect on site integrity.

9.2 There are no recognised criteria as to what can be considered trivial or inconsequential impacts. Where predicted impacts are relatively very small compared to either the population of the management unit or the area of the site or the duration of the impact, it was determined that the impact would not cause a likely significant effect.

9.3 This section addresses this first step of the HRA, for which BEIS has considered the potential impacts of the survey both alone and in combination with other plans and projects on each of the interest features of the relevant European sites to determine whether there will be a likely significant effect.

### *Harbour porpoise*

9.4 Harbour porpoise are a qualifying species for the Southern North Sea SAC and Doggersbank SAC.

9.5 Within the Southern North Sea SAC harbour porpoise are known to occur throughout the site, with particular concentrations in the northern 'summer' area over which the proposed seismic survey overlaps. Noise modelling undertaken indicates that there is potential for auditory injury to occur within 320 m of the sound source and disturbance or displacement effects to occur 7.8 km from the airguns and extend over an area of 301 $km^2$ (Table 7).

9.6 The Doggersbank SAC is 23.1 km from the nearest survey line and therefore beyond the range noise from which the seismic survey is predicted to cause disturbance. Consequently, the proposed seismic survey will not cause a likely significant effect on harbour porpoise from the Doggersbank SAC.

9.7 Based on the predicted extent of potential impacts, it is concluded that there is potential for a likely significant effect on harbour porpoise from the proposed seismic survey within or adjacent to the Southern North Sea SAC; the potential impacts on harbour porpoise are therefore considered further in the Appropriate Assessment.

### *Bottlenose dolphin*

9.8 Bottlenose dolphin are a qualifying species for the Moray Firth SAC.

9.9 The Moray Firth SAC is 118 km from the nearest survey line. However, bottlenose dolphin from the SAC are known to occur in coastal waters along the east coast of Scotland and north-east England (Arso Civil *et al.* 2019). Noise modelling undertaken indicates that there is potential for auditory injury to occur within 10 m of the sound source and disturbance or displacement effects to occur 11 km from the airguns and extend over an area of 210 $km^2$ (Table 8).

9.10 The east coast bottlenose dolphin population are not known to occur regularly in waters beyond 4 km of the coast and the nearest survey line to the coast is 26 km from the coast (GEOEX 2021a). Consequently, it is predicted that there will be no overlap in the levels of noise capable of causing disturbance and the distribution of bottlenose dolphin along the east coast of Scotland and England.

9.11 The proposed seismic survey will not cause a likely significant effect on bottlenose dolphin from the Moray Firth SAC.

### *Grey seal*

9.12 Results from noise modelling indicate that there is potential for levels of noise to cause physical injury or disturbance and displacement to grey seals.

9.13 Grey seals are a qualifying species at the Berwickshire and North Northumberland Coast SAC, the Humber Estuary SAC, Isle of May SAC and Doggersbank SAC.

9.14 Grey seal are known to routinely forage within 100 km from their haul out sites and although they occur further offshore they do so less frequently. Noise modelling undertaken indicates that there is potential for auditory injury to arise within 99 m of the sound source. The potential extent of disturbance could extend to 17 km and encompass an area of 383 $km^2$ (Table 9).

9.15 Based on the results from noise modelling, the known offshore distribution of grey seals (Figure 6) and their behaviour, it is concluded that there is potential for a likely significant effect on grey seals from the Humber Estuary SAC, Berwickshire and North Northumberland Coast SAC and the Isle of May SAC; the potential impacts on grey seal from these three sites are therefore considered further in the Appropriate Assessment.

9.16 The Doggersbank SAC is 23.1 km from the Survey Area and therefore beyond the range noise from the seismic survey is predicted to cause disturbance within the site (Table 9). Consequently, the proposed seismic survey will not cause a likely significant effect on grey seals in the Doggersbank SAC.

### *Harbour Seal*

9.17 Results from noise modelling indicate that there is potential for levels of noise to cause physical injury or disturbance and displacement to harbour seals.

9.18 Harbour seals are a qualifying species for the Doggersbank SAC.

9.19 Noise modelling undertaken indicates that there is potential for auditory injury to arise within 99 m of the sound source and levels of noise capable of causing disturbance could extend to 17 km and encompass an area of 383 $km^2$ (Table 9).

9.20 Tracking of harbour seals in UK and Dutch waters indicate that they do not routinely travel further than 60 km from their haul out sites from between April and October. Therefore, densities of harbour seal within the SAC are predicted to be relatively very low.

9.21 The Doggersbank SAC is 23.1 km from the Survey Area. Consequently, noise from the proposed seismic survey is not predicted to cause disturbance to harbour seals within any SACs for which they are a qualifying feature.

9.22 Based on the results from noise modelling and known behaviour of harbour seals it is concluded that there will not be a likely significant effect on harbour seals within the Doggersbank SAC.

### *Sea Lamprey and River Lamprey*

9.23 The sea lamprey and river lamprey are qualifying species for the Humber Estuary SAC which lies 101 km from the nearest survey line. There is also potential for noise to impact on the prey species of harbour porpoise and seals from or within designated sites.

9.24 Fish hearing is based on detecting particle motion directly stimulating the inner ear. However, those with swim bladders are also able to detect pressure waves and can detect a wider range of frequencies and sounds of lower intensity than fishes without swim bladders (Popper 2003). Fish with swim bladders include prey species for harbour porpoise and seals, such as herring, are recognised to be hearing specialists. Those without, e.g. sandeels, are considered to have a relatively low sensitivity to noise. Most fish with swim bladders can detect sound within the 100 Hz to 2 kHz range, those without swim bladders are unlikely to detect sound above 400 Hz (Popper *et al*. 2014).

9.25 Results from the noise modelling indicate that noise levels capable of causing lethal effects on fish with swim bladders could occur out to 302 m from the airgun and for fish without swim bladders impacts could occur to 140 m (Table 10). The area of impact within which physical injury could occur is therefore relatively very small. However, the area within which disturbance could occur may be s greater. Modelling undertaken by the applicant indicates disturbance to fish will occur out to 603 m (ION 2020a).

9.26 Results from the noise modelling indicate that the there is potential for an impact on sea lamprey and river lamprey to within 140 m of the seismic survey and disturbance out to 603 m. Based on the distance of the seismic surveys from the SAC and the low risk of any Lamprey occurring in the area of the proposed survey it is concluded that there will not be a likely significant effect on sea lamprey or river lamprey from the proposed survey.

### *Seabirds*

9.27 During the breeding season seabird distribution is constrained by the requirement to return to breeding colonies. However, their foraging ranges can be extensive and breeding birds from a number of SPAs could occur across the Greater Working Area (Table 5). Out with the breeding season seabirds are widely dispersed away from their colonies and it is not possible to determine from which SPA, if any, those present in the area may be from.

9.28 The results from the assessment of potential impacts presented in Section 4 indicates that the only possible risk of an impact occurring that could cause a likely significant effect on seabirds is from noise arising during seismic surveys. Seabirds that feed on or near the sea surface, e.g. fulmar, Skuas, Gulls and Terns are at very low risk of any impact from underwater noise. Any periods below the sea surface are of relatively short duration and the risk of any impact occurring is considered very low.

9.29 Previous noise modelling undertaken on seabird species including gannet, puffin, guillemot and razorbill, indicate that the area within which there is the potential of a physical impact is very localised and extends no further than 42 metres from the airguns for any species that remain below the sea surface for periods of up to 2 minutes. For species that are below the sea surface for less than 30 seconds the potential extent of physical impact is estimated to be less than 20 m from an airgun (BEIS 2016b).

9.30 The physical presence of a seismic vessel will cause displacement of seabirds on the sea surface in advance of a vessel and a significant majority of seabirds on the sea surface will be displaced away in advance of an approaching vessel. Consequently, there is a very low risk of any seabird occurring within the range at which physical injury is predicted to occur.

9.31 Although it is not possible to model the area within which there is potential for disturbance from noise arising from the airguns, it is recognised that seabirds that forage below the sea surface may be disturbed over a potentially wider area. Should this occur, it is predicted that birds will remain on the sea surface and may avoid being underwater until the seismic vessel has moved away from the area or the birds will temporarily relocate away from the seismic survey.

9.32 The physical presence of vessels during any potential seismic survey will cause localised disturbance as birds avoid the vessel. The range at which birds may be displaced varies across

species. The impact from disturbance is relatively localised and temporary and will have no measurable effect on the individuals impacted.

9.33 There is potential for the prey species of seabirds to be impacted by possible seismic survey. Studies on the impacts to fish from seismic surveys indicate that any disturbance to fish is temporary and localised (Peña *et al*. 2013; Slotte *et al*. 2004; Wardle *et al*. 2001). Should fish be displaced, seabirds will either relocate to areas where prey species are present or remain until the seismic vessel has moved further away and the fish return to the area. Any potential impacts will be very localised and temporary and any effects will be inconsequential.

9.34 Results from noise modelling indicate a very localised area of potential risk of physical harm and recognising that any displacement impacts would be of short duration it is concluded that seabirds from the relevant SPAs are not at risk of a likely significant effect.

### *Habitats*

9.35 Habitats listed in the SAC citations will not be impacted by the proposed seismic survey and are not considered to be at risk of a likely significant effect. They are therefore not considered further in this Appropriate Assessment.

### *Likely significant effects test - conclusions*

9.36 Based on the information presented within the application relating to the proposed activities and the advice received during consultation it is concluded that it is not possible to exclude a likely significant effect on the following designated sites and qualifying species:

- Southern North Sea SAC: Harbour porpoise,
- Humber Estuary SAC: Grey seal,
- Berwickshire and North Northumberland Coast SAC: Grey seal,
- Isle of May SAC: Grey seal.

9.37 For all other designated sites and associated qualifying habitats or species it is concluded that there will not be a likely significant effect from the proposed seismic survey either alone or in-combination with other plans or projects.

# 10 APPROPRIATE ASSESSMENT

10.1 An Appropriate Assessment is triggered when the competent authority, in this case the Secretary of State, determines that a plan or project is likely to have a significant effect on a European site. Guidance issued by the European Commission states that the purpose of an Appropriate Assessment is to determine whether adverse effects on the integrity of the site can be ruled out as a result of the plan or project, either alone or in-combination with other plans and projects, in view of the site's conservation objectives (EC 2018).

10.2 The following sections assess whether there will be an adverse effect on any of the European sites identified as having qualifying species for which no likely significant effect could not be ruled out from the project alone and in-combination.

10.3 A dual approach based on outputs from two sets of noise modelling and supported by the use of EDR has been used for harbour porpoise in order to determine whether an adverse effect on the integrity of the Southern North Sea SAC will occur. There are no EDRs for other species of marine mammal and therefore noise modelling results have been used to support the assessment on grey seals.

10.4 The assessment of the potential impacts from the seismic survey is based on the combined results from noise modelling undertaken by the applicant and by BEIS. This approach takes into account project specific factors that can affect the level of sound produced and its propagation within the water column. From this it is possible to estimate the number of harbour porpoise that may be affected and the overall duration of the potential impacts. Based on the study published by ASCOBANS (2015) an annual reduction in the population of 1.7% could cause a population level decline (Para. 7.11). However, a similar level of impact from disturbance is predicted to not cause a population level of decline.

10.5 Following advice received a second approach to the assessment has also been undertaken based on recommendations by the JNCC and NE. This approach is based on the use of a generic EDR for all seismic survey activities irrespective of their location and airgun size. Following published evidence and advice received from the JNCC, for the purposes of this assessment a 12 km EDR has been used for the seismic survey. The extent and duration of the survey is then measured against thresholds above which an adverse effect on site integrity could arise, as described in Section 6.

## *Southern North Sea SAC (Harbour porpoise)*

### *Physical Injury*

10.6 Noise modelling undertaken indicates that, based on the weighted SEL threshold, there is potential for sound levels to cause the onset of PTS to harbour porpoise out to 320 m of the sound source (Table 7).

10.7 The peak harbour porpoise density across the Southern North Sea SAC is estimated to be >3 per km$^2$ (Figure 5) (Heinänen and Skov 2015). Based on this peak density and the worst-case scenario of PTS occurring out to 320 m of the survey, an estimated one harbour porpoise could be affected at the start of the seismic survey.

10.8 The North Sea Management Unit harbour porpoise population is 333,808 individuals and therefore the worst-case scenario of one harbour porpoise being impacted is <0.0001% of the Management Unit population.

10.9 The estimated area of potential impact from PTS is within 500 m of the airgun array and therefore within the radius which, if marine mammals are detected during a pre-shooting search, the commencement of the firing of the airguns must be delayed by a minimum of 20 minutes, as per the JNCC guidance (JNCC 2017a). Harbour porpoise will avoid the area of potential injury and move away from the seismic survey vessel as it approaches. Consequently, apart from when the operation of the airgun initially commences, there is a very low risk of physical injury to any harbour porpoise.

10.10 There is a low risk of harbour porpoise being physically impacted by the proposed seismic survey. In the extremely unlikely event the onset of PTS does occur, it would only affect a very small proportion of the relevant population.

### *Disturbance*

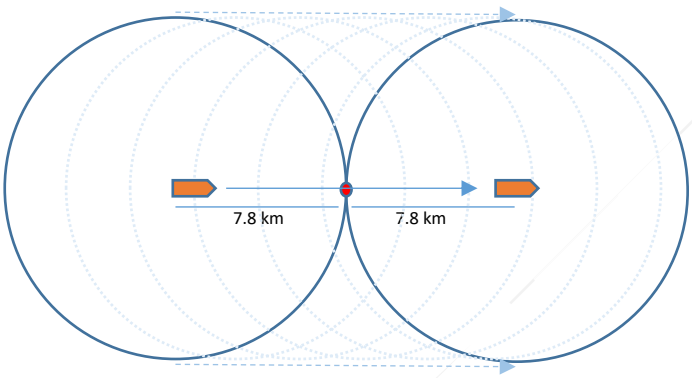
10.11 The largest distance any noise likely to cause disturbance is estimated to propagate out to is 7.8 km from the airguns, covering an area of 301 km$^2$ (Table 7). If disturbance occurs entirely within the SAC, then approximately 0.8% of the SAC as a whole and 1.1% of the 'summer' area could be affected by the proposed seismic survey at any one time.

10.12 Based on a peak site density of 3.0 ind./km$^2$ an estimated 903 harbour porpoise could be disturbed by a seismic survey. This is equivalent to 0.3% of the North Sea Management Unit harbour porpoise population being disturbed.

10.13 A seismic vessel will transit across an area and over the duration of a survey the total number of harbour porpoises disturbed will be greater. The application states that the seismic survey will be travelling at between 4.5 and 5 knots (8.4 - 9.26 km/h) (GEOEX 2021a, EPI 2021). As the vessel undertakes a survey, disturbance in any area will last less than two hours in any one location (Figure 13). Once the vessel has left the area, sound levels will reduce to background levels. The disturbance effects are therefore transient and once the vessel has moved away from an area there is, in effect, no disturbance on those porpoises previously impacted.

10.14 Studies undertaken in the Danish sector of the Central North Sea reported disturbance out to 12 km from a 3,570 cu. in. airgun, although the duration of the disturbance is not reported (Sarnocińska *et al*. 2020). Similar studies undertaken in the Moray Firth using a 470 cu in airgun

with source levels estimated to be 242–253 dB re 1 µPa @ 1 m (peak to peak), reported a decrease in the relative densities of harbour porpoises within 10 km of the airgun and an increase in densities at greater distances. However, porpoises continued to occur at sites within the impacted area during the seismic survey and there was a decline in the level of displacement over the ten day period that surveys were undertaken, indicating an increasing level of acclimation during the surveys. Once the surveys had ceased the number of detections returned to baseline levels within a day (Thompson *et al.* 2013, Pirotta *et al.* 2014). Therefore, any displacement effects caused by seismic surveys will be temporary, with porpoises predicted to return to the area impacted within 24 hrs.




● = Location of harbour porpoise in order for maximum duration of disturbance to occur.
Maximum extent of disturbance from seismic survey at 145 dB re 1 µPa at 1 m – 8.5 km.
Total distance of impact – 15.6 km.
Vessel speed – 8.4 km/h.
Total duration of disturbance impact = 1hr 50 mins.

**Figure 13: Diagram showing potential maximum duration of disturbance to harbour porpoise from seismic survey.**

### *Threshold Approach*

10.15 The JNCC advise that the assessment for harbour porpoise within the Southern North Sea SAC should be undertaken by the proposed threshold approach whereby disturbance should not exceed 20% of the SAC 'summer' or 'winter' areas over the course of one day and on average 10% of an area over the course of a single season (see Section 7). To calculate the extent of noise within the SAC using the threshold approach the extent of disturbance from a moving sound source over the course of 24 hrs and the season is required. This assessment has been undertaken by BEIS as part of this HRA.

10.16 Based on information presented within the application, BEIS have estimated the area of the survey within the SAC and within the SAC plus a 12 km buffer (the extent of the EDR).

Furthermore, by using GIS, BEIS have estimated the maximum length a single survey line may be within the SAC and the total length of line that may be surveyed within the SAC (Figure 14).

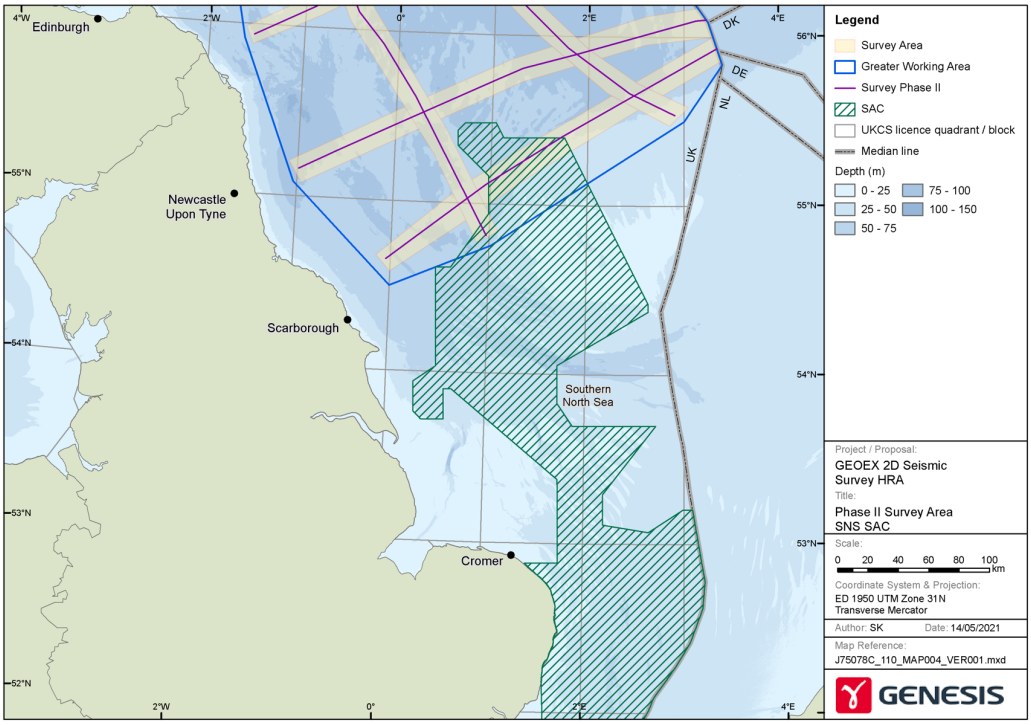



**Figure 14: Area of proposed seismic survey within the Southern North Sea SAC.**

### Daily Threshold

10.17 To calculate whether the daily threshold of 20% of the seasonal area is impacted an accurate estimate of the level of activity within the SAC is required in order to calculate the likely area impacted each day.

A total length of 64 km of survey line occurs within the SAC and noise from the seismic survey from survey lines within, or adjacent to, the SAC will cover a total area of 1,709 km$^2$, based on a 12 km EDR. There are two survey lines within the SAC with the maximum length of longest line within the SAC being 56.1 km, with a further 7.9 km to be collected along the shorter second line. The area of SAC impacted by each survey line is therefore 1,346 km$^2$ and 190 km$^2$. A further 173 km$^2$ may be impacted by survey lines adjacent to the SAC but not within it (Figure 14).

Based on the survey programme and location of the survey lines it is anticipated that noise arising from the longest line within the SAC will occur on a different day from the second, shorter line and lines adjacent to the SAC. Therefore, an estimated maximum of 3.6% of the SAC as a whole and 5.0% of the 'summer' area may be impacted on one day. Consequently, the daily threshold will not be exceeded by the proposed seismic survey on its own.

### Seasonal Threshold

10.18 The survey is planned to commence on 10 June 2021 and be completed by 30 September 2021 and be undertaken over a period of between 21 and 40 days, of which no more than two days are predicted to impact on the SAC.

10.19 The total area impacted within the SAC of 1,709 km$^2$, will occur over two days with 5.0% of the 'summer' area impacted on one day and 1.3% the second day[4]. Due to the differences in the extent of daily impact between the two days of survey within or adjacent to the SAC the seasonal thresholds for each of the two days has been calculated (Table 15).

10.20 The two combined seasonal thresholds is 0.06% and therefore the seasonal threshold of 10% is not exceeded.

**Table 15: Estimated extent of seasonal disturbance on harbour porpoise from proposed GEOEX seismic survey within the SAC.**

| SAC area | Area impacted per day (km$^2$) | Daily Threshold (%) | Estimated duration of impact (days)[1] | Seasonal Threshold (%) |
|---|---|---|---|---|
| *Day 1: Maximum daily impact - 1 day in summer period)* | | | | |
| 'summer' | 1,346 | 5.0 | 2 | 0.05 |
| *Day 2: Minimum daily impact – 1 day in summer period* | | | | |
| 'summer' | 363 | 1.3 | 2 | 0.01 |

1 - Estimated duration of impact includes one day for recovery following displacement from an area.

### *Conclusion*

10.21 Results from noise modelling indicate that no more than one harbour porpoise is at risk of physical injury from noise arising from the airguns. With proposed mitigation discussed in Section 12 there is a very low risk of any harbour porpoise being injured.

10.22 There is a risk of harbour porpoise being displaced or disturbed by the proposed seismic survey. Noise modelling indicates that up to 903 harbour porpoise may be disturbed at any one time; this is 0.3% of the North Sea Management Unit population and therefore below the predicted level of disturbance that could cause a population level effect. The disturbance will be of short duration as the vessel transits through the Survey Area. Once the vessel has passed, any changes in behaviour due to disturbance will cease quickly after the vessel has moved away and any porpoises that may have been displaced are predicted to return to the area within approximately 24 hrs.

[4] The area impacted on the second day is the combined total of 190 km$^2$ from the survey line within the SAC and 173 km$^2$ from survey lines adjacent to the SAC.

10.23 The results from the threshold approach indicate that up to 5.0% of the 'summer' area may be impacted each day and 0.06% of the seasonal threshold. The daily and seasonal thresholds are not exceeded.

10.24 The proposed survey will not affect the supporting habitats and will have a temporary and localised impact on the supporting prey species, e.g. fish. Once the proposed survey has moved away or ceased there will be no effect on the distribution, abundance and population dynamics of the species.

10.25 Based on the best available information and supported by results from noise modelling and the threshold approach, BEIS is satisfied that the proposed survey alone will not have an adverse effect upon the integrity of the Southern North Sea SAC with respect to harbour porpoise.

### *Berwickshire and North Northumberland Coast SAC, Humber Estuary SAC and Isle of May SAC*

#### *Grey seal*

10.26 It is considered, based on the known distribution of grey seals that grey seals from the Berwickshire and North Northumberland Coast SAC, Humber Estuary SAC and the Isle of May SAC are at risk of being impacted by noise arising from the proposed survey (Figure 6).

10.27 Densities of grey seal across the proposed seismic survey working area range from <1 individual per 5 $km^2$ and <50 individuals per 5 $km^2$, i.e. between <0.04 and 2.0 individuals per $km^2$ (Figure 6). Over the majority of the Greater Working Area densities of grey seals are relatively low with higher areas of usage over the UK sector of the Dogger Bank, North-east England and outer Firth of Forth.

#### *Physical Injury*

10.28 Results from noise modelling presented within the application indicate that there is a risk of physical injury in the form of PTS within 40 m of the sound source (Table 9). Additional modelling undertaken for previous assessments indicates that this could extend to 99 m (although this is based on modelling results from a different airgun).

10.29 The potential area within which the onset of PTS is predicted to occur is very localised and covers an area of no more than 0.031 $km^2$ and is likely to be less. The presence of a Marine Mammal Observers (MMO) during the survey will ensure that the risk of any grey seals being present within the area at which the onset of PTS is predicted to occur is very low.

#### *Disturbance and Displacement*

10.30 When undertaking surveys the vessel will be travelling up to 5 knots (9.26 km/h). Noise capable of causing disturbance is predicted to occur out to no more than either 6 km or 17 km (depending on modelled outputs) from the survey vessel. Consequently, as the vessel transits along a

seismic transect, disturbance in any one area will last no more than two hours based on the maximum area of noise likely to cause disturbance is predicted to occur and the vessel travelling at its slowest operating speed. Once the vessel has left the area, noise levels will reduce to ambient background levels.

10.31 The Berwickshire and North Northumberland Coast SAC lies 26.5 km from the nearest survey line, the Isle of May SAC lies 68.1 km and the Humber Estuary SAC is 101 km away. Noise levels from the proposed survey will not impact directly on the SACs. However, it could impact on seals offshore.

10.32 The density of grey seals across the Greater Working Area vary, with highest densities occurring off north-east England where densities of 2.0 ind./km$^2$ may occur (Figure 6). If disturbance occurs out to 17 km and impacts an area up to 383 km$^2$, an estimated 766 grey seal could be disturbed. Elsewhere densities are lower and predominantly below 0.2 ind./km$^2$ and in these areas an estimated 77 grey seals may be disturbed at any one time.

10.33 The estimated grey seal population for the Berwickshire and North Northumberland Coast SAC is 24,800 individuals, consequently, if all the grey seals impacted are from this SAC, at a density of 2.0 ind./km$^2$, an estimated 3.1 % of the SAC population could be disturbed at any one time.

10.34 The estimated grey seal population for the Humber Estuary SAC is 24,272 individuals, consequently, if all the grey seals impacted are from this SAC at density of 0.2 ind./km$^2$, 0.32% of the SAC population may be disturbed at any one time.

10.35 The estimated grey seal population for the Scottish east coast management area (which includes grey seals from the Isle of May SAC) is 14,216 individuals, consequently, if all the grey seals impacted are from this SAC at density of 0.2 ind./km$^2$, 0.54% of the population may be disturbed at any one time.

10.36 Note that it is extremely unlikely that all grey seals disturbed are from the one SAC and that it is highly probable that grey seals within the Greater Working Area originate from a number of sites located along the east coast and therefore all the predicted impacts will not be impacting upon a single site.

10.37 There is potential for repeated levels of noise capable of causing both displacement or disturbance to occur as the survey vessel undertakes the survey along pre-determined survey lines within the area. The duration of any potential impact depends on the total length of seismic survey line occurring within the area and the speed of the vessel.

10.38 It is likely that grey seals receiving levels of sound capable of causing disturbance will avoid the area. However, the duration of the impact for individual seals will be relatively short as the seismic vessel will move outwith the area and the seals are capable of temporarily relocating to areas away from the sound source.

10.39 Studies undertaken on seals indicate that they are not significantly impacted by seismic surveys. Harris *et al*. (2001) reported no significant difference in the number of ringed and bearded seals recorded when 1,320 cu. in. air guns with a sound source of 230 dB dB re 1 µPa (0-p) were operating compared to when they were not. However, the increase in the median distance at which they were observed from 144 m to 234 m was significant, indicating that seals did move away from the vessel when the airguns were operating. Other studies have indicated a level of displacement and potential increase in haul out behaviour when airguns have been operating but have also shown that the behaviour of seals quickly return to normal once the airguns have ceased operating (Thompson *et al.* 1998). Similar results have been reported from studies undertaken on harbour seals impacted by piling activities, where it has been shown that displacement effects can occur out to 25 km from the sound source but within two hours of the cessation of piling the distribution of seals returns to pre-piling scenarios (Russell *et al.* 2016).

10.40 The potential impacts on individual grey seals will vary, depending on individuals' sensitivities and habituation to noise. Furthermore, studies suggest that the response to noise may depend on whether the sound is sudden and causes a startle response or is more gradual and allows habituation to occur and therefore avoids a startle response. Where sound levels are increased more gradually, i.e. by soft-start, a reduced level of displacement is likely (Götz and Janik 2011).

10.41 The impacts from the proposed seismic survey may cause temporary displacement or disturbance behaviour that could reduce the ability of grey seals to forage. Grey seals are opportunistic feeders and can, if prey availability changes, adapt to foraging on alternative prey. Noise modelling indicates a relatively localised effect on potential prey species but in the unlikely event that grey seals are unable to forage in the wider area then they will be able to survive the short period of time during which the survey will be causing an impact without food, surviving off their existing fat reserves.

### *Conclusion*

10.42 It is predicted that there is a very low risk of any physical injuries to grey seals arising from the proposed seismic survey. However, grey seals from the Berwickshire and North Northumberland Coast SAC, the Humber Estuary SAC and the Isle of May SAC are at risk of being displaced or disturbed. Displaced grey seals will relocate to other areas and are predicted to return shortly after the sound levels are below that at which displacement occurs. Disturbance to grey seals may occur but results from noise modelling indicate that sound levels capable of causing disturbance will occur for less than two hours at any one point and evidence from other studies indicate that the impacts from disturbance will be temporary and predicted to be of relatively short duration.

10.43 The duration and effect of any impact on grey seals is predicted to be temporary and although the proposed survey will cause a level of displacement and disturbance, it will not cause any

direct or indirect mortality to grey seals and therefore will not impact on the population or effect its ability to maintain itself in the long-term.

10.44 The proposed survey will not affect the supporting habitats and will have a temporary and localised impact on the supporting prey species, e.g. fish. Once the proposed survey has moved away or ceased there will be no effect on the distribution, abundance and population dynamics of the species.

10.45 Based on the best available information and supported by results from noise modelling presented in the application, BEIS is satisfied that the proposed survey alone will not have an adverse effect upon the integrity of the Berwickshire and North Northumberland Coast SAC, Humber Estuary SAC and Isle of May SAC with respect to grey seals.

# 11 IN-COMBINATION ASSESSMENT

11.1 There is potential for in-combination impacts to arise due to noise from other known or planned activities and the proposed GEOEX seismic survey.

11.2 The following projects have been identified as having potential to cause an in-combination impact:

- Hornsea Project Two offshore wind farm – Pile-driving,
- UXO clearance at Dogger A and Dogger B offshore wind farms,
- Geophysical Survey at Dogger A offshore wind farm,
- Geophysical Survey at Dogger B offshore wind farm,
- Geophysical Survey at Dogger C offshore wind farm,
- Geophysical Survey at Sofia offshore wind farm,
- Geophysical Survey at Hornsea Three offshore wind farm,
- Geophysical Survey at Hornsea Four offshore wind farm,
- ION Geophysical Seismic Survey – multi-block airgun noise.
- Ithaca Geophysical survey – Block 29/10 airgun noise,
- CGG Services 3D seismic – Block 19/8 Quad 21 Phase 4 3D airgun noise,
- CGG Services 3D seismic – Block 21/30 3D airgun noise,
- CGG Services 3D seismic – Block 21/15 Brodgar Infill 3D airgun noise,
- Jersey Petroleum – Block 19-17 airgun noise,
- Nautical Petroleum 2D seismic – Block 22/11b airgun noise.
- Total Vertical Seismic Profile – Block 22/25 airgun noise.

### *Hornsea Project Two Pile driving*

11.3 The Hornsea Two offshore wind farm is located within Subzone 2 of the Round 3 Offshore Wind Farm Zone; Zone 4: Hornsea. At its closest point Hornsea Two lies 89 km from shore and covers an area of 462 km$^2$; of which 298 km$^2$ of the wind farm site lies within the SAC. In addition to the wind farm area an export cable route crosses the SAC. It is estimated that 36 km of the cable route is within the SAC (Figure 9). At its closest point, pile-driving at Hornsea two could occur no closer than 94.5 km from the closest survey line (Figure 15).

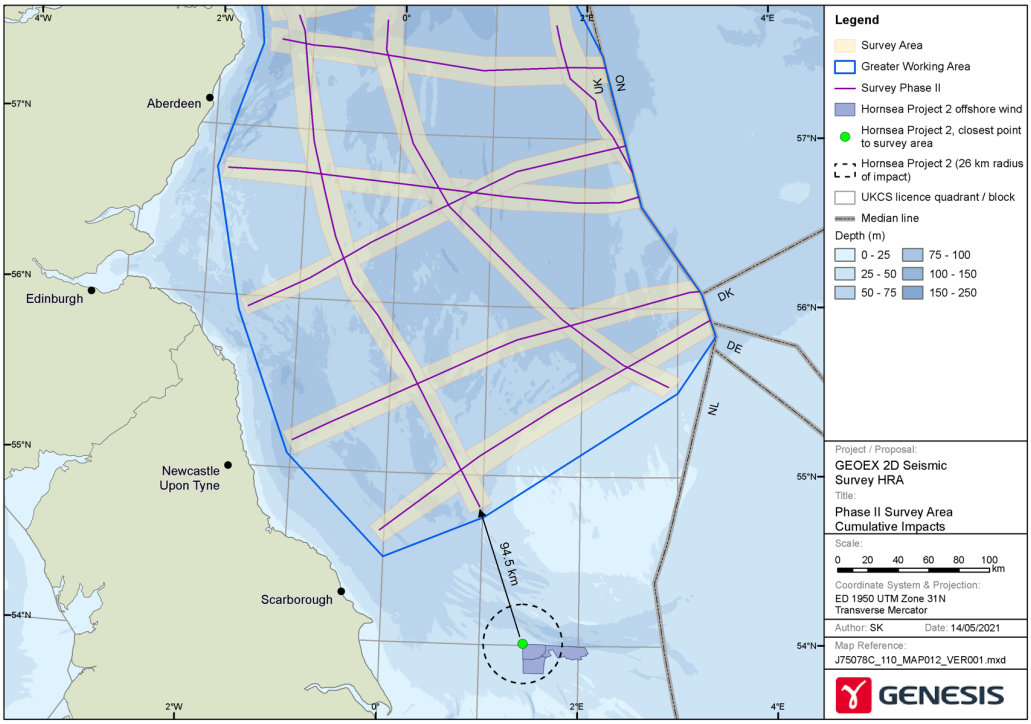



**Figure 15: Location of planned pile-driving at Hornsea Two and the proposed GEOEX seismic survey.**

11.4 Ørsted will be installing turbine foundations throughout 2021, although the exact timing of the activities are unknown. A total 165 turbines are to be installed.

11.5 For the purposes of this assessment noise modelling undertaken by BEIS for the Review of Consents within the Southern North Sea SAC has been used (BEIS 2020). The modelling results are based on the use of a 3,000 kJ hammer at Hornsea Two wind farm.

11.6 The results from the modelling (based on a weighted SEL) indicate that the onset of PTS could occur out to 1,534 m and encompass an area of 7.38 $km^2$. Levels of noise predicted to cause disturbance (based on unweighted SEL) could occur out to 29.5 km and cover an area of 2,794 $km^2$.

11.7 Based on the results from noise modelling and a peak density of 2.22 ind./$km^2$ an estimated 16 harbour porpoise are at risk of PTS from the pile-driving and 2,119 harbour porpoise may be disturbed or displaced, of which 1,982 may be within the SAC (BEIS 2020).

11.8 However, the use of an acoustic deterrent device will be operated during all pile-driving activities and this will significantly reduce the risk of any harbour porpoise occurring within the range at which the onset of PTS is predicted to arise.

11.9 Noise modelling undertaken for Hornsea Two and presented in the application indicates that the onset of PTS in grey seals would occur within 500 m of pile-driving and displacement would occur

no further than 2 km and extend over an area of 12.57 km$^2$. The estimated number of grey seal predicted to be displaced by pile-driving is no more than 25 individuals (SMart Wind 2015).

11.10 The results of the assessment based on a 26 km EDR for pile-driving turbine foundations indicate that up to 1,976 km$^2$ of the 'summer' area of SAC may be impacted. Turbines installed outwith the SAC or nearer the SAC boundary will have a smaller EDR overlapping the SAC. Consequently, an assessment based on all turbines impacting a maximum area within the SAC is an unrealistic worst-case.

11.11 As a worst-case, noise from pile-driving at Hornsea Two could cause displacement of harbour porpoise over 5.3% of the SAC as a whole and 7.3% of the 'summer' area. There will be no impacts on the 'winter' area. Based on the worst-case scenario, the seasonal average is estimated to be 6.7% of the 'summer' area (BEIS 2020).

11.12 A realistic worst-case scenario for assessing the seasonal impact is based on the average area impacted by pile-driving each of the 165 turbine foundations over the course of a single season. Based on a realistic worst-case scenario the seasonal threshold is 4.7% (Ørsted 2020).

**Table 16: Estimated extent of seasonal disturbance on harbour porpoise from proposed pile-driving at Hornsea 2 offshore wind farm within the SAC.**

| SAC area | Maximum area of SAC impacted per day (km$^2$) | Mean Daily Threshold (%) | Estimated duration of impact (days) [1] | Seasonal Threshold (%) |
|---|---|---|---|---|
| *Turbine foundation installation – Unrealistic worst-case* | | | | |
| 'summer' | 1,976 | 7.3 | 167 | 6.7 |
| *Turbine foundation installation – Realistic worst-case* | | | | |
| 'summer' | 1,401 | 5.2 | 167 | 4.7 |

1 – This accounts for two days 'recovery time' following cessation of pile-driving

## *Dogger A and Dogger B offshore wind farm UXO clearance*

11.13 The Dogger A and Dogger B offshore wind farms (formerly known as Creyke Beck A and Creyke Beck B) are located in Round 3 Offshore Wind Farm Zone; Zone 3: Dogger Bank. The Zone is located between 125 km and 290 km off the coast of Yorkshire. The Dogger A offshore wind farm is located, at its closest point, 131 km from shore and covers an area of 515 km$^2$ and the Dogger B is located, at its closest point, 131 km from shore and covers an area of 599 km$^2$. Both wind farms lie within the boundaries of the Southern North Sea SAC with Dogger B being the closest to the proposed GEOEX survey (Figure 9 and Figure 16).

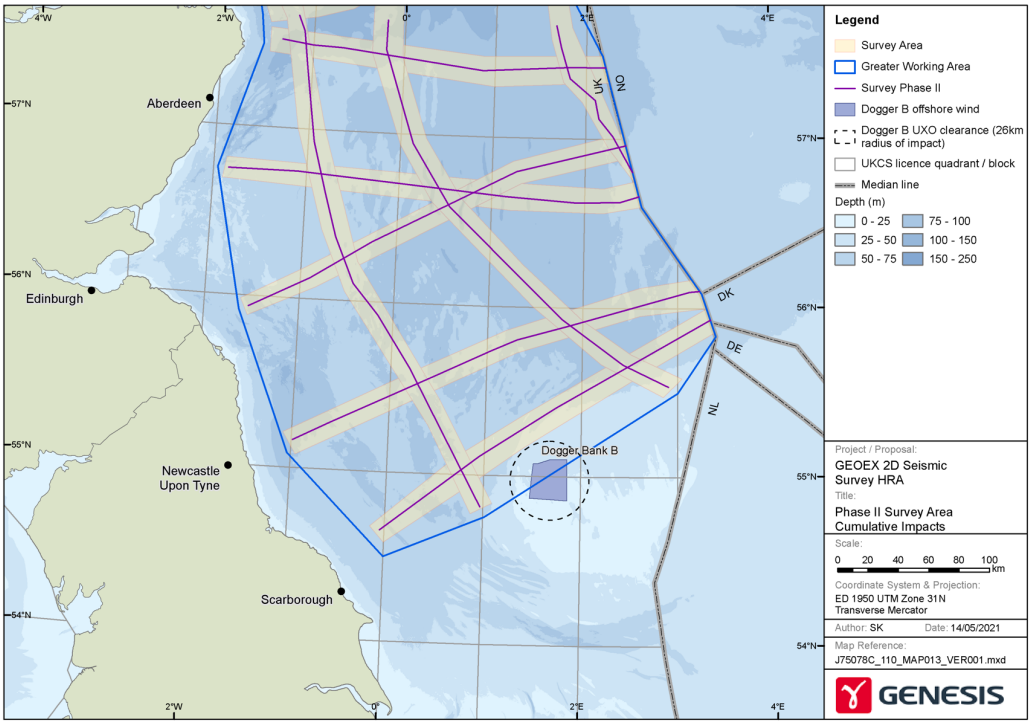



**Figure 16: Proposed UXO clearance at Dogger B and location of proposed GEOEX seismic survey.**

11.14 Clearance of unexploded ordnance within both Dogger A and Dogger B and along the export cable route is planned to be undertaken over a six week period between May and December 2021. A geophysical survey is to be undertaken to determine the presence of UXO within the survey area. The exact number of UXO items to be cleared is unknown but it is predicted that up to 25 items of UXO with a maximum charge weight of 700 kg NEQ may need to be cleared (DBWF 2021).

11.15 Mitigation to reduce the potential impacts of UXO detonation on marine mammals, fish and other marine wildlife includes the use of low-order clearance. Low-order clearance entails the use of a small charge to burn out the explosive material from a UXO, without the need of detonating the UXO. Consequently, there is a significant reduction in the level of noise arising from its use.

11.16 In the event that, following an investigation, the use of low-order clearance is deemed unsuitable, bubble-curtains will be deployed under certain environmental conditions. However, it is possible that neither the use of low-order clearance or the use of bubble curtains is possible. If this occurs then the UXO will be cleared without the use of noise limiting mitigation.

11.17 Noise modelling undertaken by the applicant indicates that the onset of PTS could occur in harbour porpoise over an area of 670 $km^{2.}$ Based on an average Southern North Sea SAC density and the Dogger Bank Zonal density both of 0.71 ind./$km^2$ an estimated 476 harbour

porpoise are at risk of PTS from the detonation of UXO (DBWF 2021, Forewind 2014, BEIS 2020) [5]. In the event that a bubble curtain is used the area impacted is reduced to 85 km$^2$ and could therefore impact on 60 harbour porpoise.

11.18 An acoustic deterrent device (ADD) will be operated during all UXO clearance. The length of time the ADD is operating will depend on whether other noise mitigation measures are being undertaken. If low-order clearance is used the ADD will be operational for 15 minutes, if bubble curtains are used the ADD will be operated for 50 minutes and if no noise limiting mitigation is being undertaken the ADD will be operated for 155 minutes. The use of the ADD will reduce the risk of any harbour porpoise from occurring within the range at which the onset of PTS is predicted to occur.

11.19 In order to estimate the number of harbour porpoise disturbed from UXO clearance the EDR of 26 km has been used, equating to an area of 2,124 km$^2$. Based on a site specific density of 0.71 ind./km$^2$, the estimated number of harbour porpoise that could be disturbed is 1,508 individuals. This is precautionary as it is anticipated that either low-order clearance or bubble curtains will be in place to significantly reduce the extent of possible disturbance.

11.20 The applicant has undertaken an assessment of the potential disturbance to harbour porpoise within the Southern North Sea SAC using the threshold approach. A number of potential worst-case scenarios have been assessed depending on the location of the UXO in relation to the SAC and a presumption that no noise limiting mitigation measures are in use, i.e. neither low-order detonation nor bubble curtains are used. The results from all three scenarios indicate that UXO cleared within either the Dogger A or B wind farm areas could impact on 7.9% of the 'summer' area. However, the average potential area of overlap ranges from between 4% of the 'summer' area along the export cable route and 7.8% of the summer area in area to be cleared within Dogger B (DBWF 2021) (Table 17).

11.21 In the event that noise reducing mitigation is used during the clearance of UXO, the realistic worst-case scenario is for the clearance to impact across an area of 707 km$^2$ contributing 2.6% of the daily threshold (Table 17)[6]

11.22 The seasonal impact ranges from between 0.55% and 1.07% of the seasonal threshold based on a realistic worst-case scenario (Table 17).

[5] Note the assessment undertaken in support of the application suggests that 595 harbour porpoise could be at risk of the onset of PTS and up to 2,003 may be disturbed (DBWF 2021). These estimates are based on the SCANS III harbour porpoise density of 0.888 ind./km$^2$. The use of site specific density data obtained from at least 24 months of survey data, as used for this assessment, is considered to be more robust than a density estimated from a single survey collected during a single month in a single year. Consequently, the estimated number of harbour porpoise impacted in this assessment is different from that estimated within the DBWF (2021) assessment.

[6] There is no published EDR for the use of bubble curtains when undertaking UXO clearance. For the purposes of this assessment it is presumed to be 15 km radius, based on the EDR for pile-driving with noise abatement.

11.23 Although it is conceivable that an item of UXO could be detonated without any form of noise limiting mitigation, the probability of this occurring is relatively low. However, as a realistic worst-case scenario it is possible for it to occur on one day and therefore contribute to the daily threshold. However, it is not realistic to presume that this would occur for all possible 25 detonations over the course of a season. Consequently, calculating a seasonal threshold based on their being no noise limiting mitigation is an unrealistic worst-case scenario.

**Table 17: Estimated extent of daily and seasonal disturbance on harbour porpoise from proposed Dogger A and Dogger B offshore wind farm UXO clearance within the SAC.**

| SAC area | Maximum area of SAC impacted per day ($km^2$) | Daily Threshold (%) | Estimated duration of impact (days) [1] | Seasonal Threshold (%) |
|---|---|---|---|---|
| *UXO clearance at Dogger A – Unrealistic worst-case (no mitigation)* | | | | |
| 'summer' | 2,124 | 7.9 | 25 | 1.07 |
| *UXO clearance at Dogger B – Unrealistic worst-case (no mitigation)* | | | | |
| 'summer' | 2,124 | 7.9 | 25 | 1.07 |
| *UXO clearance export cable route – Unrealistic worst-case (no mitigation)* | | | | |
| 'summer' | 2,124 | 7.9 | 25 | 1.07 |
| *UXO clearance at Dogger A – Realistic worst-case (no mitigation)* | | | | |
| 'summer' | 1,695 | 6.3 | 25 | 0.86 |
| *UXO clearance at Dogger B – Realistic worst-case (no mitigation)* | | | | |
| 'summer' | 2,121 | 7.8 | 25 | 1.07 |
| *UXO clearance export cable route – Realistic worst-case (no mitigation)* | | | | |
| 'summer' | 1,062 | 4.0 | 25 | 0.55 |
| *UXO clearance at Dogger A – Worst-case (with bubble curtain mitigation)* | | | | |
| 'summer' | 707 | 2.6 | 25 | 0.35 |
| *UXO clearance at Dogger B – Worst-case (with bubble curtain mitigation)* | | | | |
| 'summer' | 707 | 2.6 | 25 | 0.35 |
| *UXO clearance export cable route – Worst-case (with bubble curtain mitigation)* | | | | |
| 'summer' | 707 | 2.6 | 25 | 0.35 |

The *Unrealistic worst-case (no mitigation)* is based on the maximum area of impact occurring at all UXO clearance locations.

The *Realistic worst-case (no mitigation)* is based on the average area impacted within the SAC.

The *Worst-case (with bubble curtain mitigation)* is based on the maximum area of impact occurring at all UXO clearance locations.

11.24 The applicant has undertaken an assessment on the potential impacts on grey seals from the proposed UXO clearance. Based on noise modelling undertaken it is estimated that a total of six grey seals could be impacted by PTS if no noise limiting mitigation is undertaken and less than

one could be impacted if bubble curtains are used. The number of grey seals estimated to be disturbed by UXO clearance is 341 individuals without any mitigation, this is reduced to 14.5 individuals if bubble curtains are used (DBWF 2021).

### *Wind farm geophysical surveys*

11.25 Geophysical surveys for the offshore wind farm industry are not regulated and require a voluntary notification of the proposed activities to be submitted to the MMO. Consequently, there is no information available regarding the potential five geophysical surveys that may be undertaken within the Southern North Sea SAC during 2021.

11.26 Within the DBWF (2021) environmental information supporting the application for the proposed UXO clearance the applicant has considered the potential impacts from three of the geophysical surveys that they propose to be undertaking during 2021, namely those at Dogger A, B and C offshore wind farms and included an assessment for the proposed geophysical survey at Sofia offshore wind farm. No information on the proposed geophysical surveys at Hornsea Three or Hornsea Four are available and therefore no assessment can be undertaken for these two potential activities.

11.27 The estimated number of harbour porpoise is based on a 5 km radius of impact, as per the recommended EDR. With a site specific density of 0.71 ind./km$^2$ an estimated 56 harbour porpoise may be disturbed at any given time for each of the four proposed geophysical surveys for which there is some information.

11.28 The applicant has calculated the daily area of potential disturbance within the SAC for all four surveys to be 256 km$^2$ (DBWF 2021). Consequently, each survey could impact on the 0.9% of the daily threshold and between 0.5% and <0.01% of the seasonal threshold. (Table 18).

**Table 18: Estimated extent of daily and seasonal disturbance on harbour porpoise from proposed geophysical surveys at Dogger and Sofia offshore wind farms within the SAC.**

| SAC area | Area of SAC impacted per day ($km^2$) | Mean Daily Threshold (%) | Estimated duration of impact (days) | Seasonal Threshold (%) |
|---|---|---|---|---|
| *Dogger A geophysical survey* | | | | |
| 'summer' | 256 | 0.9 | 111 | 0.5 |
| *Dogger B geophysical survey* | | | | |
| 'summer' | 256 | 0.9 | 111 | 0.5 |
| *Dogger C geophysical survey (export cable only)* | | | | |
| 'summer' | 256 | 0.9 | 1 | <0.01 |
| *Sofia geophysical survey (export cable only)* | | | | |
| 'summer' | 256 | 0.9 | 1 | <0.01 |

11.29 The estimated number of grey seal to be impacted by each of the geophysical surveys is estimated to be 16 individuals (DBWF 2021).

## *Oil and gas industry activities*

11.30 There are a number of planned oil and gas related activities that could have the potential to cause an in-combination impact (Table 14).

### *ION 3D Seismic*

11.31 GX Technology EAME Ltd / GX Technology Corporation (ION) are undertaking a 3D seismic survey in Quadrants 34 - 38 and 40 – 44, off the east coast of England (ION 2020a,b). The survey has been subject to an HRA which concluded that there would be no adverse effects on any designated site from the survey either alone or in-combination (BEIS 2021).

11.32 The survey commenced in mid-April and will be completed by 31 October 2021. The total Greater Working Area is 21,344 $km^2$, although the Survey Area (the area within which airguns are operating) is 12,627 $km^2$ (ION 2020a). The total length of survey line wholly within the Southern North Sea SAC has been calculated by BEIS to be a maximum of 4,816 km, with a maximum length of any single line within the SAC of 73.3 km (BEIS 2021). The total volume of airguns being operated is 3,390 cu. in.

11.33 The ION seismic survey area partially overlaps the Greater Working area of the proposed GEOEX survey (Figure 17). Both surveys occur within the Southern North Sea SAC and could impact on harbour porpoise. Both surveys could also cause an in-combination impact on grey seals from the Humber Estuary SAC and Berwickshire and North Northumberland Coast SAC, but not the Isle of May SAC.

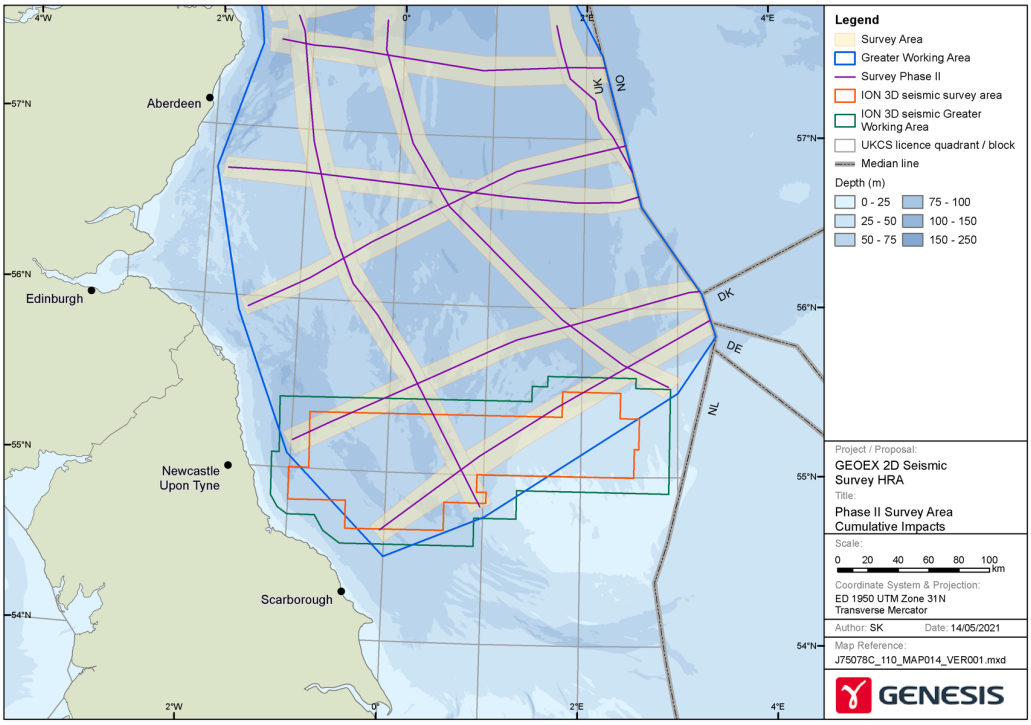



**Figure 17: Area of ION 3D seismic survey and location of proposed GEOEX seismic survey.**

11.34 Results from noise modelling undertaken in support of the ION application indicates that no more than one harbour porpoise is at risk of physical injury from noise arising from the airguns. With proposed mitigation in place there is a very low risk of any harbour porpoise being injured.

11.35 Noise modelling indicates that up to 903 harbour porpoise may be disturbed at any one time by the ION survey.

11.36 The results from the threshold approach undertaken for the HRA indicate that up to 6.5% of the 'summer' area may be impacted each day and 2.2% of the seasonal threshold (Table 19) (BEIS 2021)[7].

[7] The daily threshold was based on the maximum possible impact that could occur in any one day, whereas the seasonal threshold was based on the average length of line surveyed each day within the SAC across the course of a season.

**Table 19: Estimated extent of seasonal disturbance on harbour porpoise from proposed ION seismic survey within the Southern North Sea SAC.**

| SAC area | Area impacted per day (km$^2$) | Daily Threshold (%) | Estimated duration of impact (days) | Seasonal Threshold (%) |
|---|---|---|---|---|
| *Worst-case (Maximum daily impact - 156 days in summer period)* | | | | |
| 'summer' | 1,759 | 6.5 | 153 | 5.4 |
| *Realistic worst-case (Mean daily impact 156 days in summer period)* | | | | |
| 'summer' | 700 | 2.6 | 153 | 2.2 |

11.37 Noise modelling presented within the application indicate that there is a risk of physical injury, in the form of PTS, to grey seal within 99 m of the sound source.

11.38 Noise capable of causing disturbance is predicted to occur out to no more than either 2 km or 17 km (depending on modelled outputs) from the survey vessel.

11.39 Based on an average estimated density of 0.25 ind./km$^2$ across the Survey Area, an estimated 139 grey seals were predicted to be impacted by the ION survey (BEIS 2021).

### *CGG Service 3D Seismic Survey - Brodgar Infill 2021*

11.40 CGG Services have submitted an application to undertake a 3D seismic survey in Block 21/1 (CGG 2021a). The Greater Working Area is 1,905 km$^2$ and the working area 440 km$^2$. The survey area overlaps with the proposed GEOEX seismic survey and therefore there could be an in-combination impact.

11.41 The survey will operate 5,085 cu. in. airgun and be undertaken over a period of three days between 31 May and 31 July 2021.

11.42 The nearest coastline is 87 km from the survey area and therefore noise from the proposed activities will not impact on any SAC. Tracking data indicates that grey seals do not regularly occur in the area of the proposed survey. Consequently, there will not be any impacts on any designated site or qualifying species from the proposed survey and therefore there will be no in-combination impact.

### *CGG Service 3D Seismic Survey – Quad 21 Phase 4*

11.43 CGG Services have submitted an application to undertake a 3D seismic survey in Blocks: 19/8, 19/13, 20/6, 20/20, 21/6, 21/11, 21/16, 21/21 (CGG 2021b, Fugro 2021). The Greater Working Area is 8,074 km$^2$ and the working area is 5,536 km$^2$. The survey area overlaps with the proposed GEOEX seismic survey and therefore there could be an in-combination impact.

11.44 The survey will operate 3,460 cu. in. airgun and be undertaken over a period of 62 days between 1 April and 30 June 2021.

11.45 The nearest coastline, north-east Scotland, is 23.4 km from the survey area and therefore noise from the proposed activities will not impact on any SAC. There is potential for grey seals to occur in the survey area, in particular the survey areas in closest proximity to the coast of north-east Scotland.

11.46 Tracking data indicates that there is potential for grey seals from the Isle of May SAC to occur in the area of potential in-combination impact (Sparling *et al.* 2011, SMRU 2013). It is not possible, with the available information, to determine what proportion of seals that could be impacted are associated with the Isle of May SAC. However, it is predicted that the significant majority of seals present in the area will be from sites located in north-east Scotland or the Moray Firth and therefore not be associated with the Isle of May SAC.

11.47 No noise propagation modelling has been undertaken by the applicant to assess the impacts from disturbance, although it is estimated that significant disturbance to all marine mammals will occur within 12 km of the survey (Fugro 2021). For the purposes of this assessment the modelled outputs previously undertaken by BEIS has been used to assess the potential impacts from the proposed CGG Quad 21 Phase 4 survey (See Table 9).

11.48 Although there is potential for an in-combination impact, the impacts from disturbance are predicted to be impact on a relatively small (but unknown) proportion of the Isle of May SAC grey seal population.

### *CGG Service OBC/OBS Seismic and 3D seismic*

11.49 CGG Services limited have applied to undertake an Ocean Bottom Cable/Ocean Bottom Seismic survey and a 3D seismic survey in Block 21/30 from between 25 May and 30 September 2021. There is potential for noise from the proposed surveys to overlap with the GEOEX seismic survey and therefore could cause an in-combination impact.

11.50 The proposed survey lies approximately 179 km east of north-east Scotland and noise from the survey will not impact on any SAC. The location of the survey is in an area where grey seals are not known to regularly occur and therefore there will not be any impact from the CGG OBC/OBS seismic survey on any designated sites or qualifying feature. Consequently, there will be no in-combination impact.

### *Nautical Petroleum Diadem Marine Survey*

11.51 Nautical Petroleum have submitted an application to undertake a geophysical site survey in licence block 22/11. The survey will comprise of a 2D Seismic Survey and a CHIRP sub-bottom profiler and encompass an area of 21.84 $km^2$ (Nautical Petroleum 2021). The survey overlaps an area of the proposed GEOEX survey and therefore there is potential for an in-combination impact to arise.

11.52 The survey is due to be undertaken between 4 February and 30 June 2021 and last for a total of six days. The survey is located approximately 171 km from north-east Scotland and therefore noise from the proposed activities will not impact on any SAC. Radio tracking data from grey seals indicate that they do not occur in the area (Figure 6).

11.53 The location of the proposed survey will not impact on any qualifying species and therefore there is no potential for an in-combination impact.

### *Jersey Petroleum Greater Buchan Development Area Survey*

11.54 Jersey Petroleum have submitted an application to undertake a geophysical survey operating a sub-bottom profiler in Quadrants: 19, 20 and 21 (Jersey Petroleum 2021). The survey overlaps the same area as the proposed GEOEX survey and therefore there is potential for an in-combination impact to arise.

11.55 The survey is due to be undertaken between 7 June and 31 September 2021 and last for a total of 47 days. The survey is located approximately 120 km off north-east Scotland and therefore noise from the proposed activities will not impact on any SAC. Radio tracking data from grey seals indicate that they do not occur regularly in the area (Figure 6).

11.56 The nature and location of the proposed survey will not impact on any qualifying species and therefore there is no potential for an in-combination impact.

### *Ithaca geophysical survey*

11.57 The proposed geophysical survey is located in Block 29/10 and will be operating a sub-bottom profiler. The survey overlap with the proposed GEOEX survey and therefore there is potential for an in-combination impact. However, the Ithaca geophysical survey is located approximately 151 km from nearest coastline and therefore noise from the sub-bottom profiler will not impact on any SAC. The location of the survey is an area where grey seals do not occur regularly. Consequently, no qualifying feature will be impacted by the Ithaca geophysical survey and there will be no in-combination impacts.

### *Total – Vertical Seismic Profile*

11.58 Total have submitted an application to undertake Vertical Seismic Profile (VSP) survey in Block 22/25, approximately 235 km east of north-east Scotland. Although there is potential for noise from the proposed VSP survey to overlap with the GEOEX seismic survey there will be no impact from the VSP survey on any SAC nor any qualifying species. Consequently, there will be no-in combination impact.

## *In-combination Impacts on Southern North Sea SAC: Harbour porpoise.*

### *Noise modelling*

11.59 This section assesses the potential in-combination impacts based on the results from noise modelling undertaken for each of the applications.

#### *Physical Injury*

11.60 Based on the results from the noise modelling between 2 and 494 harbour porpoise could be at risk of PTS from proposed activities affecting the Southern North Sea SAC (Table 20). With the proposed mitigation in place for pile-driving at Hornsea two and at the Dogger A and B UXO clearance it is predicted that no harbour porpoise will be impacted by PTS. The level of noise arising from sub-bottom profilers used during geophysical surveys is below the thresholds at which the onset of PTS is predicted to arise. Consequently, it is predicted that no more than four harbour porpoise are at risk of the onset of PTS from proposed activities within the Southern North Sea SAC. It is estimated that up to 0.001% of the North Sea Management Unit harbour porpoise population could, in be impacted.

**Table 20: Estimated number of harbour porpoise at risk of the onset of PTS from proposed activities in the Southern North Sea SAC.**

| Activity | Harbour porpoise PTS |
|---|---|
| GEOEX Seismic Survey | 1 |
| ION Seismic Survey | 1 |
| Hornsea Two Pile-driving | 0 – 16 |
| Dogger A and B UXO clearance | 0 – 476 |
| Dogger A, B, C and Sofia Geophysical Surveys | 0 |
| Oil and gas geophysical surveys | 0 |
| **Total** | **2 - 494** |

#### *Disturbance*

11.61 The number of harbour porpoise predicted to be disturbed by planned activities within the Southern North Sea SAC is between 4,205 and 5,657 individuals depending on the use of noise limiting mitigation at Dogger A and B (Table 21). It is recognised that multiple UXO detonations undertaken over a wider area and the mobile nature of both the seismic and geophysical surveys will cause wider areas of disturbance and consequently increase the number of harbour porpoise potentially affected. However, the clearance of UXO is undertaken no more than once per day and the very short duration of each detonation is unlikely to elicit disturbance behaviour, in that

harbour porpoise may exhibit a startle response but are not predicted to avoid the area following a single detonation.

11.62 The estimated number of harbour porpoise that may be disturbed is equivalent to 1.25% and 1.7% of the North Sea Management Unit population. This is either within, or equal to, the threshold at which a population level of effect is predicted not to arise based on the ASCOBANS thresholds (See Para. 10.4). In particular, it is dependent on the effective use of either low ordnance clearance or bubble curtains during UXO clearance at Dogger A and B wind farms. The mitigation will significantly reduce the predicted number of harbour porpoise at risk of disturbance from these two activities. Although, it is possible that UXO could be cleared without mitigation it is considered that this is unlikely to arise as it would require both forms of mitigation to not be in place.

**Table 21: Estimated number of harbour porpoise at risk of disturbance from proposed activities in the Southern North Sea SAC.**

| Activity | Harbour porpoise PTS |
|---|---|
| GEOEX Seismic Survey | 903 |
| ION Seismic Survey | 903 |
| Hornsea Two Pile-driving | 2,119 |
| Dogger A and B UXO clearance | 56 – 1,508 |
| Dogger A Geophysical survey | 56 |
| Dogger B Geophysical survey | 56 |
| Dogger C Geophysical survey | 56 |
| Sofia Geophysical survey | 56 |
| Oil and gas geophysical surveys | 0 |
| **Total** | **4,205 – 5,657** |

### *In-combination threshold approach*

11.63 Based on the worst-case scenario without any mitigation, the daily threshold could be exceeded, between May and the end of September with up to 27.6% of the 'summer' area of the SAC potentially impacted (Table 22). This is above the maximum daily threshold, recommended by the Nature Conservation Bodies, that could cause an adverse effect on the integrity of the site.

11.64 The probability of having the maximum theoretical area of impact arising from all activities on the same day is so extremely small (approximately 1 in 6,500,000), that it is beyond reason that it will occur. It is therefore safe to conclude that the daily threshold based on the unrealistic worst-case maximum area of impact from all eight projects will not arise.

11.65 An assessment based on the average area of SAC impacted each day and the use of noise limiting mitigation provides a more probable daily threshold. Table 23 presents the daily threshold based on the maximum impacts arising from the proposed GEOEX survey and the average area of SAC impacted each day from the ION seismic survey and the average area impacted per day from pile-driving at Hornsea Two along with bubble curtains being used for UXO clearance. Under this more probable scenario the daily threshold is not exceeded during any month. For this scenario to arise the GEOEX survey must be impacting on the SAC on the same day as an item of UXO is cleared and all four geophysical surveys must be undertaken at the same time. This scenario is theoretically possible but unlikely to arise.

11.66 Based on a realistic worst-case scenario (with mitigation) the in-combination impacts across the season will be 8.3% of the 'summer' area (Table 24). Consequently, the seasonal threshold is not exceeded.

11.67 There are varying levels of confidence in the extent and duration of impacts from each of the activities that could occur within the Southern North Sea SAC which affect the results of this assessment (Table 25)[8]. Any changes in any of the Projects' schedules or scopes of work could affect the threshold based assessment.

**Table 22: Unrealistic Worst-case (no mitigation) in-combination daily threshold (%).**

| Activity | Apr | May | Jun | Jul | Aug | Sept |
|---|---|---|---|---|---|---|
| GEOEX Seismic Survey | 0 | 0 | 5.0 | 5.0 | 5.0 | 5.0 |
| ION Seismic Survey | 0 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 |
| Hornsea Two Pile-driving | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 |
| Dogger A and B UXO clearance | 0 | 7.9 | 7.9 | 7.9 | 7.9 | 7.9 |
| Dogger A Geophysical survey | 0 | 0 | 0 | 0 | 0 | 0 |
| Dogger B Geophysical survey | 0 | 0 | 0 | 0 | 0 | 0 |
| Dogger C Geophysical survey | 0 | 0 | 0 | 0 | 0 | 0 |
| Sofia Geophysical survey | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| **Total %** | **8.2** | **22.6** | **27.6** | **27.6** | **27.6** | **27.6** |

Note DBWF have committed to not undertake geophysical surveys at Dogger A, B or C in the same 24 hr period as UXO clearance is being undertaken without noise mitigation measures in place. Consequently there is no in-combination impact under the unrealistic worst-case scenario.

[8] Note Table 25 presents the confidence that activities will be undertaken on the basis that they have or will be consented. For those Projects that have not been consented this is a presumption made for the purposes of this HRA only, required in order to address potential in-combination impacts. It does not in any way fetter any future HRA conclusions or consent decisions.

**Table 23: Worst-case (with mitigation) in-combination daily threshold (%).**

| Activity | Apr | May | Jun | Jul | Aug | Sept |
|---|---|---|---|---|---|---|
| GEOEX Seismic Survey | 0 | 0 | 5.0 | 5.0 | 5.0 | 5.0 |
| ION Seismic Survey | 0 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 |
| Hornsea Two Pile-driving | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 |
| Dogger A and B UXO clearance | 0 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 |
| Dogger A Geophysical survey | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Dogger B Geophysical survey | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Dogger C Geophysical survey | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Sofia Geophysical survey | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| **Total %** | **8.8** | **14.0** | **19.0** | **19.0** | **19.0** | **19.0** |

Based on:

- Maximum area of impact from GEOEX seismic survey.
- Mean daily impacts from ION seismic survey and Hornsea Two pile-driving.
- Bubble curtains used for UXO clearance.
- Maximum area of impact from all wind farm geophysical surveys.

**Table 24: Seasonal thresholds in-combination**

| Activity | Worst-case Seasonal threshold (no mitigation) | Realistic-worst-case (with mitigation) |
|---|---|---|
| GEOEX Seismic Survey | 0.06 | 0.06 |
| ION Seismic Survey | 5.4 | 2.2 |
| Hornsea Two Pile-driving | 6.7 | 4.7 |
| Dogger A and B UXO clearance | 1.1 | 0.35 |
| Dogger A Geophysical survey | 0.5 | 0.5 |
| Dogger B Geophysical survey | 0.5 | 0.5 |
| Dogger C Geophysical survey | 0.01 | 0.01 |
| Sofia Geophysical survey | 0.01 | 0.01 |
| **Total %** | **14.3** | **8.3** |

**Table 25: Confidence in extent and duration of potential impacts from planned activities within or adjacent to the Southern North Sea SAC between April and September 2021.**

| Project | Confidence | Comment |
|---|---|---|
| GEOEX Seismic Survey | Moderate | High to Moderate confidence activities will be undertaken during summer 2021.<br>Very Low confidence on when activities will be undertaken within the SAC.<br>Very High level of confidence that the survey will be undertaken along known pre-determined survey lines.<br>High level of confidence from published evidence on the extent and duration of impacts. |
| ION Seismic Survey | High | Very High to High confidence activities will be undertaken during summer 2021.<br>Moderate to Low confidence on when activities will be undertaken within the SAC.<br>Very High level of confidence that the survey will be undertaken along known pre-determined survey lines.<br>High level of confidence from published evidence on the extent and duration of impacts. |
| Hornsea Two pile-driving | Very High | Very High confidence activities will be undertaken during summer 2021.<br>Very High confidence on when activities will be undertaken within the SAC.<br>High level of confidence in the area of SAC that could be impacted.<br>High level of confidence from published evidence on the extent and duration of impacts. |
| UXO clearance at Dogger A and B | High | Very High confidence activities will be undertaken during summer 2021.<br>High confidence on when activities will be undertaken within the SAC.<br>Very High confidence of regular usage of either low ordnance detonation or bubble curtains to mitigate noise impacts.<br>Very high confidence on the number of UXO to be cleared per day.<br>Low confidence in the number of UXO to be cleared or the number of days detonations will take place.<br>Very limited evidence on the extent of displacement from UXO clearance. No evidence supporting an EDR. |
| Dogger A, B, C and Sofia geophysical surveys | Low | Very High confidence activities will be undertaken during summer 2021.<br>Very Low confidence on what activities will be undertaken within the SAC.<br>Very Low confidence on when activities will be undertaken within the SAC.<br>Moderate level of confidence from published evidence on the extent and duration of impacts. |

### *In-combination assessment Southern North Sea SAC conclusions*

11.68 Results from noise modelling indicate that up to two harbour porpoise could be at risk of physical injury in the form of PTS from known planned activities within or adjacent to the SAC. This is 0.001% of the Management Unit population and therefore below the level of 1.7% at which a population level effect is predicted to occur. The estimated number of harbour porpoise that could be disturbed is between 4,205 and 5,657 individuals, depending on the use of noise limiting mitigation during UXO clearance. This is below the levels at which population level effects could occur.

11.69 The results from the threshold approach indicate that if there is no mitigation and all activities impact over the maximum possible area on the same day, the daily threshold will be exceeded. However, the probability of this occurring is exceedingly small. Furthermore, noise limiting mitigation to be in place for planned UXO clearance activities significantly reduces the extent of any impact. Under this, more probable, scenario the daily threshold is not exceeded.

11.70 Based on the best available information and supported by results from noise modelling and the threshold approach, BEIS is satisfied that the proposed GEOEX seismic survey in-combination with other plans will not have an adverse effect upon the integrity of the Southern North Sea SAC with respect to harbour porpoise.

### *In-combination assessment on Humber Estuary SAC and Berwickshire and North Northumberland Coast SAC: Grey seals*

11.71 There is potential for an in-combination impact on grey seals from the proposed GEOEX seismic survey, the ION seismic survey, pile-driving being undertaken at Hornsea Two offshore wind farm, UXO clearance at Dogger A and B, and both wind farm and oil and gas related geophysical surveys.

11.72 The assessment for the proposed GEOEX seismic survey on its own concludes that there will be a very low risk of any grey seals within the range at which the onset of PTS is predicted to occur (Table 9 and Para. 10.29). Consequently, there will be no in-combination impact on grey seals with respect to physical injury.

11.73 There is potential for in-combination impacts arising from displacement or disturbance. The estimated number of grey seals that could be disturbed varies depending on the densities of grey seals in the offshore area and the use of mitigation during UXO clearance. It is estimated that between 230 and 1,355 grey seals could be disturbed or displaced from in-combination impacts (Table 26).

11.74 A potential disturbance of up to 1,335 grey seals is equivalent to 5.38% of the Berwickshire and North Northumberland Coast SAC and 2.66% of the Humber Estuary SAC grey seal population. If low order clearance or bubble curtains are used during the UXO clearance the proportion of

the populations impacted are reduced to 4.01% and 1.32% at Berwickshire and North Northumberland Coast SAC and Humber Estuary SAC respectively.

11.75 The Isle of May SAC is part of the East Coast Management Area with a population of 14,216 individuals. The only other project recognised as having potential to cause an in-combination impact on grey seals is the CGG 3D seismic survey Quad 21 Phase 4. The proposed survey will at its closest location be 23.4 km from the coast. Grey seal densities in the region vary but are predominantly less than 0.4 ind./km$^2$ (Marine Scotland 2021). Based on an area of disturbance impact similar to that used for the GEOEX assessment of 383 km$^2$, it is estimated that the proposed Quad 21 Phase 4 survey could impact on 153 grey seals at any one time. This is equivalent to 1.6% of the grey seal East Coast Management Area population, which includes grey seals from the Isle of May SAC.

11.76 It is not realistic to presume that all the grey seals impacted by the proposed activities are all derived from a single SAC population. Tracking data indicates regular movements of grey seals between the SACs and other haul out sites (Sparling *et. al.* 2011). In particular, regular movements of grey seal occur between the Berwickshire and North Northumberland Coast SAC and the Humber Estuary SAC and also between the Berwickshire and North Northumberland Coast SAC and Isle of May SAC.

11.77 The proportion of the grey seal population from the combined the Berwickshire and North Northumberland Coast SAC and the Humber Estuary SAC is estimated to be between 2.3% and 2.7% depending on the use of noise limiting mitigation. For reasons presented in Section 10, it is predicted that any disturbance or displacement of grey seals will be temporary and not cause a population level effect.

**Table 26: Estimated number of grey seals at risk of disturbance from proposed activities.**

| Activity | Humber Estuary | Berwickshire and North Northumberland Coast | Isle of May |
|---|---|---|---|
| GEOEX Seismic Survey | 77 | 766 | 77 |
| ION Seismic Survey | 139 | 139 | 0 |
| Hornsea Pile-driving | <25 | <25 | 0 |
| Dogger A and B UXO clearance | 15 - 341 | 15 - 341 | 0 |
| Dogger A Geophysical survey | 16 | 16 | 0 |
| Dogger B Geophysical survey | 16 | 16 | 0 |
| Dogger C Geophysical survey | 16 | 16 | 0 |
| Sofia Geophysical survey | 16 | 16 | 0 |
| 3D Seismic Survey Quad 21 Phase 4 | 0 | 0 | 153 |
| **Total** | **320 - 646** | **1,009 – 1,335** | **230** |

### *In-combination assessment Berwickshire and North Northumberland Coast SAC and Humber Estuary SAC conclusions*

11.78 Results from noise modelling indicate that there is a very low risk of any physical injury, in the form of PTS, to grey seals from the proposed GEOEX seismic survey and therefore there is no in-combination impact with other plans or programmes.

11.79 There is potential for an in-combination impact from the proposed seismic survey and other activities to cause displacement or disturbance.

11.80 It is estimated that between 2.3% and 2.7% of the grey seal combined Berwickshire and North Northumberland Coast and the Humber Estuary SAC populations could be disturbed by planned activities.

11.81 It is estimated that 1.6% of the East Coast Management Area, including the Isle of May SAC, grey seal population could be disturbed.

11.82 Displacement or disturbance impacts will be temporary with seals capable of relocating away from an area without causing a population level effect.

11.83 Based on the best available information and supported by results from noise modelling, BEIS is satisfied that the proposed GEOEX survey in-combination with other plans or projects will not have an adverse effect upon the integrity of the Berwickshire and North Northumberland Coast SAC, the Humber Estuary SAC or the Isle of May SAC with respect to grey seal.

# 12 MITIGATION

12.1 The following section presents a summary of the planned mitigation submitted by the Applicant that will reduce the risk of an adverse effect occurring.

12.2 GEOEX have committed to following the JNCC guidelines for *minimising the risk of injury to marine mammals from geophysical surveys* (JNCC 2017a, EPI 2021). This will include:

- A minimum of 20 minutes soft-start undertaken every time the air-guns are switched on.
- The use of three dedicated Marine Mammal Observers.
- The use of Passive Acoustic Monitoring (PAM).
- Observations will be undertaken for at least 30 minutes prior to the soft-start and there will be a minimum of a 20 minute delay from the time of the last marine mammal detection within the 500 m mitigation zone and the commencement of the soft-start.
- Air-guns will be switched off at the end of each line and in the event that the survey is suspended for more than 10 minutes, a 30 minute pre-shoot search and 20 minute soft-start must be undertaken.

12.3 Compliance with the JNCC guidance will be made as a licence condition.

# 13 CONCLUSIONS

13.1 The Secretary of State has carefully considered all of the information available in order to undertake a Habitats Regulations Assessment. He considers the proposed GEOEX seismic survey to have the potential to cause a Likely Significant Effect alone and in-combination with other plans or projects on the qualifying species of the Southern North Sea SAC, Berwickshire and North Northumberland Coast SAC, Humber Estuary SAC and Isle of May SAC.

13.2 The Secretary of State has undertaken an Appropriate Assessment in respect of the sites' Conservation Objectives to determine whether the project, either alone or in-combination with other plans or projects, will result in an adverse effect on integrity.

13.3 The Secretary of State has undertaken a robust assessment using all of the information available to him.

13.4 Having considered all of the information available to him the Secretary of State has concluded that the proposed GEOEX seismic survey will not have an adverse effect on the integrity of any of the designated sites either alone or in-combination with other plans or projects.

# 14 REFERENCES

Aarts, G., Cremer, J., Kirkwood, R., van der Wal, J.T., Matthiopoulos, J. and Brasseur, S. (2016). *Spatial distribution and habitat preference of harbour seals (Phoca vitulina) in the Dutch North Sea*. Wageningen Marine Research report C118/16, 43pp.

Anderson, H. B., Evans, P. G. H., Potts, J. M., Harris, M. P. and Wanless, S. (2014). The diet of Common Guillemot *Uria aalge* chicks provides evidence of changing prey communities in the North Sea. *Ibis,* 156: 23–34. doi: 10.1111/ibi.12099.

Arso Civil, M., Quick, N.J., Cheney, B., Pirotta, E., Thompson, P.M., and Hammond, P.S. (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.

ASCOBANS (2015). *Recommendations of ASCOBANS on the Requirements of Legislation to Address Monitoring and Mitigation of Small Cetacean Bycatch*. October 2015.

Aynsley, C.L. (2017). Bottlenose dolphins (*Tursiops truncatus*) in north-east England: A preliminary investigation into a population beyond the southern extreme of its range. Newcastle University MsC Thesis.

Bach, S.S. Skov, H. and Piper, W. (2010). *Acoustic Monitoring of Marine Mammals around Offshore Platforms in the North Sea and Impact Assessment of Noise from Drilling Activities*. Society of Petroleum Engineers.

BEIS (2016a). Record of the Habitats Regulations Assessment undertaken under Regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) regulations 2001 (as amended): *South-west (Inshore) 2D Seismic Survey*. BEIS August 2016.

BEIS (2016b). Record of the Habitats Regulations Assessment undertaken under Regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) regulations 2001 (as amended): *East Shetland Platform (Inshore) 2D Seismic Survey*. BEIS July 2016.

BEIS (2020). *Review of consented offshore wind farms in the Southern North Sea Harbour Porpoise SAC*. Final issued September 2020.

BEIS (2021). Record of the Habitats Regulations Assessment undertaken under regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (As Amended). ION Southern North Sea Seismic Survey 2021. Issued April 2021. Rev 3.0. BEIS.

BEIS (*in prep.*). *Strategic Habitats Regulations Assessment for oil and gas activities in the Southern North Sea SAC* In prep.

Brereton, T., Kitching, M., Browne, A. and Scott, C. (2013). *Recent surveys to evaluate the Importance of the Farne Deeps and surrounding waters off the Northumberland coast for white-beaked dolphin and other cetaceans and seabirds of Conservation Concern*. MarineLife.

Camphuysen, C.J. (2002). Post-fledging dispersal of common guillemot *Uria aalge* guarding chicks in the North Sea: The effect of predator presence and prey availability at sea. *Ardea* 90.1:103 -119.

CGG (2021a). Application to carry out a Marine Survey Application GS/1200/1 (Version 1). 17 May 2021.

CGG (2021b). Application to carry out a Marine Survey Application GS/1191/0 (Version 1). 2 March 2021.

Clark, N. (2005). *The Spatial and Temporal Distribution of the Harbour Porpoise (P. phocoena) in the Southern Outer Moray Firth, NE Scotland*. Unpublished Master of Science Thesis. University of Bangor.

Cox, S. L., Miller, P. I., Embling, C. B., Scales, K. L., Bicknell, A. W., Hosegood, P. J., Morgan, G., Ingram, S. N. and Votier, S. C. (2016). Seabird diving behaviour reveals the functional significance of

shelf-sea fronts as foraging hotspots. *Royal Society open Science*, 3 (9), 160317. doi:10.1098/rsos.160317.

Cucknell, A. Boisseau, O., Leaper, R., Mclanaghan, R. and Moscrop, Anna. (2016). Harbour porpoise (*Phocoena phocoena*) presence, abundance and distribution over the Dogger Bank, North Sea, in winter. *Journal of the Marine Biological Association of the United Kingdom*. -1. 1-11. 10.1017/S0025315416000783.

Daunt, F., Wanless, S., Greenstreet, S. P. R., Jensen, H., Hamer, K. C. and Harris, M. P. (2008). The impact of the sandeel fishery closure in the northwestern North Sea on seabird food consumption, distribution and productivity. *Canadian Journal of Fisheries and Aquatic Sciences* 65: 362–391.

DBWF (2021). *Dogger Bank A Array Site and Dogger Bank A & B Export Cable Unexploded Ordnance (UXO) Clearance Supporting Environmental Information and Information to Support Habitats Regulations Assessment*. Dogger Bank Offshore Wind Farm.

Defra (2003). UK small cetacean bycatch response strategy. Department for Environment, Food and Rural Affairs. March 2003.

Defra (2012). The Habitats and Wild Birds Directives in England and its seas. Core guidance for developers, regulators & land/marine managers. December 2012.

Defra (2015). *An analysis of potential broad-scale impacts on harbour porpoise from proposed pile driving activities in the North Sea*. Report of an expert group convened under the Habitats and Wild Birds Directives – Marine Evidence Group.

Diederichs, A., Brandt, M., and Nehls, G. (2010). Does sand extraction near Sylt affect harbour porpoises? *Wadden Sea Ecosystem*, 26:199–203.

Dietz, R., Teilmann, J., Andersen S. M. Rige´t, F. and Olsen, M. T. (2013). Movements and site fidelity of harbour seals (Phoca vitulina) in Kattegat, Denmark, with implications for the epidemiology of the phocine distemper virus. *ICES Journal of Marine Science*, 70: 186–195.

DeRuiter, S.L. (2008). *Echolocation-based foraging by harbor porpoises and sperm whales, including effects of noise and acoustic propagation*. PhD Thesis. Massachusetts Institute Of Technology and the Woods Hole Oceanographic Institution. September 2008.

Dooling, R.J. and Therrien, S.C. (2012). Hearing in birds: what changes from air to water. *Adv. Exp. Med. Biol*. 2012;730:77-82. doi: 10.1007/978-1-4419-7311-5_17.

EAOWL (2015). *East Anglia Three offshore wind farm. Environmental Statement.* Scottish Power Renewables, Vattenfall.

EC (2018). *Managing Natura 2000 sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/CEE.* Commission Note. Brussels, 21.11.2018 C(2018) 7621 final. Luxembourg: Office for Official Publications of the European Communities.

Eglington, S.M. and Perrow, M.R. (2014). Literature review of tern (Sterna & Sternula spp.) foraging ecology. Final report July 2014. ECON.

English Nature (1997). *Habitats Regulations Guidance Note, HRGN 1.*

EPI (2021). 2D Marine Seismic Survey: Environmental Impact Assessment Marine Seismic Survey. EPI Report No. 2085.

Erbe, C., Dunlop, R. and Dolman, S. (2018). *Effects of Noise on Marine Mammals.* In: Effects of Anthropogenic Noise on Animals (pp.277-309).

Evans, P.G.H. and Teilmann, J. (editors). (2009). Report of ASCOBANS/HELCOM Small Cetacean Population Structure Workshop. ASCOBANS/UNEP Secretariat, Bonn, Germany. 140pp.

Everley, K.A., Radfod, A.N., Simpson, S.D. (2016). Pile-Driving Noise Impairs Antipredator Behavior of the European Sea Bass *Decentrarchus labrax*. In: Popper A.N., Hawkins, A.D. (eds). The effects of noise on aquatic life, II. Springer Science Business Media, New York. pp. 273 – 279.

Forewind (2013). *Dogger Bank: Creyke Beck offshore wind farm Environmental Statement.* Forewind.

Forewind (2014). *Dogger Bank: Teesside A & B offshore wind farm Environmental Statement*. Forewind

Franco, A., Perez-Dominguez, R. and Cutts, N. (2011). *Assessment of potential impacts of Able Marine Energy Park (AMEP) on sea and river lamprey in the Humber Estuary*. IECS report to ABLE UK Ltd.

Fugro (2021). *EIA Justification and EPS Risk Assessment for Quad 21 Seismic Survey Report | Central North Sea* 210162-R-001(02) | 26 February 2021 Final.

Furness, B. and Wade, H. (2012). *Vulnerability of Scottish seabirds to offshore wind turbines.* Report commissioned by Marine Scotland. 39pp.

Garthe, S., Benvenuti, S., and Montevecchi, W. (2000). Pursuit plunging by northern gannets (*Sula bassana*) feeding on capelin (*Mallotus villosus*). *Proceedings. Biological sciences / The Royal Society.* 267. 1717-22. 10.1098/rspb.2000.1200.

Geelhoed, S.C.V., Scheidat, M., van Bemmelen, R.S.A and Aarts, G. (2013). Abundance of harbour porpoises (*Phocoena phocoena*) on the Dutch Continental Shelf, aerial surveys in July 2010-March 2011. *Lutra* 56(1): 45-57.

GEOEX (2021a). Application to carry out a Marine Survey Application GS/1199/0 (Version 2). Multiclient Geophysical, Filial Av Geoex Ltd. 17 March 2021.

GEOEX (2021b). Application to carry out a Marine Survey Application GS/1205/0 (Version 2). Multiclient Geophysical, Filial Av Geoex Ltd. 19 April 2021.

Gilles, A., Peschko, V., Scheidat, M. and Siebert, U. (2012). *Survey for small cetaceans over the Dogger Bank and adjacent areas in summer 2011*. 19th ASCOBANS Advisory Committee Meeting, 20-22 March 2012. AC19/Doc.5-08 (P).

Götz, T. and Janik V.M. (2011). Repeated elicitation of the acoustic startle reflex leads to sensitisation in subsequent avoidance behaviour and induces fear conditioning. *Neuroscience* 2011, 12:30.

Greene, R. (1987). Characteristics of oil industry dredge and drilling sounds in the Beaufort Sea. *Journal of the Acoustical Society of America* 82:1315-1324.

Greenstreet, S., Armstrong, E., Mosegaard, H., Jensen, H., Gibb, I., Fraser, H., Scott, B., Holland, G. and Sharples, J. (2006). Variation in the abundance of sandeels *Ammodytes marinus* off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. *ICES Journal of Marine Science* 63: 1530-1550.

Hammond, P. S. (2006). *Small Cetaceans in the European Atlantic and North Sea (SCANS II).* LIFE Project No. 04NAT/GB/000245.

Hammond, P.S., Benke, H., Borchers D.L., Buckland S.T., Collet A., Hiede-Jørgensen, M.P., Heimlich-Boran, S., Hiby, A.R., Leopold, M.F. and Øien, N. (1995). *Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and adjacent waters*-Final report. Life 92-2/UK/027.

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, M.L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D., Gordon, J., Hiby, L., Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C.G.M., Ridoux, V., Rogan, E., Samarra, F., Scheidat, M., Sequeira, M., Siebert, U., Skov, H., Swift, R., Tasker, M.L., Teilmann, J., Van Canneyt, O. and Vázquez, J.A. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation* 164: 107-122.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J. and Øien, N. (2017). *Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys*. University of St Andrews. https://synergy.st-andrews.ac.uk/scans3/category/researchoutput/ (accessed May 2021).

Hansen, K. A., Larsen, O. N., Wahlberg, M. and Siebert, U. (2016). Underwater hearing in the great cormorant (*Phalacrocorax carbo sinensis*): *Methodological considerations. Meetings on Acoustics. Proceedings*, 27(1).

Hanson Aggregates Marine Ltd. (2013). *Licence Renewal Environmental Statement for Area 401/2.* Volume 1: Environmental Statement. July 2013.

Harris, R.E., Miller, G.W. and Richardson, W.J. (2001). Seal response to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. *Marine Mammal Science* 17: 795 – 812.

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Østensen, Ø., Fonn, M. and Haugland, E.K. (2004). Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). *ICES Journal of Marine Science* 61 (7), pp.1165-1173.

Hawkins, A.D., Roberts, L., and Cheesman, S. (2014). Responses of free-living coastal pelagic fish to impulsive sounds. *Journal of the Acoustical Society of America* 135: 3101 - 3116. PMID: 24926505.

Heath, M.R., Rasmussen, J., Bailey, M.C., Dunn, J., Fraser, J., Gallego, A., Hay, S.J., Inglis, M. and Robinson, S. (2011). Larval mortality rates and population dynamics of Lesser Sandeel (*Ammodytes marinus*) in the northwestern North Sea. *Journal of Marine Systems* 93, pp. 47- 57.

Heinänen, S. and Skov, H. (2015). *The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area*. JNCC Report No.544 JNCC, Peterborough.

Hermannsen, L., Tougaard, J., Beedholm, K., Nabe-Nielsen, J. and Madsen, P.T. (2015). Characteristics and Propagation of Airgun Pulses in Shallow Water with Implications for Effects on Small Marine Mammals. *PLoS ONE* 10(7): e0133436. doi:10.1371/ journal.pone.0133436.

Holland, G.J., Greenstreet, S.P.R., Gibb, I.M., Fraser, H.M. and Robertson, M.R. (2005). Identifying sandeel *Ammodytes marinus* sediment habitat preferences in the marine environment. *Mar. Ecol. Prog. Ser.* 303, 269– 282.

IAMMWG (2015). *Management Units for cetaceans in UK waters (January 2015).* JNCC Report No. 547, JNCC, Peterborough.

IAMMWG, Camphuysen, C.J. and Siemensma, M.L. (2015). *A Conservation Literature Review for the Harbour Porpoise (Phocoena phocoena).* JNCC Report No. 566, Peterborough. 96pp.

ICES (2016). Working Group on Bycatch of Protected Species (WGBYC), 1–5 February 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:27. 82 pp.

ION (2020a). *ION UKCS Southern North Sea 3D Seismic Survey*. Version 02. ION. 9 December 2020.

ION (2020b). *Application to carry out a Marine Survey. Application GS/1163/0 (Version 1).* GX Technology EAME Ltd. 11 December 2020.

Jak, R.G., Bos, O.G., Witbaard, R. and Lindeboom, H.J. (2009). *Conservation objectives for Natura 2000 sites (SACs and SPAs) in the Dutch sector of the North Sea.* Report number C065/09. IMARES Wageningen UR.

James, J., Hopkins, H., Crowell, S., Berlin, A.M., Fiely, J and Olsen, G.H. (2018). *Measuring Underwater hearing in diving birds.* USGS.

Jersey Petroleum (2021). Application to carry out a Marine Survey Application GS/1234/0 (Version 1). 7 May 2021.

JNCC (2017a). *JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys*. Joint Nature Conservation Committee, Aberdeen. April 2017.

JNCC (2017b). *Species abbreviations and Management Units (MU) abundance values, in "Instructions.doc".* Available from: http://jncc.defra.gov.uk/page-7201.

JNCC (2017c). SAC Selection Assessment: Southern North Sea. January 2017. Joint Nature Conservation Committee, UK. Available from: http://jncc.defra.gov.uk/page-7243.

JNCC (2017d). *A potential approach to assessing the significance of disturbance against conservation objectives of the harbour porpoise cSACs. Version 3.0.* Discussion document 14/02/2017. Workshop Noise management in harbour porpoise cSACs. The Dome Room, New Register House, 3 West Register Street, Edinburgh, Scotland EH1 3YT. 27th February 2017.

JNCC (2017e). *Noise assessment and management in harbour porpoise SACs. Briefing note: Use of thresholds to assess and manage the effects of noise on site integrity*. Workshop Noise management in harbour porpoise cSACs. The Dome Room, New Register House, 3 West Register Street, Edinburgh, Scotland EH1 3YT. 27th February 2017.

JNCC (2019a). *Southern North Sea MPA*. http://jncc.defra.gov.uk/page-7243..

JNCC (2019b). *Natura 2000 – Standard data form UK0030395. Southern North Sea*. Joint Nature Conservation Committee 26 March 2019.

JNCC (2020a). *Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland).* JNCC Report No. 654, JNCC, Peterborough, ISSN 0963- 8091. May 2020.

JNCC (2020b). Berwickshire and North Northumberland Coast SAC. https://sac.jncc.gov.uk/site/UK0017072. (accessed May 2021).

**JNCC (2021a) JNCC ADVICE ON APLICATION**

JNCC and NE (2019). *Harbour Porpoise (Phocoena phocoena) Special Area of Conservation: Southern North Sea Conservation Objectives and Advice on Operations*. March 2019. Joint Nature Conservation Committee and Natural England.

Jones, E.L. Smout, S. and McConnell, B.J. (2015). *Determine environmental covariates for usage preference around the UK*. Marine Mammal Scientific Support Research Programme MMSS/001/11. MR 5.1: Report At-sea usage and activity. SMRU 2015.

Judd, A., Warr, K. and Pacitto, S. (2011). *Fisheries Sensitivity Maps in British Waters – Guidance for Pile-driving.* Cefas contract report <ME5403 Mod13>.

Kastelein, R.A., Hardeman, J. and Boer, H. (1997). *Food consumption and body weight of harbour porpoises (Phocoena phocoena).* In: The biology of the harbour porpoise (1997). Eds. Read, A.J., Wiepkema, P.R. and Nachtigall, P.E. pp.217-233. DeSpil Publishers, Woerden, The Netherlands, ISBN90-72743-07-5.

Kastelein, R. A., Gransier, R., Hoek, L. and Olthuis, J. (2012). Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4 kHz. *Journal of the Acoustical Society of America.* 132(5): 3525–3537.

Kastelein, R.A., Schop, J., Hoek, L. and Covi, J. (2015). *Hearing thresholds of a harbor porpoise (Phocoena phocoena) for narrow-band sweeps (0.125-150 kHz) SEAMARCO* final report 2015-02.

Kastelein, R.A., Van de Voorde, S. and Jennings, N. (2018). Swimming Speed of a Harbor Porpoise (*Phocoena phocoena*) During Playbacks of Offshore Pile Driving Sounds. *Aquatic Mammals* 2018, *44*(1), 92-99, DOI 10.1578/AM.44.1.2018.92.

Learmonth, J.A, Murphy, S., Luque, P.L., Reid, R.J., Patterson, I.A.P., Brownlow, A., Ross, H.M., Barley, J.P., Santos, M.B., Pierce, G.J. (2014). Life history of harbour porpoises (*Phocoena phocoena*) in Scottish (UK) waters. *Marine Mammal Science* 30: 1427-1455.

Lenhardt, M.L. and Sismour, E. (1995). *Hearing in the sea lamprey (Petromyzon marinus) and the long nose gar (Lepisosteus spatula).* 1995, 259, Session I3, Poster Abstract. http://www.aro.org/archives/1995/259.html (Accessed May 2021).

Lockyer C. (2003). Harbour porpoises (*Phocoena phocoena*) in the North Atlantic: biological parameters. *NAMMCO Scientific Publications*, 5, 71–89.

Lucke, K., Lepper, P. A., Blanchet, M-A. and Siebert, U. (2008). Testing the acoustic tolerance of harbour porpoise hearing for impulsive sounds. *Bioacoustics* 17: 329-331.

Macleod, K. and Sparling C., (2011). *Assessment of The Crown Estate Aerial survey marine mammal data for the Firth of Forth development areas*. SMRU Ltd.

Maes, J. Turnpenny, A. W. H. Lambert D. R. Nedwell J. R. Parmentier A. and Ollevier F. (2004). Field evaluation of a sound system to reduce estuarine fish intake rates at a power plant cooling water inlet. *Journal of Fish Biology* Volume 64 Issue 4,938–946.

Marine Scotland (2021). National Marine Plan Interactive Version: 1.6.8.1 (NMPI). https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=1584. (Accessed May 2021).

Maitland, P. S, (2003). *Ecology of the River, Brook and Sea Lamprey*. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

McCauley, R.D. (1998). *Radiated Underwater noise measured from the drilling rig Ocean General, rig tenders Pacific Ariki and Pacific Frontier, Fishing vessel Reef Venture and natural sources in the Timor Sea, Northern Australia.* Shell Australia, 1998.

MeyGen (2011). MeyGen Tidal Energy Project Phase 1 Environmental Statement. Meygen.

Miller, L. A., and Wahlberg, M. (2013). Echolocation by the harbour porpoise: life in coastal waters. *Frontiers in Physiology*, 4, 52. http://doi.org/10.3389/fphys.2013.00052.

Mitchell, I., Macleod, K. and Pinn, E. (2018). Harbour Porpoise bycatch. UK Marine Online Assessment Tool, available at: https://moat.cefas.co.uk/biodiversity-food-webs-and-marine-protected-areas/cetaceans/harbour-porpoise-bycatch/. (accessed May 2021)

MMO (2015). *Modelled mapping of continuous underwater noise generated by activities.* A report produced for the Marine Management Organisation, pp50. MMO Project No. 1097. ISBN 978-1-909452-87-9.

MMO (2017a). *Anonymised AIS derived track lines 2015.* https://data.gov.uk/dataset/anonymised-ais-derived-track-lines-2015. Marine Management Organisation.

MMO 2017b. https://data.gov.uk/dataset/4bd80f1a-4ead-44c5-b3fa-975da1cb4d7d/fishing-activity-for-uk-vessels-15m-and-over-2016. (Accessed May 2021).

MMO (2020). MMO Licence Application: L/2018/00075/3 (Marine Licence). Variation request 3. L/2018/00075/3 (Marine Licence) https://marinelicensing.marinemanagement.org.uk/mmofox5/fox/live/?thread_id=jfguhdr80tpu9np8m5pj3ntq9snfqqnkv2096gp5cgkg7opihf0hu60qcp5mu3cen1sf6omergs2t06c2cuquspgm91bgggs6qn2&resume=1 (Accessed May 2021).

MMO (2021). MMO Licence Application MLA/2020/00581 (Marine Licence). https://marinelicensing.marinemanagement.org.uk/mmofox5/fox/live/. (Accessed May 2021).

Monaghan, P. (1992). Seabirds and sandeels: the conflict between exploitation and conservation in the northern North Sea. *Biodiversity and Conservation* 1: 98–111.

Morris, C., Thompson, D., Duck, C. (2021). Provisional Regional PBR values for Scottish seals in 2021. SCOS –BP 20/07

Mueller-Blenkle, C., McGregor, P. K., Gill, A. B., Andersson, M. H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D. T. and Thomsen, F. (2010). *Effects of Pile-driving Noise on the Behaviour of Marine Fish*. COWRIE Ref: Fish 06-08, Technical Report.

Natural England (2018a). *European Site Conservation Objectives for Humber Estuary Special Area of Conservation Site Code: UK0030170*. Natural England November 2018.

Natural England (2019). European Site Conservation Objectives for Flamborough Head and Bempton Cliffs Special Protection Area Site Code: UK9006101. Natural England February 2019.

NatureScot (2021a). Sitelink. https://sitelink.nature.scot/site/8278. Accessed May 2021.

NatureScot (2021b). *Conservation and Management Advice: Moray Firth SAC.* March 2021. NatureScot.

Nautical Petroleum (2021). Application to carry out a Marine Survey Application GS/1166/1 (Version 2). 2 February 2021.

Nedwell, J.R. and Edwards, B. (2004). *A review of underwater man-made noise.* Subacoustech Report 534R0109.

NGVL (2018a). *Offshore Environmental Statement: Volume 2*. National Grid Viking Ltd. August 2017.

NGVL (2018b). *Viking Link UXO clearance report to inform an Appropriate Assessment*. National Grid Viking Ltd. June 2018.

NGVL (2019). *Viking Link UXO Clearance: Report to Inform an Appropriate Assessment – update 01* May 2019. National Grid Viking Ltd.

OGP and IAGC (2004). *Seismic surveys and marine mammals*. Joint OGP/IAGC position paper.

Ørsted (2020). Hornsea Project Two Offshore Wind Farm: Report to Inform Appropriate Assessment for the Southern North Sea Special Area of Conservation. Ørsted. March 2020.

OSPAR (2009) *Overview of the impacts of anthropogenic underwater sound in the marine environment*. OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic (www.ospar.org).

OSPAR (2017). *Intermediate Assessment 2017: Harbour porpoise bycatch*. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/harbour-porpoise-bycatch/. (Accessed May 2021).

Otani S., Naito Y., Kawamura A., Kawasaki M., Nishiwaki S., and Kato A. (1998) Diving behavior and performance of harbor porpoises, *Phocoena phocoena*, in Funka Bay, Hokkaido, Japan. *Marine Mammal Science*, 14, 209–220.

Otani S. Naito Y., Kato A. and Kawamura A. (2000). Diving behaviour and swimming speed of a free ranging harbor porpoise, *Phocoena phocoena*. *Marine Mammal Science*, 16, 811– 814.

Parvin, S.J, Nedwell, J.R. and Harland. E. (2007). *Lethal and physical injury of marine mammals and requirements for Passive Acoustic Monitoring.* Subacoustech Report.

Parvin, S.J., Nedwell, J.R., Kynoch, J, Lovell, J., and Brooker, A.G. (2008). *Assessment of underwater noise from dredging operations on the Hastings shingle bank*. Report No. Subacoustech 758R0137. Subacoustech Ltd, Bishops Waltham, 81p.

Peña, H., Handegard, N.O. and Ona, E. (2013). Feeding herring schools do not react to seismic air gun surveys. *ICES Journal of Marine Science.*

Pichegru, L., Nyengera, R., McInnes, A.M., and Pistorius, P. (2017). Avoidance of seismic survey activities by penguins. *Scientific Reports*. 7, Article number:16305 (2017).

Pierce, G.J., Miller, A., Thompson, P.M. and Hislop, J.R.G. (1991). Prey remains in grey seal *(Hulichoerus grypus)* faeces from the Moray Firth, north-east Scotland. *Journal of Zoology, London* 224:337-341.

Pirotta, E., Brookes, K.L., Graham, I.M. and Thompson, P.M. (2014). Variation in harbour porpoise activity in response to seismic survey noise. *Biological. Letters*. 10: 20131090. http://dx.doi.org/10.1098/rsbl.2013.1090.

Popper, A.N. (2003). Effects of anthropogenic sounds on fishes. *Fisheries 28*(10):24-31.

Popper, A. N. Hawkins, A. D., Fay, R. F., Mann, D. A., Bartol, S., Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Løkkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, D. G., and Tavolga, W. N. (2014). *Sound Exposure Guidelines for Fishes and Sea Turtles*: A Technical Report

prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014.

Quick, N., Arso, M., Cheney, B., Islas, V., Janik, V., Thompson, P.M. and Hammond, P.S. (2014). *The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC*. Department of Energy and Climate Change: Strategic Environmental Assessment.

Quick, N. and Cheney, B. (2011). *Cetacean baseline characterisation for the Firth of Tay based on existing data: bottlenose dolphins.* Report for Forth Tay Offshore Windfarm Developers Group (FTOWDG).

Reid, J.B., Evans, P.G.H., and Northridge, S.P. (2003). *Atlas of Cetacean distribution in northwest European waters*. Joint Nature Conservation Committee, Peterborough.

Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson D.H. (1995). *Marine Mammals and Noise*. Academic Press, San Diego, 576pp.

Ropert-Coudert, Y., Daunt, F., Kato, A., Ryan, P.G., Lewis, S., Kobayashi, K., Mori, Y., Gremillet, D. and Wanless, S. (2009). Underwater wingbeats extend depth and duration of plunge dives in northern gannets *Morus bassanus*. *Journal of Avian Biology* 40: 380-387.

Russell, D.J.F. (2016). Movements of grey seal that haul out on the UK coast of the southern North Sea. Report for the Department of Energy and Climate Change (OESEA- 14-47).

Russell, D. J.F., Hastie, G. D., Thompson, D., Janik, V. M., Hammond, P. S., Scott-Hayward, L. A.S., Matthiopoulos, J., Jones, E. L. and McConnell, B. J. (2016). Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology* pp 1365-2664.

Russell, D J F, Jones E L and Morris, C D. (2017). Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals. *Scottish Marine and Freshwater Science* Vol 8 No 25, 25pp. DOI: 10.7489/2027-1.

Santos, M.B. and Pierce, G.J. (2003). The diet of harbor porpoise (*P. phocoena*) in the Northeast Atlantic. *Oceanography and Marine Biology: an Annual Review 2003*, 41, 355–390.

Santos, M.B., Pierce, G.J., Reid, R.J., Patterson, I.A.P., Ross, H.M., and Mente, E. (2001). Stomach contents of bottlenose dolphins (*T. truncatus*) in Scottish waters. *Journal of the Marine Biological Association of the United Kingdom,* 81: 873-878.

Sarnocińska, J., Teilmann, J, Balle, J.D., van Beest, F.M., Delefosse, M. and Tougaard, J. (2020) Harbor Porpoise (*Phocoena phocoena*) Reaction to a 3D Seismic Airgun Survey in the North Sea. *Front. Mar. Sci*. 6:824. doi: 10.3389/fmars.2019.00824.

SCOS (2015). *Scientific Advice on Matters Related to the Management of Seal Populations: 2015*. Sea Mammal Research Unit (SMRU). http://www.smru.st-andrews.ac.uk/documents/scos/SCOS_2015.pdf. (accessed May 2021).

SCOS (2016). Scientific Advice on Matters Related to the Management of Seal Populations: 2015. Sea Mammal Research Unit (SMRU). http://www.smru.st-andrews.ac.uk/files/2017/04/SCOS-2016.pdf (accessed May 2021).

SCOS (2019). *Scientific Advice on Matters Related to the Management of Seal Populations: 2019*. Sea Mammal Research Unit (SMRU). http://www.smru.st-andrews.ac.uk/files/2020/08/SCOS-2019.pdf (accessed May 2021).

Slotte, A., Hansen, K., Dalen, J. and One, E. (2004). Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fish. Res.* 67: 143-150.

SMart Wind (2015). *Hornsea offshore wind farm. Project two environmental statement.*

SMart Wind (2017). *Hornsea Project Three Offshore Wind Farm. Preliminary Environmental Information*.

SMRU (2004). *Sea Mammal Research Unit Scientific Report*. http://www.smru.st-andrews.ac.uk/documents/SMRU_Scientific_Report.pdf. (Accessed May 2021).

SMRU (2011). Grey seal diet composition and prey consumption. Marine Mammal Scientific Support Research Programme MMSS/001/11. CSD 3.3 Report. http://www.smru.st-andrews.ac.uk/documents/scotgov/CSD3-3_Grey_Seal_Diet_Composition_and_Prey_Consumption_Summary.pdf. (Accessed May 2021).

SMRU (2013). *Grey and harbour seal density maps, Task MR5 (part)*. Marine Mammal Scientific Support Research programme MMSS/001/11. Sea Mammal Research Unit report to Scottish Government.

Southall, B., Bowles, A., Ellison, W., Finneran, J., Gentry, Ro., Greene Jr., C., Kastak, D., Ketten, D., Miller, J., Nachtigall, P., Richardson, W., Thomas, J. and Tyack, P. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific recommendations. *Aquatic Mammals*. 33(4), 411-521.

Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall, P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P. and Tyack, P.L. (2019). Marine mammal noise exposure criteria: Updated Scientific recommendations for residual hearing effects. *Aquatic Mammals* 2019, *45*(2), 125-232, DOI 10.1578/AM.45.2.2019.125.

Sparling, C., Russell, D., Lane, E., Grellier, K., Lonergan, M., Matthiopoulous, J. & Thompson, D. (2011). *Baseline seal information for the FTOWDG area.* 29.08.10.FDG – FTOWDG Seals.

Sveegaard, I. (2011). *Spatial and temporal distribution of harbour porpoises in relation to their prey*. Unpublished PhD Thesis, Aarhus University.

Teilmann, J., Larsen, F. and Desportes, G. (2007). Time allocation and diving behaviour of harbour porpoises (*Phocoena phocoena*) in Danish and adjacent waters. *J. Cetacean Res. Manage*. 9(3):201–210, 2007.

Thaxter, C.B., Wanless, S., Duant, F., Harris, M.P., Benvenuti, S., Watanuki, Y., Cremiller, D. and Hamer, K.C. (2009). Influence of wing loading on the trade-off between pursuit-diving and flight in common guillemots and razorbills. *The Journal of Experimental Biology* 213:1018 -1025.

Therrien, S.C. (2014). *In-air and Underwater Hearing of Diving Birds*. Dissertation. University of Maryland.

Thompson, D., Sjoberg, M., Bryant, M.E., Lovell, P., and Bjorge, A. (1998). Behavioural and physiological responses of harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals to seismic surveys. Report to European Commission of BROMMAD Project. MAS2 C7940098.

Thompson, P. and Brookes, K. (2011). *Technical report on pre-consent marine mammal data gathering at the MORL and BOWL wind farm sites*. University of Aberdeen.

Thompson, P.M., Brookes, K.L., Graham, I.M., Barton, T.R., Needham, K., Bradbury, G. and Merchant, N.D. (2013). Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. *Proc R Soc Lond B Biol SAC* 2013, 280:20132001.

Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W. (2006). *Effects of offshore wind farm noise on marine mammals and fish*. Cowrie Report.

TKOWFL (2011). *Triton Knoll Offshore Wind Farm Environmental Statement.* RWE npower renewables.

Todd V.L.G., Lepper P.A. and Todd I.B. (2007). *Do harbour porpoises target offshore installations as feeding stations?* IADC Environmental Conference and Exhibition, 3rd April 2007, Amsterdam, Netherlands, 62pp.

Todd, V. L. G., Pearse, W. D., Tregenza, N. C., Lepper, P. A., and Todd, I. B. (2009). Diel echolocation activity of harbour porpoises (*Phocoena phocoena*) around North Sea offshore gas installations. *ICES Journal of Marine Science*, 66: 734–745.

USFWS (2011). *Environmental Science panel for marbled murrelet underwater noise injury threshold*. Final Summary report.

Van der Kooij, J., Scott, B.E. and Mackinson S. (2008). The effects of environmental factors on daytime sandeel distribution and abundance on the Dogger Bank. *Journal of Sea Research* 60: 201–209.

Villadsgaard A., Wahlberg M., Tougaard J. (2007). Echolocation signals of wild harbour porpoises, *Phocoena phocoena J. Exp. Biol.* 210 56–64.

Wanless, S., Morris, J. A. and Harris, M. P. (1988). Diving behaviour of guillemot Uria aalge, puffin Fratercula arctica and razorbill Alca torda as shown by radio telemetry. *J. Zool. Lond*. 216, 73-81

Wanless, S.; Corfield, T.; Harris, M. P.; Buckland, S. T.; Morris, J. A. (1993). Diving behaviour of the shag Phalacrocorax aristotelis (Aves: Pelecaniformes) in relation to water depth and prey size. *Journal of Zoology*, 231 (1). 11-25.

Wardle, C.S., Carter, T.J., Urquart, G.G., Johnstone, A.D.F., Ziolkowski, A.M., Hampson, G. and Mackie, D. (2001). Effects of seismic airguns on marine fish. *Continental shelf research* 21: 1005 – 1027.

Weir, C.R., Stokin, K.A., and Pierce, G.J. (2007). Spatial and Temporal Trends in the Distribution of Harbour Porpoises, White- Beaked Dolphins and Minke Whales Off Aberdeenshire (UK), North-Western North Sea. *J. Mar. Biol. Assoc. UK* 87: 327-338.

Whaley, A.R. (2004). *The distribution and relative abundance of the harbour porpoise (P. phocoena L.) in the southern outer Moray Firth, NE Scotland*. Unpublished bachelor of Science thesis. School of Geography, Birkbeck College.

Wisniewska, D.M., Johnson, M., Teilmann, J., Rojano-Doñate, L., Shearer, J., Sveegaard, S., Miller, L.A., Siebert, U. and Madsen, P.T. (2016). Ultra-high foraging rates of harbor porpoises make them vulnerable to anthropogenic disturbance. *Current Biology* 26: 1441–1446, Elsevier Ltd.

Wisniewska, D.M., Johnson, M., Teilmann, J., Siebert, U., Galatius, A., Dietz, R. and Madsen, P.T. (2018). High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocena phocoena*). *Proc. R. Soc. B.* 285: 20172314. http://dx.doi.org/10.1098/rspb.2017.2314.

Woodward, I, Thaxter, C.B., Owen, E. and Cook, A.S.C.P. (2019). *Desk-based revision of seabird foraging ranges used for HRA screening*. BTO Research Report No. 724. December 2019. The British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU.

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